Experience with the development of off-peak bus services
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- transport authority and operator staff in each of the seven centres covered in the project – particular mention should be made of the major contributions by Brian Bothwell (Brisbane Transport), Tom Wilson and Andrew Every (Department for Transport, Energy and Infrastructure, South Australia) and Nataniel Wolfson and colleagues (Department of Transport, Victoria)
- members of the project steering group (listed in section 1.4)
- the peer reviewers, who provided independent appraisal of the draft report (also listed in section 1.4).

Abbreviations and acronyms

ADL	Adelaide
AKL	Auckland
Australasia	Australia and New Zealand
BAU	Business-as-usual
BNE	Brisbane
BT	Brisbane Transport
CHC	Christchurch
DoI	Department of Infrastructure (now Department of Transport, Victoria
DoT	Department of Transport, Victoria
DUN	Dunedin
HAM	Hamilton
MEL	Melbourne
NZTA	New Zealand Transport Agency
PER	Perth
PT	public transport
PTD	Public Transport Division of the South Australia Department for Transport, Energy and Infrastructure (now the Public Transport Services Division of the SA Department of Planning, Transport and Infrastructure)
RP	revealed preference
SA	South Australia
SP	stated preference

Contents

Executive summary

This research, which was undertaken in 2010–2011, appraised experience with the development of off-peak bus services in three New Zealand cities (Auckland, Dunedin, Hamilton) and four Australian cities (Perth, Adelaide, Brisbane, Melbourne). The appraisal focused particularly on evidence from the Australian cities, which had all implemented substantial off-peak bus service enhancements during the last 10 years.

The primary focus of the project was on the effects of improving off-peak bus services on patronage levels, and hence estimation of service frequency elasticities. Particular aspects of interest included the differences in elasticities by day type (weekday, Saturday, Sunday) and time period (weekday interpeak, evening periods), and the pattern of patronage response and elasticities over time following the service change ('ramp-up profiles'). The secondary focus was on the effects of bus service enhancements on mode choice, on attitudes and perceptions about the services, and on providing greater travel opportunities for people experiencing transport disadvantage and/or social exclusion.

The project included a review of international evidence and experience on quantitative market responses to urban bus service enhancements in off-peak periods. The review emphasis was on disaggregated evidence (service frequency elasticities, etc) relating to key market dimensions of particular interest to the overall project. However, only very limited evidence was identified on service elasticity estimates generally, and particularly at the disaggregated level.

Service elasticity analysis and findings

The analyses were based on a 'before and after' methodology, using 'control' routes to estimate the counter-factual situation (ie in the absence of the service change being assessed). Key features of the analysis methodology related to geographic scope, temporal scope, patronage data, application of control routes, elasticity formulation and elasticity estimation methods.

The project elasticity findings drew primarily on the analyses for Adelaide, Melbourne and Brisbane, and are separated for reporting purposes into: (i) elasticity estimates for the fourth quarter (average of months 10–12) following the various service changes; and (ii) elasticity variations over time (the 'ramp-up' profile) relative to the fourth quarter estimates.

Q4 elasticity estimates

The primary differentiator of elasticity (Q4) values was found to be the day type/time period in which the service operated. Within a given day/time period, there was no clear evidence of significant differences in elasticity values between centres, by initial level of service or by other route or market characteristics. Our conclusions on typical (Q4) elasticities by day type/time period are summarised in the following table.

Typical service frequency elasticity values (Q4), by day type/time period

Day type	Time period	Typical Q4 elasticity ('own period')[a]
Weekday	Peak	0.25–0.35
	Interpeak	0.4–0.5
	Evening	0.5–0.7
	Overall	0.4–0.5
Saturday/Sunday	Overall	0.6–0.75
	Evening	0.8–1.1

a) Relates to service changes in single period only and patronage changes only in that period (refer to text). This will tend to understate the total market response, particularly when service changes are made in multiple periods.

Elasticity trends over time

The project analyses all showed generally similar ramp-up profiles of patronage and elasticity trends over time following a service change. The typical ramp-up profile was very much 'sharper' than is commonly stated in the literature relating to bus service improvements; ie the patronage growth rate was higher in the early months but relatively lower subsequently. The medium/long-run elasticity values (c.5 years after the service change) were in the order of only 10–15% greater than the short-run (c.12 months) values.

Other elasticity dimensions

The following table summarises the project findings in relation to the various other 'dimensions' of service frequency elasticities investigated.

Service elasticity findings – 'other' dimensions

Dimension	Findings	Notes, comments
Initial level of service	Little evidence of differences by initial service frequency.	A surprising result, although the evidence not conclusive (refer next dimension below) – generalised cost theory suggests that elasticities would reduce as frequencies increase, and there is some empirical support for this.
Day type/time period	Clear differences between weekday/ weekend and peak/interpeak/evening (refer to the earlier table).	It remains unclear to what extent the observed differences by day type/time period reflected (i) the different frequencies prevalent by period and/or (ii) underlying characteristics of the market at different periods.
Extent of service change	No evidence of significant differences by extent of service change.	There was minimal international evidence on this aspect.
Direction of service change	Evidence (limited) indicates no significant differences for increase vs decrease in services.	Evidence was based on only one case of service increase followed by decrease.
Service type and market demographic, etc factors	For a given time period, there was a strong consistency of values both within cities (by route) and between cities.	Any differences by service type, market, etc were likely to be second order – an encouraging result in terms of the transferability of values between cities and routes.

Summary of market research findings

The qualitative appraisal of the effects of off-peak bus service improvements on mode choice, on enhancing travel opportunities, and on attitudes and perceptions about the services reviewed the extensive market research evidence relating to the bus service improvements that have been implemented in Melbourne in recent years.

The main findings from this market research programme were as follows:

- *Previous and alternative means of travel for users of new/improved services:* The previous means of travel for the trip in question (or the alternative means of travel if the service were not available) depended very much on whether any alternative PT services could cater for the trip. Where reasonable alternative services previously operated, the majority of users of any new/improved services would have used these alternatives; otherwise, only a small proportion of the users of the new/improved services would have made the trip by PT. For passengers who would *not* have used another PT service as their alternative, typical alternative mode shares were: car driver c.30–40%; car passenger (lift) c.15–25%; walk/cycle c.10–20%; taxi/other c.5–15%; not make the trip c.10–20%. These proportions were influenced by the specific situation, but were generally consistent with results from market research elsewhere.

- *Desired service improvements:* For typical low-frequency (unimproved) suburban bus services, users' highest priority aspects for service improvements were good service frequencies and extended service hours (to run in evenings and weekends). This finding was consistent with the relatively high off-peak service frequency elasticities reported above. Other priority aspects included: more direct services (following the main roads), improved reliability, improved bus stops, real-time passenger information and stop-specific timetables. For PT services to attract current non-users who had access to a car, key aspects for improvement were more frequent services, services to better match required origins (home) and destinations, and more/better information and marketing of services.
- *User response to service improvements:* The Melbourne SmartBus market research indicated that those features of the improved services that most influenced people's decision to use them were: improved frequencies, faster travel/direct routings, longer service hours, and stop-specific timetables/real-time information. These features were also those for which SmartBus users expressed the highest levels of satisfaction. These findings for improved services are generally consistent with the improvement priorities expressed by users of 'unimproved' services (above).

  The evidence indicated that a substantial proportion of new passengers using improved PT (particularly suburban bus) services tended to be people with limited travel options. The improved PT services are likely to promote increased mobility, accessibility and self-reliance; provide better access to employment, health services and leisure activities; and thus contribute to reducing social exclusion.

Conclusions

This research has provided much-improved Australasian evidence on bus service frequency elasticity estimates for the various (weekday and weekend) off-peak periods; this indicates marked and systematic variations in service elasticities over the various day types/time periods, and a consistent pattern of increasing elasticity values over time since the service change (ramp-up profile).

It also found a strong consistency in frequency elasticity values across cities, across routes, by the extent and direction of service changes, and over time from the service change; this provides confidence regarding the transferability of the project estimates between cities, routes and situations, at least within Australasia.[1]

The pattern of elasticity estimates derived in the project should also make a significant contribution to the somewhat sparse international evidence base on this topic.

Further research priorities

Aspects of the market response to service frequency improvements that would warrant priority for future research are:

- separating out the impacts of (i) the day type/time period and (ii) the initial service frequency, on elasticity values
- the impacts of service changes in one time period (eg weekday evening) on patronage in other time periods (eg weekday daytime/interpeak)

[1] There is no evidence from this project, or from other elasticity research of which we are aware, that urban transport demand elasticities differ significantly between Australian and New Zealand cities. We therefore take the view that elasticities found in one of the two countries are likely to be directly transferable to the other country.

- the ‘synergy’ effects on patronage, and hence elasticities, of improving services ‘across the board’ (eg through the whole weekday) rather than at just a single time period (eg weekday evening).

Such research would substantially improve understanding of service elasticities in a range of situations, and hence be of considerable value to PT service planners/analysts internationally. It would not necessarily have to be based on Australasian evidence to be useful in the Australasian context.

Abstract

This research was undertaken in 2010–2011 to appraise evidence from three New Zealand cities (Auckland, Dunedin, Hamilton) and four Australian cities (Adelaide, Brisbane, Melbourne, Perth) on the market impacts of improvements in urban bus services at off-peak periods. The primary focus was on the estimation of patronage changes and the corresponding demand elasticities in response to service frequency changes.

Particular attention was given to the following aspects of service frequency impacts, as measured through elasticities: impacts in the various off-peak periods (principally weekday interpeak, weekday evening, Saturday, Sunday); progressive impacts over time following the service change; and variations in elasticities according to initial service frequency, extent of service change, direction (increase/decrease) of service change, and other service and market characteristics.

Recommendations have been made on the most appropriate set of service frequency elasticities, for the various off-peak periods, to be used in New Zealand and Australia for assessing the impacts of bus service improvement schemes over the short and medium terms.

1 Introduction

1.1 Project overview

The overall objective of this research project was defined as:

> *To collate and appraise recent experience in Australia and New Zealand with the enhancement of off-peak urban public transport services, principally bus services, and with a primary emphasis on the evening and weekend periods. The appraisal was to address in particular (to the extent that evidence was available) the impacts of service enhancements on patronage, mode switching and accessibility.*

The project involved an appraisal of evidence and experience over the last 10 years with the enhancement of urban bus services in three New Zealand centres (Auckland, Dunedin, Hamilton) and four Australian centres (Adelaide, Brisbane, Melbourne and Perth).

The project was undertaken in the period 2010–2011 by consultants Ian Wallis Associates (IWA) as part of the NZ Transport Agency (NZTA) research programme. Additional funding support was provided by the Department of Transport, Victoria.

1.2 Project context

A previous NZTA[2] research project by Ian Wallis (2004), *Review of passenger transport demand elasticities*, involved an extensive international review of urban public transport (PT) service and price elasticity evidence, and developed a set of service frequency and fare elasticities for application in New Zealand conditions (in the absence of any specific local evidence). The report provided elasticities for bus and rail services in both peak and off-peak situations, with its main off-peak emphasis being on the weekday interpeak period (rather than on evening and weekend periods).

Over the last 5–10 years, a number of New Zealand regional councils have made (or planned) substantial enhancements to PT (principally bus) services in the evening and weekend periods. However, the expected market response to such initiatives has been very uncertain. In the case of the Dunedin Public Transport Strategy (Gabites Porter 2007), the peer reviewer commented that: 'The impact of the large increase in services at evenings and weekends needs more investigation ... The forecasts of patronage provided ... may not be very reliable.'

Our re-examination of the international literature confirmed that evidence on the patronage impacts of service enhancements in the evening and weekend periods (as distinct from 'off-peak' periods generally) was remarkably limited. Hence, while there was a clear need for better information on this topic to assist authorities considering service improvements, there was a significant knowledge gap.

Since the early 2000s, most of the major cities in Australia (especially) and New Zealand have implemented extensive enhancements of their off-peak bus services, particularly over evening and weekend periods. The rather limited evidence available indicated that these enhancements had been generally quite successful in increasing patronage, but very limited robust monitoring of the effects of the enhancements had been undertaken.

[2] Previously Land Transport NZ.

This project was thus conceived to monitor (post-evaluate) the effects of the off-peak bus service enhancements implemented in Australia and New Zealand over the last 10 years, and thus to develop guidance on patronage effects (principally through service elasticities) and related impacts that could be applied to assist authorities (and operators) contemplating future off-peak service improvements. This guidance was intended to be directly applicable to New Zealand and Australian PT authorities, and to be potentially also applicable internationally. It would thus fill the knowledge gap identified above.

1.3 Project scope

1.3.1 Principal tasks

As set out in the original consultant proposal, the project involved the following principal tasks:

A: Inception

B: Scoping and case study selection

C: International review

D: Case study appraisal

E: Conclusions and recommendations.

The following summarises the conclusions from 'Task B: Scoping and case study selection', while tasks C, D, and E are covered in the remainder of this report.

1.3.2 Modes, time periods and types of service enhancements

It was decided early in the scoping stage that the project should cover bus services only (ie excluding other urban PT modes), because:

- the main interest of PT authorities in New Zealand (and Australia) was in enhancements to bus service levels rather than services on rail or other PT modes
- considerable data was available from these authorities on bus service enhancements undertaken over the last 10 years.

For bus services, the focus was to be on off-peak periods: in this context, 'off-peak' was interpreted as covering all periods except the weekday AM and PM peak periods. The project aimed to examine evidence separately for the three main off-peak segments – ie weekday interpeak, weekday evening, and weekend – with the weekend period being further segmented where evidence was available (eg Saturday v Sunday, daytime v evening).

In terms of the types of service enhancements of interest, it was decided the primary focus should be on service frequency improvements (on existing routes)[3], given that:

- most service enhancements contemplated by PT authorities in New Zealand/Australia are of this type
- most of the service enhancements undertaken by these authorities over the last 10 years have been of this type

[3] These could include extending the span of operating hours on existing routes (eg continuing services later in the evening).

- service frequency elasticity values can be estimated for the previous enhancements, and are particularly transferable to other situations where service frequencies are to be modified.[4]

1.3.3 Centres covered

The project analyses covered bus service enhancements in seven centres – three in New Zealand (Auckland, Dunedin, Hamilton) and four in Australia (Perth, Brisbane, Adelaide, Melbourne). Table 1.1 provides summary information for each of these centres on the types of service changes analysed and the parties (PT authorities and operators) that were involved in the project – through provision of information on the service changes and related patronage data, and in ongoing liaison and review of our draft analyses and conclusions.

At the scoping stage of the project, we also investigated the feasibility of undertaking similar analyses for service changes in Wellington (with New Zealand Bus) and Christchurch (with Environment Canterbury). For both these centres, we identified a number of difficulties affecting the required analyses, principally data issues and deficiencies, and difficulties in separating the effects of the service changes of interest from other factors affecting patronage on these services. Given these difficulties, we did not pursue analyses in either of these centres.

Table 1.1 Summary of service changes analysed and parties involved

Centre	Service changes analysed – summary	Principal parties involved[a]
New Zealand		
Auckland	Frequency improvements, interpeak and Saturday, Mt Eden Road	NZ Bus (operator)
Dunedin	Frequency improvements, Sunday services	Otago Regional Council
Hamilton	New services – Orbiter, CBD Shuttle	Environment Waikato
	Sunday services introduced on existing routes	
Australia		
Perth	Early evening (6pm–9pm) frequency improvements to feeder bus services to Northern Suburbs rail line	WA Public Transport Authority (Transperth)
Brisbane	Frequency improvements (evening, Saturday, Sunday) to 6 major ('BUZ') bus routes	Brisbane Transport (operator)
Adelaide	Frequency improvements to interpeak (8), evening (3) and Saturday/Sunday (7) bus services	Dept for Transport, Energy & Infrastructure, SA (South Australia)
Melbourne	• Introduction/enhancements of SmartBus routes (6) • Extension of (mainly) evening service hours on weekdays (30 cases) and weekends (25 cases)	Dept of Transport, Victoria[b], Bus Association Victoria[c]

a) The parties listed here all contributed by providing service and patronage data. In addition, the parties listed in Brisbane, Adelaide and Melbourne gave extensively of their time to provide previous analyses, discuss/resolve data issues, and review draft working papers that documented our analyses and results.

b) DoT Vic was a co-funder of the project.

c) We acknowledge in particular the extensive help provided on the Melbourne analyses by Chris Loader (then an employee of the Bus Association Victoria).

[4] Where, for example, route structures are changed, it is very difficult to generalise from the results to other situations involving route structure changes.

1.4 Project participants

1.4.1 Funders

The principal funding agency for the project was the NZ Transport Agency. Additional funding was provided by the Department of Transport, Victoria, to enable the project to be extended to include assessment of the experience in Melbourne.

1.4.2 Consultants

The research work for this project was undertaken by Ian Wallis Associates (IWA): the principal researcher was Ian Wallis, assisted by David Kennedy and Ankit Shishoo.

1.4.3 Participating authorities

The parties (PT authorities and operators) that participated in the project through the provision of service and patronage data are shown in table 1.1. In addition, we note that the parties listed for Brisbane, Adelaide and Melbourne gave extensively of their time to discuss/resolve data issues and to review draft working papers giving the project analyses and results.

1.4.4 Project steering group

A project steering group was set up by the NZTA to monitor project progress and to provide advice to the consultants as appropriate. The members were as follows:

- NZTA – Leah Murphy (Chair), Jeremy Traylen/Rosemary Barrington, Michelle McCormick
- Ministry of Transport – Anke Kole/Joanne Leung
- GWRC – Doug Weir
- NZ Bus – Rachel Drew/Scott Thorne.

1.4.5 Peer reviewers

Two peer reviewers were commissioned to provide independent reviews on the research, in particular through review of the draft report. They were:

- Professor Graham Currie – Professor of Public Transport, Monash University, Melbourne
- David Cope – NZTA.

1.5 Report structure

Following this introductory chapter, the remainder of this report is structured as follows:

- Chapter 2 summarises our international review of evidence on off-peak service level (frequency) elasticities for urban bus services. The full review is given in appendix A.
- Chapter 3 outlines the methodology used in deriving off-peak service elasticity estimates for each city. It includes discussion of service elasticity definitions and issues, scope of analysis and the use of control routes, analysis methods and the derivation of elasticity estimates.
- Chapter 4 reports and comments on the service elasticity estimates derived for the seven cities. Full details are given by city, in appendices B–H.

- Chapter 5 provides a comparative summary and commentary on the elasticity results for the seven cities.
- Chapter 6 summarises our review, focusing on Melbourne evidence, of previous market research on traveller attitudes and perceptions relating to off-peak bus services, including qualitative responses to service enhancements. The full review is given in appendix I.
- Chapter 7 summarises the project findings and conclusions, in relation to service elasticity estimates and other market impacts of service enhancements, and sets out recommendations on the potential applications of the project findings, principally in the New Zealand context, and on priorities for further research on the market response to service frequency enhancements.
- Chapter 8 lists the project references.

The following technical appendices detail the analyses undertaken for each centre as well as certain other aspects:

- Appendix A: Impacts of service improvements – international review
- Appendix B: Service elasticity assessments – Auckland
- Appendix C: Service elasticity assessments – Dunedin
- Appendix D: Service elasticity assessments – Hamilton
- Appendix E: Service elasticity assessments – Perth
- Appendix F: Service elasticity assessments – Brisbane
- Appendix G: Service elasticity assessments – Adelaide
- Appendix H: Service elasticity assessments – Melbourne
- Appendix I: Market research review of bus service improvements – Melbourne.

2 International review

2.1 Scope of this review

This chapter summarises the full international review that is set out in detail in appendix A.

As stated in the project proposal, the scope of this task was:

> *To collate/review available international literature on market responses to off-peak urban bus service enhancements. This will involve an update and extension of the earlier work on service level effects undertaken for Land Transport NZ by Ian Wallis.*[5]

Consistent with the primary focus of the overall project, the international review focused on urban bus service frequency improvements (on existing routes), for which it was possible to derive service frequency elasticity estimates, which could be transferable to frequency improvements in other areas or situations. However, the review did not attempt comprehensive documentation and appraisal of all the international evidence on urban bus service frequency improvements (and hence elasticities) in general: this topic was covered in the earlier NZTA research report (Wallis 2004). Rather, its emphasis was on disaggregated evidence (elasticities) relating to key market dimensions and issues, which are not extensively covered in the existing international literature but were of particular interest to this project.

Key dimensions examined (to the extent that evidence was available) included:

- variations in responses between different off-peak periods (principally weekday interpeak, weekday evening, Saturday, Sunday)
- trends in responses over time following a service change (the initial 'ramp-up' of responses and subsequent changes over five or more years)
- variations in responses according to the initial level of service
- impacts of service changes in one time period on patronage in other periods of the day/week
- differences between impacts on a route basis and on a wider corridor and network basis
- evidence of the prior behaviour (mode of travel, etc) of 'new' bus passengers attracted by improved services.

The international literature on the patronage effects of improvements in urban bus service frequencies was significant in volume, but not as extensive as perhaps might have been expected.[6] It provided a modest number of urban bus service frequency elasticity estimates for the overall market, with only a few of these being disaggregated by key dimensions (eg long v short run, day of week/period of day).

We note two further points here:

- Most of the international literature is based on studies of actual behaviour ('revealed preference' – RP), usually using 'before and after' analyses or econometric analysis of time series data on patronage and various causal variables.

[5] Refer to Wallis 2004.

[6] One of the major international publications on factors affecting the demand for public transport (Balcombe et al 2004) gives some four pages to the evidence on the 'effects of service intervals', as compared with some 50 pages to the evidence on the effects of fare changes.

- Some of the literature is based on stated intentions of how people said they would respond to changes in services (stated preference – SP). This review focused on the RP evidence as, where it is available, it generally provides a more reliable guide than SP evidence.

2.2 Disaggregated service frequency elasticity values – evidence and conclusions

A detailed review[7] of the key international (including New Zealand) sources that provide estimates of service frequency elasticity values for urban bus (and in some cases tram or train) services gave rise to the following findings:

- Almost all the literature covered had derived elasticity values from analysis of changes in actual market behaviour (ie RP rather than SP sources).
- Where possible, our review was based on appraisal of the original studies, rather than consolidated review articles.
- However, in general we did not attempt to examine the original data sets used in the studies, and therefore accepted the elasticity values derived by the original authors.
- One implication of this is that we (implicitly) had to accept the modelling methods and the definitions of the elasticities used in the original studies. Different studies used different modelling methods and elasticity definitions, and hence the results quoted across the full range of studies are often not consistent. We note in particular that various different formulations for calculating elasticities are common in the literature.[8]

Table 2.1 (following) presents a summary of the international evidence and our overall conclusions for each of the following disaggregation aspects:

- A Changes over time from service change (short-, medium- and long-run impacts)
- B Changes by time of day and day of week (weekday/Saturday/Sunday)
- C Changes by market segment, specifically by:
    - passenger type (adults, pensioners, children, etc)
    - CBD- v non-CBD-oriented travel
    - trip distance
- D Type of region or area
- E Initial service frequency.

We note that with the exception of item A (changes over time), the extent of evidence on each of these aspects was very sparse, in each case being based on a maximum of four separate studies.

In addition to the above, we originally intended to examine the disaggregated evidence on the following three aspects:

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[7] This review is presented in detail in appendix A (table A.1 in particular).

[8] Refer to chapter 3 in this report and Wallis 2004 (appendix L) for further discussion on this point.

- variations in elasticity responses according to the extent and direction (increase/decrease) of service changes
- impacts of service changes in one time period (or day type) on patronage at other time periods
- differences between impacts on patronage on a single route and impacts on the overall network (allowing for switching between routes).

However, we were unable to identify any worthwhile evidence on these three important aspects.

Table 2.1 Service level elasticities – summary of international evidence

Aspect	Reference/service	Summary of evidence	Overall conclusions
A Changes over time	MR Cagney 2009 (Aust. metro bus services)	Elast. relative to 9–12 months values: • 0–3 months – 63% • 3–6 months – 94% • 6–9 months – 101%	• Impacts in first 12 months Elast. values relative to 9–12 months: - 0–3 months – 60–85% - 3–6 months – 80–95% - 6–9 months – 90–100% • Impacts in medium term (beyond 12 months) Elast. value relative to 9–12 month results: - 2–4 years – 110–115% • Short/medium/long-run values (SR: within 12 months, LR = beyond 7 years or ultimate equilibrium) - LR:SR ratios in range 1.3 to 2.3 (favoured range 1.5 to 2.0).
	BAH 2002 (NZ metro bus services)	Ratios 3 months:12 months elast. values: • AKL route 007 – 86% • CHC Orbiter weekday – 74%, Saturday – 83%, Sunday – 80% Ratios 3 months:8 months elast. values: • CHC Lyttleton weekday – 62%, Sunday – 94% Longer run elast. rel. to 9–12 month results: • AKL route 007 – 24 months – 111%, 36 months – 111%, 48 months – 114%	
	Oxera 2000 (GB bus services)	LR:SR elast. range from around 0.9 to 2.3	
	Oxera 2005 (GB rail)	Time period to achieve 90% of ultimate patronage response (using rigorous statistical modelling methods) ranged from 1.0 to 4.7 years	
	Dargay and Hanly 1999 (GB bus)	Elast. ratios LR (when adjustment process completed): SR (within 1 year) generally in range 1.5–2.0 National level results give LR (within 7 years):SR (within 1 year) ratio of around 2.2	
	Dargay and Hanly 2002 (GB bus)	LR:SR elast. ratios generally in range 1.7 to 2.1	
	Preston 1998 (GB bus)	LR:SR elast. ratios generally in range 1.3 to 2.0	
	De Rus 1990 (Spain urban bus)	MR:SR elast. ratios around 1.5. Static model elast. results generally fall between SR and MR values	
	Holmgren 2007 (various)	LR:SR elast. ratios around 1.3	

Aspect	Reference/service	Summary of evidence	Overall conclusions
B Time of day and week	Preston 1998 (GB bus)	Best estimate SR values: • Interpeak – 0.17, evening – 0.35, peak – 0.38, Saturday – 0.52, Sunday – 1.05	No clear conclusions from the limited evidence: • Weight of evidence suggests off-peak elast. greater than peak values, and evening/weekend elast. greater than interpeak values – but considerable uncertainty. • Results likely to be confounded by typical frequency levels differing between time periods (refer to aspect E).
	Preston and James 2000 (GB metro/urban bus)	Off-peak (interpeak?) values between 1.0 and 3.0 times peak values	
	Wilson 2001 (Adelaide bus)	Best estimate SR values (mean values from samples, 7–11 routes). • Weekday evening – 0.46, Saturday – 0.49, Sunday – 0.20.	
	Hensher 2008	Off-peak elast. greater than peak elast	
C Market segment: C1 Passenger type	Preston and James 2000 (GB metro/ urban bus)	Elast. for adult pax greater than that for other pax types	No clear conclusions from the limited evidence.
	Brown and Singleton 1980 (Melbourne tram)	Elast. for pensioner pax greater than that for other pax types	
	Cheung et al 1985 (Netherlands, weekend urban services)	Elast. for older people (>45 years) greater than that for younger people	
C2 CBD v non-CBD trips	Preston and James 2000 (GB metro/ urban bus)	• In peak periods, elast. for CBD trips greater than for non-CBD trips • In off-peak periods, elast. for CBD trips less than for non-CBD trips	No clear conclusions from the limited evidence.
C3 Trip distance	Brown and Singleton 1980 (Melbourne tram)	Mixed evidence on variations in elast. with trip distance	No clear conclusions from the limited evidence.
	Hensher 2008 (various)	Elast. values similar for passenger trips and passenger km (indicating that no great differences in elast. values by trip distance)	

Aspect	Reference/service	Summary of evidence	Overall conclusions
D Type of region/area: D1 Metropolitan v other areas	Dargay and Hanly 1999; 2002 (GB bus)	Elast. for services in shire counties around twice those for metro areas	Reasonably strong evidence that elast. values in smaller urban centres and rural/semi-rural areas are higher than in metro areas. However this result may reflect the relative service levels rather than intrinsic market differences.
	Oxera 2000 (GB bus)	Elast. for services in other GB regions greater than for London	
D2 Urban densities and types of development	Hensher 2008 (various)	Found no significant differences in elast. values between US/Australasia (low density, car-dependent cities) and other, mostly EU (high density, less car dependence)	Cannot draw conclusions with confidence from the limited evidence.
E Initial service frequency	Cheung et al 1985 (Netherlands, weekend urban services)	Elast. values for lower-frequency services (<1/hour) were up to 0.9, for higher-frequency services (>2/hour) zero to 0.2	There is surprisingly little evidence on this aspect. The best source of evidence (Cheung et al) is consistent with expectations that elast. values would be substantially lower for higher-frequency services than for lower-frequency services.
	Renolen and Kjorstad (nd) (Norway bus services)	Analysis of daily PT trips rates by service frequency suggests that ‘elasticity’ value (% trip rate change:% service change) increases with base service frequency. This is contrary to expectations, but seems likely to reflect self-selection effects rather than expected service elasticities	

2.3 Previous travel modes – evidence and conclusions

Appendix A details the international (including New Zealand) evidence on the previous travel modes of additional PT passengers attracted as a result of service improvements. It focuses particularly on evidence relating to:

- bus services
- off-peak periods (where available)
- enhancements to existing services rather than the introduction of new mode or service types.

The relevant New Zealand and international evidence (set out in full in appendix A) focuses on three groups of bus service enhancement schemes:

- various New Zealand schemes (including one ferry scheme), mostly involving the introduction of new routes
- the Adelaide 'TransitLink' services, which primarily involved the introduction of limited-stop services to supplement the conventional routes
- an extensive set of bus service improvements in Norway, including service frequency increases – these trials were extensively monitored by the Norwegian government, and the evaluation results should be regarded as being of high quality.

Table 2.2 below provides a summarised version of this evidence, focusing on the previous travel modes of new bus users for each of the three groups of services. Key findings include the following:

- In the two Australasian cases, between half and two-thirds of the new PT trips were previously made by car (the proportion in the Norwegian cases appeared to be somewhat lower, most likely reflecting the differences in the areas and markets served).
- For these previous car trips the split between car driver and car passenger was fairly even, with the car passenger share of the car total varying between about 30% and 60%. (This result implies a greater propensity for car passengers to switch to PT than for car drivers, given the relative 'base' mode shares for car drivers and car passengers.)
- The proportion of new PT trips that were previously made by walking or cycling was typically around one-third.
- There was conflicting evidence on the proportion of completely new ('pure' generated) trips, ie cases where the improved PT service resulted in a new trip that would not otherwise have been made (even to a different destination). We believe this conflict largely reflects differences in survey methods and interpretation. We consider that the Norwegian trial project study is likely to give the most reliable results, indicating a 'new trips' share of around 6%.

Table 2.2 Previous travel modes of new bus users – summary (from appendix A)

Project/scope	Proportions of new users by previous modes		
	Car driver (CD)/car passenger (CP)	**Walk/cycle**	**Did not travel**
New Zealand – bus service enhancements	50–66% (20%, 29% CD in 2 cases)	27–41%	N/A
Adelaide – TransitLink Services	56% peak (33% CD, 23% CP) 58% interpeak (42% CD, 16% CP)	N/A	37% peak 34% interpeak
Norway – various trial projects	27–50% overall, 44% increased service frequency	27–51% overall, 33% increased service frequency	c.6% overall

3 Service elasticity concepts and analysis methodology

3.1 Scope of chapter

This chapter outlines the methodology developed for the analysis of service frequency elasticities in the seven centres covered. The methodology used was essentially similar in all the centres, although with some adaptations specific to the services under analysis and the form of patronage data available in each case.

The purpose of the analyses was to derive service frequency elasticity estimates for each of the service changes examined. Particular focus was given in the development of the analysis methodology to ensure its appropriateness for:

- deriving elasticity values in such a way that they would be consistent and comparable across all centres, and potentially transferable to other centres not covered in the project
- deriving elasticity values by separate day types (weekday, Saturday, Sunday) and time periods (principally interpeak, evening) wherever practicable
- assessing trends in elasticity values over time since the service change
- ensuring, wherever possible, that the elasticity effects estimated were in net terms (ie allowing for any patronage changes on other routes and at other time periods) rather than in gross terms (ie covering the effects only on the route and time period subject to the service change).

Sections 3.2 to 3.4 address the scope of the 'scheme' to be analysed; section 3.5 outlines the patronage data requirements for the analysis; section 3.6 describes the elasticity formulation used; and sections 3.7 to 3.9 outline the analysis methodology adopted and the format of reporting the results.

3.2 Geographic scope of scheme

If services are improved on one route, patronage is likely to be affected either positively or negatively not just on that route but also on other routes in the vicinity:

- In the case of 'competing' routes (broadly parallel to the improved route), the service improvements will generally result in the abstraction of passengers from these competing routes. Thus the system-wide elasticity (net effect on patronage) will be lower than the route-specific elasticity (gross effect).
- In the case of 'complementary' routes (which feed passengers to/from the improved routes), the service improvements will generally result in the generation of additional passengers on these complementary routes. In this case the system-wide elasticity will be greater than the route-specific elasticity.
- In practice, the competing routes case tends to be more common than the complementary routes situation, and the (negative) patronage effects on competing routes generally greater than the (positive) effects on complementary routes.

As noted above, wherever possible we aimed to estimate the net patronage effects of any service change. This required consideration of any likely impacts on other routes (both 'competing' and 'complementary') and the inclusion of these other routes within the 'scheme' for analysis whenever the patronage effects on these routes were expected to be significant.[9]

In the next chapter, we provide some examples of cases where we estimated elasticities both in gross terms (ie based only on the route experiencing the service change) and in net terms (ie including competing routes): these examples illustrate that the difference in elasticity estimates in the two situations may be substantial.

3.3 Temporal scope of scheme – alternative elasticity measures

Analogous to the discussion above relating to competing and complementary routes, if a service is improved at one time period (eg evening), there may well be effects on patronage at other time periods:

- In some cases, the improved service may cause passengers to switch from other time periods to the time period with the improved service (this is the 'competing' case).
- In other cases, the improved service may result in increases in patronage at other time periods (the 'complementary' case). For example, an improvement in evening services would be most likely to result in a net increase in patronage in interpeak/PM peak periods – new passengers would make their outward trip in these periods, and their return trip in the evening.

In general, we would expect the 'complementary' effects to outweigh the 'competing' effects in this case, and hence the net effect on patronage (over all time periods) is likely to exceed the gross effect (in the period with the service change).

As in the previous section, whenever possible we have aimed to estimate the net patronage effects of any service change, deriving elasticities by relating the net patronage change to the service change in the relevant period. But in practice a number of problems and qualifications should be noted, as follows (refer to table 3.1):

- Our preferred (net) elasticity measure is item B1, ie comparing the overall patronage change (all periods) with the service change in the relevant period.
- The gross elasticity measure often used by analysts is item A, where no allowance is made for patronage changes outside the period in which the services are changed. Typically, as noted above, this measure will tend to understate the total market response: this will be particularly significant for analyses by time period within a day type (eg for enhancements in evening services).
- In practice, in cases where the period affected by a service change represents the whole day (a weekday, Saturday or Sunday), we have ignored any possible effects on patronage on other day types. This may be considered as a conservative assumption: particularly in the longer term, it would seem probable that service improvements on one day type would tend to increase patronage on other days (however, these effects are likely to be second-order, and very difficult to estimate).
- In cases where elasticity estimates are sought for different periods of the day (eg AM/PM peaks, interpeak, evening) but services are improved over the whole day (or in more than one period), it is not

[9] In order to assess whether such effects are likely to be significant, preliminary analysis of patronage changes on the route in question might be required.

possible to separate out the effects of the change in one period on patronage in the other periods. Hence only an 'own period' assessment can be undertaken: this is shown as item C in table 3.1.

- The final, but important, point of comment here is how the period in which the service change occurs is defined for the elasticity assessment. The most intuitive definition, which we favour, would encompass only that period over which the services are changed. For instance, if service frequency levels were improved after 1900 hours, then the proportionate service increment and the 'base' level of patronage would be calculated for the period 1900 onwards, not for the whole day. While the literature is generally not specific on this point, it appears that analyses in this case often adopt the 'whole-day' approach (item B2 in table 3.1), which would tend to result in substantially lower elasticities than the 'evening-focused' approach.[10]

Our main conclusions and recommendations relating to both the geographic and temporal dimensions of the elasticity analyses, and having regard to the desirability of producing consistent and comparable results, are as follows:

- The focus of patronage changes should be on net rather than gross effects.
- The measurement of service changes should focus on the specific periods subject to the change, not on a much wider period.
- Whatever methodology is adopted, analysts should provide greater clarity on the bases for their assessments.

When presenting the results of our analyses for the seven centres in chapter 4, we have attempted to put these recommendations into practice.

Table 3.1 Elasticity methodology – alternative 'temporal' measures

Periods of service change	Basis for measurement		Notes
	Patronage change (numerator)	Service change (denominator)	
A Single period	Own period	Own period	Often used, but far from ideal
B1 Single period	All periods	Own period	Preferred measure (where possible)
B2 Single period	All periods	All periods	Often used, but not recommended
C Several periods	Own period	Own period	May be necessary (but period effects confounded)

3.4 Use of 'controls'

All elasticity assessments of this (before/after) type require 'base' estimates of the patronage levels that would have been expected in the period subsequent to the service change, if that change had not occurred: this is referred to as the 'business-as-usual' (BAU) or 'counter-factual' case. A simplistic assumption might be that this BAU patronage would be unchanged from the 'before' period, or based on an unchanged trend line.

[10] This result reflects that the average patronage levels (per trip or per service km) over the whole day are generally considerably higher than those for the evening only.

However, in general, such assumptions are likely to be unrealistic, and the use of ‘control’ services is desirable: these are intended to allow for any factors, other than the service change under examination, which might have affected patronage on the service in question over the analysis period. We have applied control services in all the analyses undertaken.

The general requirement for control services is for services on which, over the required analysis period:

- the service levels, etc, have not changed significantly
- the patronage has not been significantly affected by service changes on other services in their vicinity or by other localised factors
- their patronage trends are expected to be similar to those on the service being analysed (in the absence of service changes).

Given these requirements, other than in exceptional cases, the view was taken that all controls should relate to the same period(s) of the week/day as the service change being analysed. Control routes (by time period) were then selected consistent with the above requirements.

Ideally, we would advocate using multiple separate control routes: examination of the patronage changes on the route in question relative to these separate controls would enable confidence ranges to be placed on the elasticity estimates. In practice, this is not always possible; but where it is not, we advocate using larger (eg by combining multiple routes) rather than smaller controls. In any event, it is important in selecting controls to review the patronage changes on the potential control routes over the analysis period and to avoid using any routes that appear to be subject to significant localised influences (including data problems).

In chapter 4, we describe the controls selected for our elasticity analyses in each centre.

3.5 Elasticity formulation and application

3.5.1 Elasticity formulations[11]

The **elasticity of demand** is a measure frequently used to summarise the responsiveness of demand to changes in the factors determining the level of demand (such as the frequency of service provided). The basic expression of elasticity is:

$$E = \text{Proportional change in demand/Proportional change in explanatory variable}$$
$$= (\Delta y/y)/(\Delta x/x) \qquad \text{(Equation 3.1)}$$

where:

Δy is the change in the demand y

Δx is the change in the explanatory variable x.

This definition refers to a change Δx which is vanishingly small, so may be expressed mathematically as:

$$E_p = (\partial y/y)/(\partial x/x) = (\partial y/\partial x).x/y \qquad \text{(Equation 3.2)}$$

This elasticity represents the slope of the demand curve ($\partial y/\partial x$) at a particular point multiplied by the ratio of the explanatory variable (x) to the level of demand (y) at this point.

[11] The text in this section is drawn from the earlier NZTA research project (Wallis 2004) and the Transport Research Laboratory 2004 report (Balcombe et al 2004). A more detailed exposition is given in the latter report.

This is referred to as a **point elasticity** measure, representing the elasticity only at a particular point on the demand curve. In practice, point elasticities cannot be computed from empirical data unless the shape of the demand curve is known (or postulated) and its parameters may then be estimated from the observed data. Therefore other elasticity formulations, which do not require this knowledge, are commonly applied.

The **arc elasticity** concept is frequently employed in practical analysis, to estimate the elasticity from observations for two points on the demand curve: for small changes it approximates the point elasticity. If we assume a constant elasticity demand function over the range of change, the arc elasticity can then be calculated as:

$$E_A = \frac{\Delta ln\ y}{\Delta ln\ x} = \frac{ln\ y_2 - ln\ y_1}{ln\ x_2 - ln\ x_1} = \frac{ln\ (y_2/y_1)}{ln\ (x_2/x_1)} \quad \text{(Equation 3.3)}$$

This is equivalent to $(y_2/y_1) = (x_2/x_1)^E$, which is consistent with the constant elasticity demand function:

$$y = k.(x)^E \quad \text{(Equation 3.4)}$$

In terms of the application of the elasticity approach in this project, the explanatory variable is the service level, denoted by S, and the dependent variable (demand) is the patronage, denoted by P. Hence the formula for the elasticity of patronage with respect to service frequency is expressed as:

$$E = ln\ (P_2/P_1)/ln\ (S_2/S_1) \quad \text{(Equation 3.5)}$$

This (natural) logarithmic function[12] has a number of advantages over alternative elasticity functions in terms of the project requirements, including that it provides consistent elasticity results in cases where:

- two sets of service changes are made on a route: the total patronage effects calculated for the two separate changes will be the same as if the patronage effect was calculated for both changes together
- a service increase is followed by a service decrease (or vice versa), resulting in no net service change: this method will calculate no net patronage change, while other methods generally do not.

The above formulation is dependent on the assumption that the demand elasticity is constant over the range of changes under consideration.[13] While this assumption is commonly made, it is open to significant debate: there is evidence that both service elasticities and fare elasticities tend to increase with higher service headways (lower frequencies) and with higher fares. Such tendencies are consistent with a constant 'generalised' cost elasticity view of demand functions, under which the elasticities for any trip attribute would increase as that attribute accounts for a greater proportion of the total 'generalised cost' of the trips in question.

Given the potential significance of this aspect, while our elasticity estimation methods assumed a constant elasticity function over the range of each service change examined (see chapter 4) we reviewed whether our results provided any evidence for or against the constant elasticity hypothesis.

[12] 'ln' is the symbol commonly used for the natural logarithmic function.

[13] Assuming this assumption is valid, while elasticities are most commonly calculated and applied to relatively small changes in services (or other variables), there is no reason why they may not be calculated/applied to larger changes.

3.5.2 Application in the project

In the project's estimation of elasticities using the above function, we compared:

- patronage in each 'after' monthly period with that for the corresponding month in the 12 months immediately before the service change (thus accounting for any seasonality effects)
- these patronage changes on the route under examination (together with any competing/complementary routes) with patronage changes on a specified 'control' (unaffected) route group, and calculated elasticities based on the net patronage change (thus allowing for any other 'external' factors that might have affected patronage over the relevant period).

On this basis, the above elasticity function was expanded to the following:

Estimated elasticity $$E_e = \frac{\ln[(P_R^{Ta}/P_R^{Tb})/(P_C^{Ta}/P_C^{Tb})]}{\ln(S_R^{Ta}/S_R^{Tb})}$$ (Equation 3.6)

where:

E_e = service frequency elasticity estimate (by specified day type/time period)

P = patronage in specified period

S = number of service trips or service km over time period

R = route experiencing service change (together with any competing/complementary routes)

C = control route group

T_a = time period (month, quarter, etc) since the service change

T_b = corresponding month, etc in the year immediately before the service change.

3.6 Data and analysis requirements – overview

The overall purpose of the analyses was to estimate service frequency elasticities for previous bus service frequency changes in the seven centres, by comparison of 'after' patronage and service levels with 'before' patronage and service levels. The following were key requirements in this regard:

- The service change examined involved service frequency changes (without changes in route structure) by day type/time period, with an emphasis on off-peak periods – specifically weekday interpeak, weekday evening, Saturday all day/evening, Sunday all day/evening.
- The time periods were defined in each case to cover the distinct span of hours in which the services were increased (and not to extend far outside these hours).
- Elasticities were to be derived on a 'net' rather than 'gross' basis wherever possible. This involved including in the assessment any competing/complementary routes and time periods in which patronage was significantly affected by the service change being assessed (refer to sections 3.2, 3.3).
- Elasticity estimates were required on a periodic basis for as long after the service change as was possible given the data available (in practice up to five years).
- Elasticities were to be reported primarily on a quarterly basis, but estimated first on a monthly basis where possible.

- The patronage changes ('before' to 'after') were to be calculated by comparing each 'after' period with the corresponding 'before' period in the 52 weeks immediately prior to the service change.
- All elasticities were to be estimated allowing for extraneous patronage trends, as represented by control routes (refer to section 3.4).

3.7 Service and patronage data inputs

3.7.1 Service data

For straightforward service changes, the data required was the number of service trips on the route(s) in question within the specified time period, both before and after the service change.

For more complex service changes, involving some short runs, etc, estimates were made of the total service km before and after, as it was considered this would give a more representative estimate of the effective change in service levels. Similarly, when more than one route (including complementary/ competing routes) was included in the service change 'package', estimates were made of the total before and after service km for the whole package.

The required service information was, in principle, readily available from timetables.

3.7.2 Patronage data

The basic unit used for 'patronage' data was recorded passenger boardings, for the routes/time periods of interest. Boardings were used in preference to other potential measures (eg passenger km; passenger origin–destination journeys), as boardings data was more readily available and it was the primary unit of market output used by authorities and operators.

Passenger boardings were generally represented by the number of tickets validations recorded. While in a number of cases, a significant proportion of all boardings were not validated, these proportions were generally similar on the routes of interest and the control routes, so omission of non-validated boardings would not have resulted in significant bias in the results.[14]

In other cases where there were major problems with the ticket validation equipment, there was doubt whether the resulting extent of under-reporting was consistent across the various routes of interest (including control routes). In such cases, the data for the period concerned was not used.[15]

The most detailed level at which patronage data was required was by individual bus trip, ie total patronage disaggregated by route, day type/time period, date, direction and individual trip. Following inspection of the data at this level, the data was aggregated to provide average daily patronage (both directions combined) by month, by day type/time period.[16] Subsequent analyses were undertaken on this data, using the average monthly and/or average quarterly figures.

[14] One example of this was Melbourne, where validations were estimated to account for around 90–95% of total boardings over the period of interest.

[15] This was particularly a problem in Brisbane, where the introduction of new ticketing equipment resulted in serious under-reporting of ticket validations over the period September 2007–February 2008.

[16] Where the data allowed, the start of the first monthly 'after' period was defined as the day that the service changes were introduced. However, in some cases, data was only available on a calendar monthly basis: in such cases, the first monthly 'after' period was taken as the first full month following the service change.

Overall, once the data had been inspected and 'cleaned', as described above, and adjusted for any patronage changes on the control routes, the resulting datasets were generally of a good quality for the purpose of estimating elasticities. While the 'raw' analysis results often showed quite substantial month-to-month variations in the estimated elasticities, in most cases such variations were subsequently 'smoothed' through the process described below (section 3.9).

3.8 Analysis methodology – estimation of elasticity values

Starting from the average daily statistics by month for the routes/time periods of interest, both before and after the service change, the following were calculated:

- after:before patronage ratios – for routes of interest (including any competing/complementary routes)
- after:before patronage ratios – for control routes
- after:before service ratios – for routes of interest.

These inputs were then used with the elasticity formula defined earlier (section 3.6.2) to derive estimated elasticity values for the route(s)/time period on a monthly basis. Similar analyses were undertaken to derive averages on a quarterly basis and, as required, for longer (annual) periods.

3.9 Analysis methodology – 'smoothed' assessment

As noted above, we initially estimated elasticity values on a monthly average basis compared with the same month in the 12-month period prior to the service change. We then derived quarterly average (and annual average) elasticity values from the monthly estimates. As expected, the monthly values on their own showed quite wide variability, although this was reduced when quarterly values were considered; these showed a reasonably smooth curve, increasing over time since the service change but at a gradually decreasing rate.

In order to be able to generalise from the various results, it was useful to fit a smooth curve to the results, indicating the 'underlying' trends over time. In this case, a saturation-type curve was most appropriate, reflecting an expectation that in the long run the elasticity would be expected to approach a fixed value (rather than continue to increase indefinitely).

In developing our saturation curves, we adopted a popular equation for curve fitting – the 'two-parameter saturation growth' function:

$$E_S = A.T/(B+T) \qquad \text{(Equation 3.7)}$$

where T is time (following the introduction of the service change), and A and B are two parameters.

An alternative popular equation used for curve fitting is the 'two-parameter exponential' function:

$$Y = A\ (1\text{-}exp(\text{-}B*T)) \qquad \text{(Equation 3.8)}$$

where T is time, and A and B are two parameters.[17]

[17] Formula sourced from Kirk (2005).

Both of these equations were initially tested and compared. We found that both equations provided a similar fit to the set of elasticity estimates. However, the ‘two-parameter saturation growth’ method generally provided a better fit for off-peak data. Therefore, that method was employed for all our analyses where the ‘smoothing’ process was undertaken.

Hence the saturation curve formula adopted was:

Curve-fitted elasticity $E_s = A.T/(B+T)$ (Equation 3.9)

where:

A is a parameter representing the long-run elasticity

B is a parameter representing the speed of convergence to the long-run elasticity

T is time since introduction of service change.

Analysis of the dataset of actual elasticity estimates enabled A and B to be estimated so as to minimise the following:

Sum of squared error $\sum_{t=0}^{t=n}$ (derived elasticity–curve-fitted elasticity)^2

(Equation 3.10)

$$= \sum_{Ta=0}^{Ta=n} [\mathrm{E_e} - \mathrm{A.}T_\mathrm{a}/(\mathrm{B} + T_\mathrm{a})]^2$$

3.10 Analysis methodology – reporting of results

As noted earlier (section 3.8), our analyses provided elasticity values on a monthly basis (relative to the corresponding month in the 12 months prior to the service change). Quarterly and annual values could be derived through the same process.

For most of the project work in assessing patterns of elasticity results, we focused on average quarterly periods after the service change. We thus derived elasticity estimates for Q1, Q2, Q3, Q4, etc following the service change. In practice, the continuing rate of growth in market response (and hence elasticity estimates) was much reduced beyond the first 12 months, and hence we derived annual average elasticities beyond the first year. This resulted in a set of average elasticity estimates for the following periods: Q1, Q2, Q3, Q4, Y2, Y3, Y4, etc.

These estimates were derived on an ‘unsmoothed’ basis and, where the ‘smoothing’ process was applied, also on a ‘smoothed’ basis. Where ‘smoothed’ estimates were available, our reporting generally used these in preference to the ‘unsmoothed’ figures, so as to minimise the effects of random fluctuations in the data.

In reporting and discussing the elasticity results in the remainder of this report, we have largely segmented the discussion into two ‘dimensions’:

- estimates for Q4 (ie relating to the period covering months 10, 11 and 12 after the service change) – we adopted these estimates as our single primary indicator of market response to service changes, because they were largely consistent with the definition of short-run elasticities often found in the literature (ie the response after about one year)
- estimates for other periods (quarters, years) relative to the Q4 estimate – these reflected the pattern of patronage growth over time, including the rapid growth over the first 12 months followed by continually diminishing rates of growth thereafter.

4 Patronage and elasticity assessments, by city

4.1 Scope of chapter

This chapter reports on the assessments of patronage and elasticity impacts of service changes implemented in the seven cities, and comments on the results derived. It is arranged by city, in the following sections:

4.2 Auckland

4.3 Dunedin

4.4 Hamilton

4.5 Perth

4.6 Brisbane

4.7 Adelaide

4.8 Melbourne.

With the exception of Hamilton, all these assessments involved estimates of service elasticities associated with improvements in bus service frequencies, predominantly in off-peak periods.

Full details of the assessments undertaken for each city are provided in appendices B to H.

4.2 Auckland

The Auckland assessment covered the Mt Eden Road (Three Kings) route group, which serves one of the major radial corridors in the middle/inner suburbs. It covered two service frequency improvement schemes for this route group:

- weekday interpeak (Feb 2008) – typical headways improved from c.12mins to c.9mins (57% overall service increase in this period)
- Saturday (Oct 2008) – typical headways improved from c.20mins to c.15mins (37% overall service increase in this period).

The parallel Sandringham Road services, in the same time periods, were used as the controls in both cases.

For both the interpeak and Saturday services, the assessment was restricted by the limited 'after' period for which patronage data was available: data was available for the period up to April 2009, while the service improvements were implemented in February 2008 (interpeak) and October 2008 (Saturday).

The assessment summary and results are given in table 4.1. We offer additional comments as follows:

- The interpeak results should be regarded as more robust than the Saturday results.
- The results for both periods are similar, and the differences are not significant.
- The interpeak results suggest that the market response had stabilised after the first six months, while the response in the first quarter was around 75–80% of the total response by the second quarter.

Table 4.1 Assessment for Auckland Mt Eden Road (Three Kings) routes – interpeak and Saturday service increases

Item	Weekday interpeak	Saturday
Routes	Mt Eden Road (Three Kings) route group	
Operator	NZ Bus	
Controls	Sandringham route	
Period of service change	0900–1500	0800–1900
Date of service change	Feb 2008	Oct 2008
Headway before (typical)	12min	20min
Headway after (typical)	9min	15min
% increase in services	57%	37%
Data/analysis period (source)	Jan 2007–Apr 2009 (operator)	
Analysis methodology	• Econometric (time series) analyses of weekly data, with/without allowance for time trend • Own period elasticities	
Elasticity estimates:		
0–3 months after	0.36	≈0.40
4–6 months after	0.46	≈0.50
7–9 months after	0.47	
10–12 months after	0.45	
95% confidence interval	±0.15	±0.20
Notes, comments	High-quality results, suggesting that market response stabilised after 6 months	Medium-quality results, covering first 6 months only (later data not available)

4.3 Dunedin

The Dunedin assessment covered the doubling of Sunday services (from two-hourly to hourly) on the combined city routes (together with the St Clair–Normanby route) in July 2000.

Given the limited data available on Sunday patronage on other routes, the Saturday patronage on the combined city routes was used as the control. However, the ratio Sunday:Saturday patronage had grown quite substantially in the 'before' period, and it was unclear whether this trend would have continued in the 'after' period. Hence two versions of the 'after' Sunday:Saturday patronage ratio, in the absence of the service change, (ie the 'business as usual' case) were examined.

The assessment summary and results are given in table 4.2. Additional comments are as follows:

- Although the 'smoothed' quarterly elasticities shown appear well behaved and in line with prior expectations, they may be on the high side (given the uncertainty about the BAU case).
- This is particularly an issue beyond the first year: while the results show a continuing gradual growth in elasticity over the whole of the analysis period (up to year 8), this trend should not be given great weight.

Table 4.2 Assessment for Dunedin City routes – Sunday services increase

Item	Description
Routes	• Combined city routes • St Clair – Normanby route
Service change	Sunday, 2-hourly to hourly
Introduction	July 2000
Control routes	Combined city routes – Saturdays
Patronage data	Quarterly by route, Sept 1991–Dec 2007
Analysis methodology	• Assessed quarterly patronage growth (relative to control routes) over period 1996 Q3–2007 Q4. • Derived elast. estimates by quarter on two extreme assumptions for BAU case: (a) Sun:Sat (control) patronage ratio would have been unchanged in the 'after' period; (b) ratio would have continued to increase (reflecting increased Sunday shopping and other effects) at same rate as in 'before' period (from c.20% to 30% over 4 years). • Calculated quarterly unsmoothed and smoothed elast. estimates on both bases.
Elasticity estimates	Q1 ≈ 0.15, Q2 ≈ 0.30, Q3 ≈ 0.40, Q4 ≈ 0.45 Y2 ≈ 0.50, Y3 ≈ 0.57, Y4 ≈ 0.61, Y5 ≈ 0.64
Notes, comments	• Adoption of BAU assumption (a) above gives more plausible elast. results, so used in reporting (smoothed values given above) – but resultant estimates may be on the high side, with greater uncertainty in the medium/longer term. • Data indicates a continuing slow increase in elast. values over years 4–7, but this result should not be given much weight given the BAU uncertainties.

4.4 Hamilton

4.4.1 New routes – CBD Shuttle and Orbiter

This assessment covered the introduction of two new bus routes in Hamilton – the free CBD shuttle service (April 2006) and the Orbiter route (July 2006).

In both cases, the patronage growth trends were analysed on monthly and quarterly bases, from the time of introduction up to May 2009.[18] These analyses were divided into weekday peak, weekday off-peak and Saturday periods. Four typical existing Hamilton routes were used as the control. Monthly patronage data on these routes was provided for the period starting June 2003.

Table 4.3 provides a summary of these assessments and further comments are as follows:

CBD shuttle:

- The quarterly patronage trends were somewhat inconsistent, particularly for the Saturday services.

[18] However, results beyond July 2008 were affected by further service developments – in August 2008 the CBD shuttle was connected to the Orbiter, and in September 2008 the Orbiter was rerouted. Hence they are not reported here.

- For the weekday services, on a smoothed basis, the patronage trends (relative to Q4) averaged Q1 c.50%, Q2 c.75%, Q3 c.90%, Q4 100%, Y2 c.120%.
- For the Saturday services, saturation appeared to be reached within the first two quarters, but the results were erratic and should be discounted.
- By early 2009, weekday patronage had reached about 1400 passenger/day (400 peak, 1000 off-peak), and Saturday patronage had reached about 250 passengers/day.

Orbiter:

- The pattern of results was generally similar to those for the CBD Shuttle, with some inconsistencies for the Saturday services in particular.
- For the weekday services, on a smoothed basis, the patronage trends (relative to Q4) averaged Q1 c.58%, Q2 c.80%, Q3 c.92%, Q4 100%, Y2 c.111%.
- By early 2009, weekday patronage had reached about 2800 passenger/day (1400 peak, 1400 off-peak), and Saturday patronage had reached about 500 passengers/day.

Table 4.3 Assessment for Hamilton new routes – Orbiter and CBD Shuttle

Service	CBD Shuttle	Orbiter
Introduction	April 2006	July 2006
Service levels: Weekday Weekends	10mins 0700–1800 10mins 0900–1300	15mins to 1800, 35mins to 2200 35mins 0600–2000, Sat/Sun
Control routes	**Routes 5, 10, 14, 30**	
Patronage levels: Weekday Saturday	1400/day 250/day	2800/day[a] 500/day
Patronage growth curve: Weekday Saturday	'Saturation' after Q8 – c.20% growth Q4–Q8 'Saturation' within 2Q	Close to saturation after Q4 Growth appeared to be fastest on Saturdays, slowest in peak periods

a) Orbiter weekday patronage approx double combined patronage on three control routes.

4.4.2 New Sunday services

This assessment covered the introduction of Sunday services in September 2008 on 12 'key' routes that were previously operated only Monday–Saturday. The Sunday timetables were identical to those on Saturdays for the same route.

The assessment was based on monthly patronage data for the period up to May 2009 (ie nine months): for each route, Sunday patronage was calculated as a proportion of the corresponding Saturday patronage.

The assessment indicated that saturation occurred relatively quickly: by month 4, the Sunday services were carrying approximately 1700 passengers/day (approximately 70% of the patronage being carried on the corresponding Saturday services) and this proportion remained generally unchanged for the remainder of the analysis period (up to month 9).

4.5 Perth

This assessment covered increases in service levels (introduced in 2008) in Perth for bus routes operated as feeders to the Northern Suburbs Rail line (NSR), in the early evening period:

- The feeder routes concerned linked to five of the NSR stations – refer to table 4.4.
- Service frequencies on these routes were enhanced in the weekday post-PM peak/early evening period 1800–2100 (principally 1900–2000): frequencies were improved by between 30% and 78% from their previous levels of approximately hourly.
- The service improvements were implemented in August and October 2008.
- Patronage data provided covered the period July 2007–April 2009, with patronage by route, week and hour of day. Thus in each case the patronage data covered only the first six to nine months after the service change.
- For each route, the control used was the same route over the weekday interpeak (0900–1500) period.[19]

Econometric analyses were undertaken, using the following four separate models to examine the patronage changes on each route:

(A) Route patronage trends, including time trend term.

(B) Route patronage trends, excluding time trend term.

(C) (Route less control) patronage trends, including time trend term.

(D) (Route less control) patronage trends excluding time trend term.

Model D was generally judged to be the preferred model, and the results given in table 4.4 relate to this model. Comments on these results are as follows:

- The Clarkson elasticity estimates are not significant. This may reflect that the service increase was the least of all the five routes, and/or may indicate that the additional services did not affect patronage levels, for whatever reasons.
- All the other elasticity estimates are highly significant (mostly at the 0.1% level), except for the Joondalup 0–3 months figure.
- Of the nine elasticity estimates that are significant at the 0.1% level, in eight cases the best estimates lie between 0.33 and 0.52. This is a reasonably narrow range for such analyses and this range is generally consistent with most other evidence on short-run bus service elasticities.[20].
- Apart from Clarkson, there is no clear difference in elasticity values between the other four routes.
- There is no clear pattern of increase in elasticities over time from the introduction of the service increases – although there is some weak evidence that the elasticity values beyond the first three months are rather higher than in the initial period.

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[19] There is a possibility that some of the additional trips resulting from the increased early evening service frequencies would make their outward trip in the interpeak period. However, this was thought likely to be a small effect.

[20] However, elasticities for rail feeder bus services (for which park & ride/kiss & ride represent the main alternative access mode) may be distinctly different from the values for bus services generally: we are not aware of any specific evidence on this point.

Table 4.4 Assessment for Perth rail feeder routes to Northern Suburbs Railway

	Whitfords	Warwick	Stirling	Joondalup	Clarkson
% increase in services	58%	78%	56%	44%	30%
Elasticity:					
0-3 months after	0.33	0.26	0.52	0.13	0.06
4-6 months after	0.41	0.42	0.45	0.40	-0.11
7-9 months after	0.36	0.34	0.74	n/a	n/a
95% confidence interval[a]	±0.09	±0.15	±0.17	±0.19	±0.23
Robustness of model	Med	Low	High	Low	Low

a) Average of the 95% confidence intervals for the three best-estimate elasticity results given above.

4.6 Brisbane

4.6.1 Services and service changes assessed

The assessments undertaken involved enhanced service frequencies on six Brisbane routes run by Brisbane Transport (BT), which were implemented over the period November 2004–February 2009. Details are provided in table 4.5, with additional notes as follows:

- The routes for assessment are shown in column 1.
- Preliminary data inspection and discussions with BT staff resulted in the identification of ‘related’ (competing) routes in four cases, as shown in column 2. The services and patronage on these routes were therefore included in the ‘package’ for assessment.
- Control routes for each assessment were selected in discussion with BT, as shown in column 4.
- Patronage data for each assessment covered the periods shown in columns 5/6. In every case, the data series included at least 12 months before the service change, and generally continued until December 2009: this resulted in a minimum period for ‘after’ data of nine months, but in three of the cases a period of three to four years.
- Assessments were undertaken separately for service improvements in weekday evenings, Saturdays and Sundays. The table shows the initial headways and the proportionate frequency increases involved in each service improvement (for those changes involving a route package, these figures are shown both for the route in question on its own and for the total package being assessed). It is evident that in most cases the frequency increases were substantial.

Table 4.5 Brisbane routes and service changes assessed

Route no	Related routes(a)	Service change date	Control routes	Period of pax data		W/day evening (1900-2300)(b)		Saturday (1000-1800)(b)		Sunday (1000-1800)(b)	
				Start period	End period	Initial headway (mins)	Frequency increase (%)	Initial headway (mins)	Frequency increase (%)	Initial headway (mins)	Frequency increase (%)
1	2	3	4	5	6	7	8	9	10	11	12
140	130	Feb-09	120+170+180	Jan-06	Dec-09	53.3	256%	30	100%	42	178%
						(10.4)	(50%)	(10)	(33%)	(11)	(47%)
150	--	Nov-04	140	Oct-02	Jun-08	53.3	278%	30	100%	41.7	178%
190/199	191/196	Feb-06	375	Feb-04	Dec-09	60	300%	30	100%	30	100%
						(30)	(194%)	(15)	(50%)	(15)	(50%)
199	196	Nov-08	375	Nov-07	Dec-09			15	50%		
								(10)	(33%)		
200	--	Apr-05	210+212	Mar-03	Dec-09	48	220%	30	100%	40	167%
345	--	Feb-06	330	Jan-04	May-08	60	313%	30	100%	30	100%

(a) 'Related' routes are those other routes on which patronage was significantly affected by the change in question, and therefore were included as part of the 'package' assessed.

(b) Periods defined in terms of start times of bus trips. Unbracketed figures refer to only the route in question (col. 1); bracketed figures refer to the route package, including the related routes (col. 1 + col. 2).

4.6.2 Basis of assessment

The assessment methodology used was generally consistent with that outlined in chapter 3. Some particular points are worthy of note:

- The assessment started from daily patronage data (by route and time period) provided by BT. This daily data, for both the package being assessed and the control route, was then aggregated into moving 4-weekly and 13-weekly averages.
- Elasticities were then calculated on a quarterly (13-week) basis, using the methodology described in chapter 3.
- Elasticity values were estimated on two approaches:
  - based on patronage changes on the route (package) relative to the control route
  - based on changes in route patronage relative to an extrapolation of the 'before' patronage trends on the route – this approach was adopted particularly where the trends in the control patronage appeared to be abnormal.
- Based on inspection of the results from these two approaches, the preferred methodology was selected, using one or other approach, or a weighted combination of the approaches.
- Saturation curves were fitted to the quarterly elasticity estimates, and the resultant 'smoothed' quarterly estimates have been used in reporting results (below).
- All the elasticity assessments used the 'own period' basis, ie comparing the service change (bus trips per hour) in the period to which the change applied with the patronage change in the same period.[21]

4.6.3 Summary and commentary on Q4 elasticity results

The saturation curve elasticity estimates for the fourth quarter after the service change (ie average for months 10, 11 and 12) are given in table 4.6. Key findings, based on these results alone, were as follows:

- The unweighted average elasticity values for the three time periods were: weekday evening 0.59 (range 0.47–0.70), Saturday 0.73 (range 0.49–0.83), Sunday 0.74 (range 0.65–0.84).
- Prima facie (in the absence of statistical testing) these results suggest that:
  - Saturday and Sunday elasticities were not significantly different from each other
  - weekday evening ('own period') elasticities were significantly lower than weekend elasticities (for example, four of the five Saturday estimates were higher than all the evening estimates).[22].

[21] Given that, in most cases assessed, the services were changed in several periods on the same date, it would not have been possible to assess the effects of service changes in one period on patronage at other periods of the day or week.

[22] However, note that these are all 'own period' elasticities, and that the evening elasticity in particular is likely to understate the 'all period' elasticity. For example, if half the additional people making bus journeys in the evening period had made their outward trip by bus earlier in the day, then inclusion of these additional bus trips would result in the evening elasticity being in the range 0.75–0.80, ie very similar to the weekend estimates.

- From this limited sample, there was no evidence of systematic variations in elasticity values with:
  - initial service frequencies
  - extent of service increases.
- There was also no evidence that would suggest significant differences in elasticity values between routes (ie the differences in the best estimate values between routes, after allowing for other factors, could well have been the result of data or analysis issues).

Further analyses of these results and testing of hypotheses on elasticity relationships were undertaken subsequently, using the results drawn from all the centres covered in the project (refer to chapter 5).

The service changes on route 140 and routes 190/199 were examined both on a 'stand-alone' basis for that route only (not reported here) and on a 'package' basis, (including 'related' routes, as shown in table 4.6). In all these (six) cases the package elasticity estimates (as shown) were considerably lower than the stand-alone elasticities. The ratios of package values to stand-alone values (for the saturation curves) were between 56% and 78%, averaging 68%. This implies that, on average, about one-third of the additional patronage on the improved routes as a result of the service improvements was 'abstracted' from competing routes, while the other two-thirds represented additional bus passenger trips (further details are given in appendix F.

Table 4.6 Brisbane elasticity results summary, Q4

Route no.[a]	**Evening**		**Saturday**		**Sunday**	
	Freq. incr. %[b]	**Q4 elast.**[c]	**Freq. incr. %**[b]	**Q4 elast.**[c]	**Freq. incr. %**[b]	**Q4 elast.**[c]
140 (+130)	*50%*	0.59	*33%*	0.81	*47%*	0.65
150	*278%*	0.47	*100%*	0.80	*178%*	0.73
190/199 (+191/196)	*194%*	0.62	*50%*	0.49	*50%*	0.77
199 (+196)			*33%*	0.80		
200	*220%*	0.70	*100%*	0.72	*167%*	0.72
345	*313%*	0.59	*100%*	0.83	*100%*	0.84
Average[d]		**0.59**		**0.73**		**0.74**

a) 'Related' routes included in the assessment given in brackets.

b) Frequency increases include related routes.

c) Elasticity values are 'smoothed' estimates (based on saturation curve formulation).

d) Unweighted average value of figures for each route.

4.6.4 Summary of ramp-up profiles

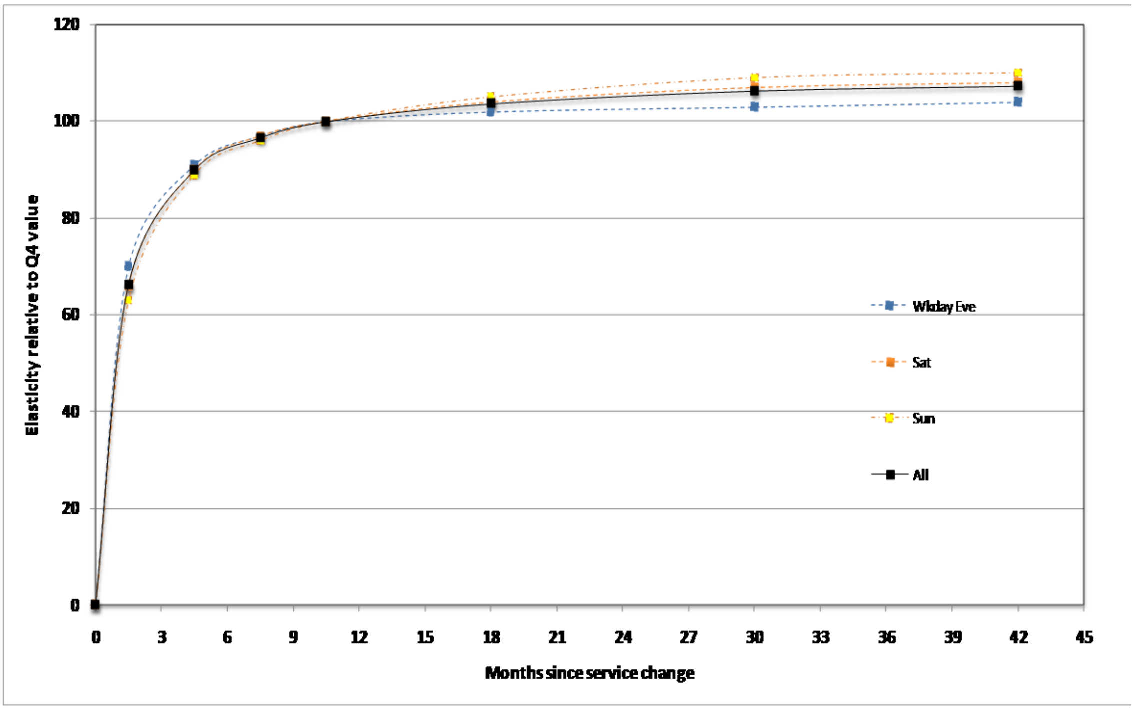
For each of the elasticity assessments undertaken, elasticity ramp-up profiles were derived on the 'smoothed' basis, expressed in each case relative to the Q4 values given in table 4.6 (with Q4 = 100).

Figure 4.1 summarises the ramp-up profiles obtained for each of the three time periods (weekday evening, Saturday, Sunday) and for the three periods combined. More detailed results, by individual route, are given in appendix F.

Comments on the figure 4.1 results are as follows:

- Key profile statistics for the all periods/all services average are:
  - Q1 c.67%, Q2 c.90%, Q3 c.96%, Q4 100%
  - Y1 average c.89%, Y2 c.104%, Y3 c.107%, Y4 c.109%.
- This represents a relatively sharp ramp-up profile (compared with the profile often assumed) – around 90% of the ultimate patronage increase occurred within the first 12 months following the service improvement, and around 80% within the first six months.
- Inspection of the more detailed results by route and time period suggested that, based on these relatively small samples, any differences in the ramp-up profiles by route and/or time period are not significant. This is unsurprising, given the similar nature of the various services and service changes assessed.

Figure 4.1 Brisbane average ramp-up profile



4.7 Adelaide

4.7.1 Services and service changes assessed

The assessments undertaken involved 18 cases of enhanced service frequencies[23] on a range of Adelaide bus routes (14 separate routes or route groups), which were implemented over the period January 2003–January 2008.

Details are provided in table 4.7, with additional notes as follows:

[23] In two of these cases, services were reduced (from two trips per hour to one trip per hour).

- Eight of the service changes assessed were for the weekday interpeak period (0900–1500), three for weekday evenings (1900–2400) and seven for weekends (three Saturday, four Sunday).[24].
- In cases where it was evident, from patronage data inspection and discussions with PTD[25] staff, that competing/complementary routes were affected by the service change, these were included in the package of routes to be assessed.
- For the weekday interpeak period, the typical 'before' frequency was either one or two trips per hour, and in most cases these frequencies were doubled. For the evening and weekend periods, the typical 'before' frequency was one trip per hour, which again was doubled.[26]
- In all cases, the control used was the patronage for the time period in question on all bus routes (in aggregate) expected to be unaffected by service changes over the analysis period. Inspection of this control patronage showed that it varied only slightly over most of the analysis period, although with some increases towards the end of the period (from mid-2008 onwards).
- Patronage data used for each assessment generally started 12 months before the service change and continued as long as possible after the change, generally up to January 2010: the total 'after' period in the various cases was between 2.5 and 7.0 years.

Table 4.7 Adelaide service changes assessed

Time period	No. of changes assessed	Notes
Weekday interpeak (0900–1500)	8	• Typically initial frequency (1–2/hour) doubled
Weekday evening (1900–2400)	3	• Typically initial frequency (1/hour) doubled
Saturday/Sunday	7	• 3 Saturday, 4 Sunday changes • Typically initial frequency (1/ hour) doubled • One case where frequency increased and subsequently decreased
Total	**18**	• **All changes over period Jan 2003–Jan 2008**

4.7.2 Basis of assessment

The assessment methodology used was generally consistent with that outlined in chapter 3. Some particular points worthy of note are as follows:

- The assessments started from monthly average passenger boardings per day (both directions combined) for the route (and control routes) during the relevant time period. All patronage data was provided by PTD.
- Patronage changes and hence elasticities were calculated (relative to the control routes) using the methodology described in chapter 3.

[24] Originally, 12 service changes were assessed for the weekday interpeak period. However, following review and discussions with PTD, four of these were eliminated because of overlap with wider route groups and data deficiencies.

[25] PTD is the Public Transport Division of the SA Department for Transport, Energy and Infrastructure.

[26] In one (Saturday) case, the 'before' frequency of 1 trip per hour was initially doubled to 2 trips per hour, and then some 2.5 years later was halved, back to its initial frequency.

- The analyses were first undertaken on a monthly basis, starting in each case from the first complete month after the service change and comparing with the corresponding month in the 12-month period immediately prior to the change. Subsequently, the monthly results were grouped to derive quarterly elasticity estimates.
- Saturation curves were also fitted to the quarterly elasticity estimates, and the resultant 'smoothed' quarterly estimates have generally been used in reporting results (below).[27]
- All the elasticity assessments were undertaken on an 'own period' basis, ie comparing the service change (bus trips per hour) in the period to which the change applied with the patronage change in the same period.

4.7.3 Summary and commentary on Q4 elasticity results

The 'smoothed' elasticity estimates for each service change for the fourth quarter after the change (ie average for months 10, 11 and 12) are given in table 4.8.

Key findings, based on these results alone, are as follows:

- For the weekday interpeak period, the unweighted mean of the eight elasticity results was 0.47, with a range between 0.35 and 0.61. For the weekday evening period, the unweighted mean of the three results was 0.52 (range 0.40 to 0.70).
- For the weekend (Saturday/Sunday) results, the unweighted mean of the seven results was 0.61, with a relatively narrow range between 0.50 and 0.74. There was no evidence of significantly different values between Saturdays and Sundays.

[27] In some cases, inspection of the monthly elasticity trends suggested that the saturation curve results might not have been representative: in such cases, a 'smoothed' estimate (differing from the saturation curve estimate) was derived, to provide a more representative estimate.

Table 4.8 Adelaide off-peak service improvements – service elasticities summary

Route no.	Service change date	Initial freq. (1-way trips/hr)	Frequency increase (%)	Q4 elast. estimate -smoothed[a]	PTD elast. estimate[b] (SR unadj)	Notes[c]
Weekday interpeak (0900–1500)						
113	Jan-04	1	100%	0.61	0.50	
122–125	Jan-03	4	50%	0.58	0.21	
140–142	Jan-03	2	100%	0.37		
143	Jan-03	1	100%	0.45	0.15	
178	Jan-08	2	100%	0.55	0.33	Results beyond Q2 not reliable because of increase in service levels on control routes (from July 2008). Not used for R-U profile
203 (200)	Oct-06	3	33%	**0.35**	0.13	**Not used for R-U profile**
263	Oct-06	1.33	50%	**0.35**	0.10	**Not used for R-U profile**
864	Feb-07	1	100%	**0.50**	0.41	**Not used for R-U profile.**
			Mean	**0.47**		
			Min.	**0.35**		
			Max.	**0.61**		
Weekday evening (1900–2400)						
172	Oct-06	1	100%	**0.40**	0.12	Result not v reliable – v erratic pattern of route patronage; difficult to separate apparent effects of earlier change in peak services. Not used for R-U profile.
203 (200)	Oct-06	1	100%	**0.45**	0.12	
682	Aug-05	2	-50%	**0.70**	0.02	Erratic patronage pattern, giving not v reliable results – appear to be affected by apparent drop in patronage prior to service redn. Not

Route no.	Service change date	Initial freq. (1-way trips/hr)	Frequency increase (%)	Q4 elast. estimate -smoothed[a]	PTD elast. estimate[b] (SR unadj)	Notes[c]
						used for R-U profile.
			Mean	0.52		
			Min.	0.40		
			Max.	0.70		
Saturday and Sunday						
155 (Sat)	Feb-03	1	100%	**0.65**	0.47	Nice illustration of symmetry between service increases and decreases!!
	Aug-05	2	-50%	**0.58**	0.72	Not used for R-U profile.
291 (Sat)	Jan-08	1	100%	**0.59**	0.62	Not used for R-U profile.
167/8 (Sun)	Aug-05	1	100%	**0.50**	0.18	Est. elast. affected by volatile route pax prior to service change. Not used for R-U profile.
171 (Sun)	Jan-08	1	100%	**0.52**	0.37	Not used for R-U profile.
203 (200) (Sun)	Oct-06	1	100%	**0.70**	0.50	Volatile results, because of large pax fluctuations in year prior to service change. Not used for R-U profile.
291 (Sun)	Jan-08	1	100%	**0.74**	0.78	Not used for R-U profile.
			Mean	**0.61**		
			Min.	**0.50**		
			Max.	**0.74**		

a) These elasticity estimates are representative estimates derived from inspection of the trends in quarterly elasticity values.

b) Elasticity (shrinkage ratio) estimate derived directly from the PTD data for a single month before and after the service change (with no 'control' routes).

'R-U' = 'ramp-up.

Based on the Adelaide evidence alone, we would draw the following tentative conclusions:

- The elasticities over the various off-peak periods analysed averaged 0.53.
- The mean values for the three periods were 0.47 (interpeak), 0.52 (evening) and 0.61 (weekend). Given the distributions of the individual results within each period, it appears these mean values were not significantly different.

  It should be borne in mind that the elasticity estimates derived were 'own period' elasticities, ie they did not allow for any patronage effects outside the period in which the services were changed. This is likely to mean that the elasticities presented understate the full market response to service changes. The extent of this understatement is likely to be greater for interpeak and particularly evening service changes, less for weekend service changes: if 'all period' elasticities were derived, it would seem quite probable that the weekday evening elasticity would be much closer to the values for the weekend periods.[28]
- There was insufficient evidence to detect any significant variations in elasticities according to either the initial service frequency or the magnitude of the service change.
- It remains unclear to what extent the apparent elasticity differences between routes reflected any intrinsic differences in the markets of different routes, or whether they were primarily the result of data and analysis issues. We would incline more towards the latter view.

4.7.4 Symmetry of elasticity values (service increases and decreases)

In the case of route 155, the Saturday services were increased from one trip per hour (each direction) to two trips per hour in February 2003, then subsequently decreased back to one trip per hour in August 2005. This provided a (rare) opportunity to examine whether elasticity responses are symmetric (reversible), ie the elasticity values for the service increases and decreases are identical or similar.[29]

The best (saturation curve) estimates obtained were for an elasticity of 0.65 for the service increase, 0.58 for the service decrease. Given the difficulties and uncertainties in estimating elasticities, these two estimates seemed unlikely to be significantly different. Thus the results were consistent with a hypothesis that elasticity responses are symmetric for service increases and decreases. (Clearly a lot more cases would need to be examined before it could be concluded that the symmetry hypothesis is generally valid.)

4.7.5 Some comparisons of project Q4 results with PTD elasticity estimates

PTD had previously undertaken their own analyses to estimate elasticity values for almost all the service changes assessed in the project. Their analyses examined the change in patronage in a single month in the 12 months after the service change relative to the patronage in the same month 12 months earlier: no control routes were used. They estimated elasticities from this data, using a 'shrinkage ratio' formulation.[30]

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[28] For instance, if it is assumed that all passengers affected make a simple (out and back) return trip, and 50% of them make one of their two trips outside the analysis period (evening), then the estimated elasticity would need to be increased by 33% to allow for the full market response.

[29] Under the elasticity formulation used in this project, in the case of a service increase followed by an equivalent decrease, with patronage returning to its original level, the resultant elasticity estimates for the increase and decrease would be identical. With other elasticity formulations, the values for the increase and decrease would differ.

[30] The 'shrinkage ratio' is defined as the ratio of the % change in patronage (relative to the 'before' patronage) to the % change in the service level (relative to the 'before' service level). Refer to Balcombe et al (2004) for further details.

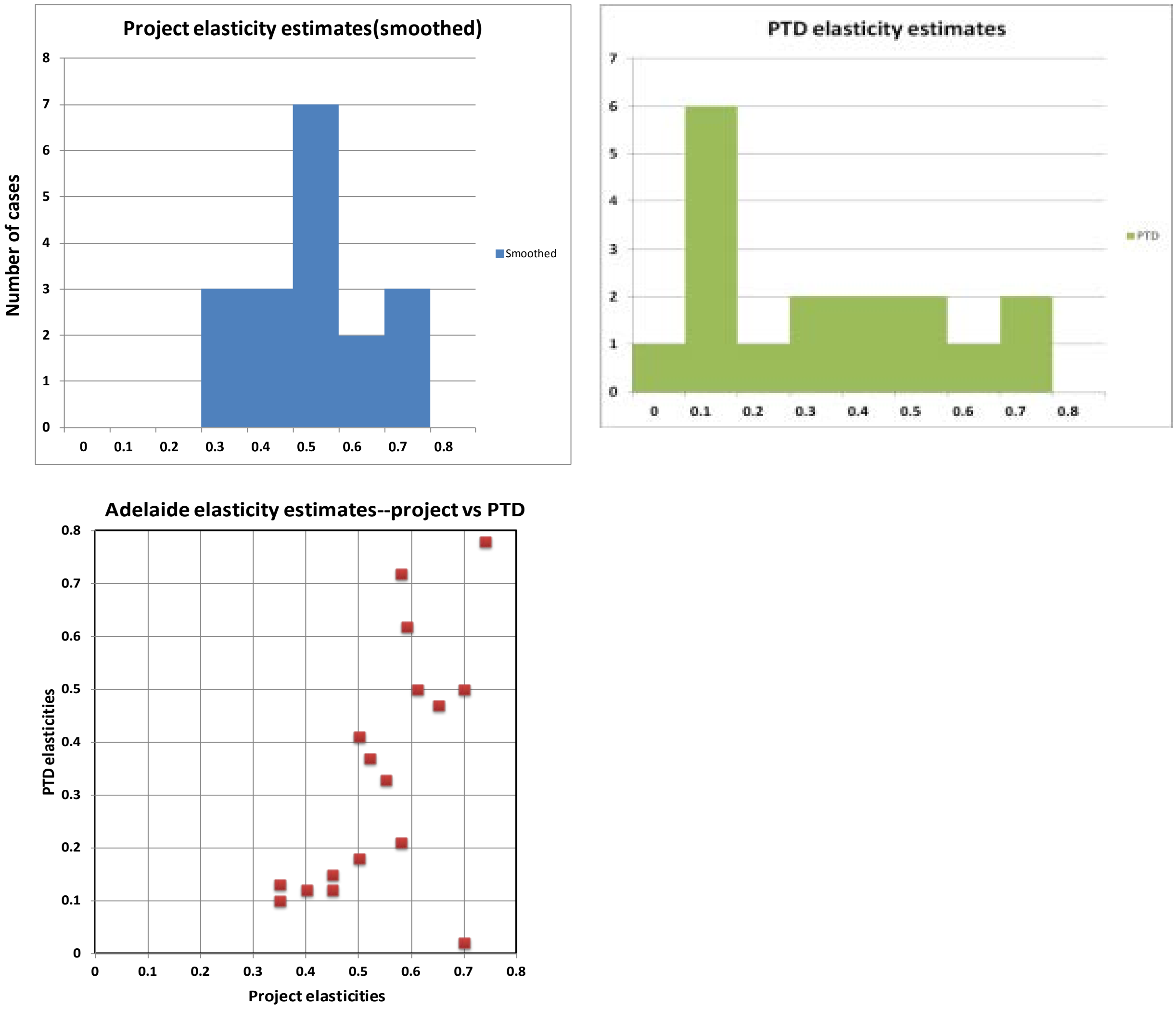
Figure 4.2 compares this project's best estimate ('smoothed') elasticity values with those derived by PTD, in terms of the estimates for each service change and the overall distribution of values:

- The project's estimates were substantially more consistent (less variability) than the PTD estimates.
- In 14 of the 17 cases, the project's estimates were higher than the PTD estimates, in most cases by a considerable margin.
- The mean of the project's estimates was 0.54, substantially higher than the mean of the PTD estimates of 0.34.

These differences illustrate that elasticity estimates can be sensitive to the data and methodology used in their derivation. Important aspects in this regard include:

- data periods used for 'before' and 'after' patronage figures
- use of control routes
- elasticity formulation used
- use of 'smoothing' techniques to adjust for data perturbations.

Figure 4.2 Comparison of Adelaide project elasticity estimates (Q4) v PTD estimates

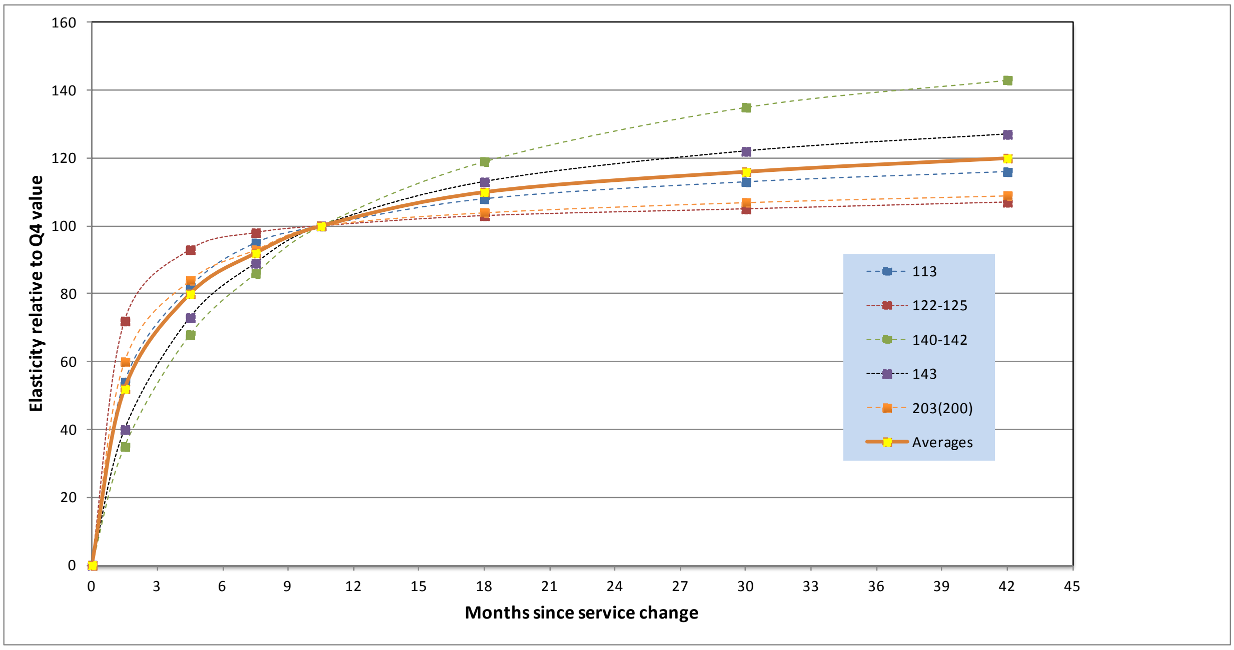


4.7.6 Summary of ramp-up profiles

Ramp-up profiles of elasticity values relative to the Q4 estimates were derived for only five of the 18 service changes, and the results are shown in figure 4.3. For the other service changes, profiles could not be derived with sensible reliability: reasons for this included the shortness of the 'after' time period for which valid patronage data was available (only 18 months in some cases); and cases where the saturation curves did not appear to adequately reflect the underlying patronage trends.

The small samples were such that no further analysis could usefully be undertaken on Adelaide ramp-up patterns (but refer to chapter 5 for an assessment of ramp-up results across all the centres covered).

Figure 4.3 Adelaide elasticity ramp-up profiles



4.8 Melbourne

4.8.1 Services and service changes assessed

Since year 2002, extensive improvements to bus services have been made in the Melbourne metropolitan area, with most having a particular emphasis on enhancing off-peak service frequencies. Our assessments analysed the impacts of those service changes on patronage, with the services considered in two main groups:

- **SmartBus services** – six new major routes introduced over the period 2002–2009 and summarised in table 4.9. The SmartBus service enhancements typically involved:
  - enhanced service frequencies and hours of operation (evenings and weekends)
  - bus priority measures
  - bus stop upgrades
  - real-time information at major stops
  - local marketing campaigns.

Our assessment analysed the effects on patronage of the full SmartBus 'package' of measures, with these effects being estimated by separate time periods (weekday evenings, peak, interpeak periods, Saturdays, Sundays). The patronage effects in each period were related to the increase in the service frequency in that period, thus providing 'proxy' service frequency elasticities.[31] While it was not possible to separate out the patronage effects of each component of the SmartBus package implemented on each route, we made broad estimates of adjustment factors that might be applied to these proxy values to derive elasticity estimates reflecting only the service frequency aspects of the combined package.

Table 4.9 Melbourne SmartBus routes assessed

Route no.	Name	Implementation date	End analysis period
888/9	Green Orbital Stage 1 (Chelsea–Nunawading)	Aug 02	Nov 06
703	Blackburn Rd (Middle Brighton–Blackburn)	Aug 02	Nov 04
700	Red Orbital Stage 3/Warrigal Rd (Mordialloc–Box Hill)	June 05	Apr 09
901	Yellow Orbital Stage 1/Stud Rd (Frankston–Ringwood)	Mar 08	May 10
900	Wellington Rd (Stud Park–Caulfield)	Oct 06	Apr 10
903	Red Orbital Stage 2 (Box Hill–Altona)	Apr 09	May 10

- **Service span** ('safety net') enhancements. Over the period September 2006–May 2008, the daily spans of services were extended in over 80 cases, both on weekdays and weekends. These span extensions were mostly in the evenings, typically extending the time of the last service from around 1800–1900 out to 2100–2200. In some cases, services were also extended at the start of the day (the first bus started earlier), while in other cases some (usually minor) changes were also made to daytime services.

  Our assessment focused on 55 of these span enhancements, as outlined in table 4.10. The remaining span enhancements were omitted from the assessment for a variety of reasons, including the following:

  - They involved significant service changes outside the evening period.
  - No 'before' service existed within the evening time period, to provide the base for estimation of elasticity.
  - It was not feasible to separate their impacts on patronage from the effects of other service changes implemented nearby in the same time period.
  - There were anomalies in patronage data.

Table 4.10 Melbourne service span changes assessed

Item	Weekday	Weekend
Total cases examined	44	39
Cases analysed:		
• Evening span/frequency increases only	10	16
• Evening span/frequency increases mainly	13	2
• Evening span/frequency increases and some AM changes	7	7
Total cases analysed	**30**	**25**

[31] In the case of two of the SmartBus routes (900, 903), there was no effective service in the corridor prior to the introduction of the SmartBus scheme, and hence effectively no 'before' route to provide the base for any elasticity assessment. Hence, for these routes, while we analysed the 'after' patronage trends over time, no elasticity estimates could be made.

4.8.2 Basis of assessment

A similar (but not identical) methodology, generally consistent with that outlined in chapter 3, was applied for the assessment of both the SmartBus and the service span changes. Some particular points worthy of note are as follows:

- Patronage (boardings) data was provided by DoT Vic from its ticket validations database.[32] This database gave average daily validations per month, by route, by day type, by time period.
- For the SmartBus assessments, the monthly average patronage data was extracted for weekdays (school term only), Saturdays and Sundays. The weekdays were further divided into three time periods, ie evenings (departure after 1900), peaks (arrivals 0700–0859, departures 1500–1759) and interpeak (arrivals 1000–1459).[33] For the span assessments, 'evening' services were defined as all services starting at or after 1800.
- For each of the SmartBus initiatives, a 'package' of routes was defined for assessment purposes, to cover the full group of routes on which patronage was expected to be affected by the initiative: such a package would (as appropriate) include both competing and complementary routes.[34]
- For the selected package, the numbers of bus trips before and after the service initiative were derived from the DoT Vic timetable database. To estimate the proportional change in services for the package, adjustments were then made for differences in route lengths, short 'runs', etc.
- Four 'control' route groups were defined, for use in both the SmartBus and span analyses, according to the area of the service being assessed (Inner, Middle, Outer, Eastern Freeway). Each group comprised services in the relevant area that had not changed significantly during the assessment period and were unlikely to be affected by the initiatives being assessed.
- The analyses compared the average validations (by route package, by time period) for each month/quarter after the service change with the corresponding number in the comparable month/quarter in the 12 months prior to the change, to derive a route patronage index. An equivalent control patronage index was derived and the ratio route:control patronage index then calculated. This was compared with the relevant service index and the service elasticity calculated by month/quarter.
- Finally, a saturation curve was fitted to the monthly elasticity estimates to derive monthly/quarterly 'saturation' curve elasticity estimates.
- For both the SmartBus and span analyses, the elasticities derived were 'own period' elasticities, ie relating the patronage change in the time period in question to the service change in that period: they did not allow for any effects of service changes in one period on patronage in other periods of the day/week.[35]

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[32] DoT advised that, over the time period of interest, ticket validations accounted for at least 90% of all bus boardings. Since the non-validated boardings proportions would apply to the control routes as well as the assessment routes, this was judged adequate for our analysis purposes.

[33] These three time periods covered the great majority of, but not all, weekday services.

[34] For the span assessments, in most cases the 'package' comprised only the route directly subject to the service change.

[35] For the SmartBus initiatives, such an analysis would not be possible, as the services were enhanced at all time periods simultaneously. For the span initiatives, attempts were made to examine the effects of expanding evening services on patronage earlier in the day. However, generally estimation of such effects was found to be very unreliable:

4.8.3 SmartBus Q4 elasticity results – summary and commentary

4.8.3.1 'Raw' Q4 results

For the four SmartBus routes for which elasticity estimates could be made, table 4.11 provides our estimates of the 'own period' elasticities by route and time period for Q4 (ie months 10–12 inclusive following the service change).

Table 4.11 Melbourne SmartBus elasticity summary (Q4)

Time period analysed		SmartBus route no.					
Day	Time period	888/889	703	700 (+766/7)	901	Averages	
						Base	Adjusted[a]
Weekday	Evening	1.20	0.96		1.31	**1.16**	**0.87**
	Interpeak	0.51	0.57	0.51	0.63	**0.55**	**0.41**
	Peaks	0.48	0.32	0.36	0.43	**0.40**	**0.30**
	Total	0.52	0.66	0.63	0.54	**0.59**	**0.44**
Saturday		0.67	0.90	1.29	0.65	**0.88 (0.85 ave.)**	**0.66 (0.64 ave.)**
Sunday			0.77	0.90	0.72	**0.80**	**0.60**

a) Previous column multiplied by 0.75 (refer to text).

We comment as follows, first focusing on the 'raw' results:

- While there were a few apparent 'outliers', the level and pattern of elasticity results across the four routes was fairly consistent: for weekday total, interpeak and peak periods, and for Sundays, all the individual results were within 15–20% of the (unweighted) average values. This was regarded as a relatively narrow range, particularly given the differences in the characteristics of the various SmartBus routes.[36]
- By day type, in all four cases weekend elasticities were greater than weekday total elasticities. Saturday and Sunday elasticities were not sensibly distinguishable on the limited data available.
- Within weekdays, in all cases:
  - evening elasticities were greater than interpeak elasticities (typically by a factor of c.2.0)
  - interpeak elasticities were greater than peak elasticities (typically by a factor between 1.0 and 1.8).
- Taking the unweighted averages for the four routes, we got the following average values (as shown in the 'Averages – Base' column of table 4.11):
  - peak 0.40 (68% of weekday total)
  - interpeak 0.55 (93% of weekday total)
  - evening 1.16 (197% of weekday total)
  - weekend 0.85 (144% of weekday total).

the effects on patronage earlier in the day appeared generally to be small (in proportionate terms) and not possible to separate from other factors affecting daytime patronage.

[36] Given the underlying variability in the validation data, our judgement is that differences between the routes within such relatively narrow ranges may well not be statistically significant.

4.8.3.2 Interpretation and adjustment of elasticity estimates

The SmartBus initiatives involved a package of service frequency improvements together with other service enhancements, including:

- real-time bus arrival information at major stops
- significant bus stop upgrades, including new shelters, hardstands, higher visibility totems
- bus priority measures designed to improve bus travel times and reliability
- local marketing campaigns to promote the upgraded services.

There was no direct evidence available (from ‘after’ market research, etc) as to what proportion of the benefits of the SmartBus packages related to the service frequency improvements, which would have allowed adjustments of our estimated total elasticities to represent the service frequency improvements alone. However, the report for the Department of Transport, Victoria on ‘Review of SmartBus trial’ (Sinclair Knight Merz 2004) concluded that:

> *It is clear from the analysis and discussions that the majority of benefits come from the increased service levels, which give rise to time savings (including waiting time savings) for existing users and are also the primary reason that new users are attracted to the services.*

Further, the economic evaluations undertaken in that report for SmartBus routes 703 and 888/9 indicated that between about 50% and 60% of the total user benefits for each scheme was the savings in average waiting time, which was the direct result of the increased service frequencies.

We note that, in several of the SmartBus schemes, the ‘other’ proposed service enhancements (to complement the frequency improvements) were not fully implemented initially, and hence the initial market response would predominantly reflect the frequency improvements.

Having discussed this matter in some depth with DoT staff, we applied a factor of 0.75 (ie c.25% reduction) to the ‘raw’ elasticity estimates to derive ‘adjusted’ estimates, which represented the likely market responses to service frequency improvements only. These average adjusted service elasticity estimates are given in the last column of table 4.11. While these adjusted figures should be regarded as no more than indicative, it appears unlikely that they are more than ±20% in error due to the choice of the adjustment factor.

4.8.4 SmartBus ramp-up profiles summary

For the four SmartBus routes for which elasticity estimates were able to be made, this section summarises the evidence on how the elasticity estimates varied over time, relative to the Q4 values.

Based on the saturation curve estimates, and after omitting some apparently anomalous values, figure 4.4 shows the average elasticity ramp-up profiles by time period (averaged over the relevant routes) and for all time periods combined.

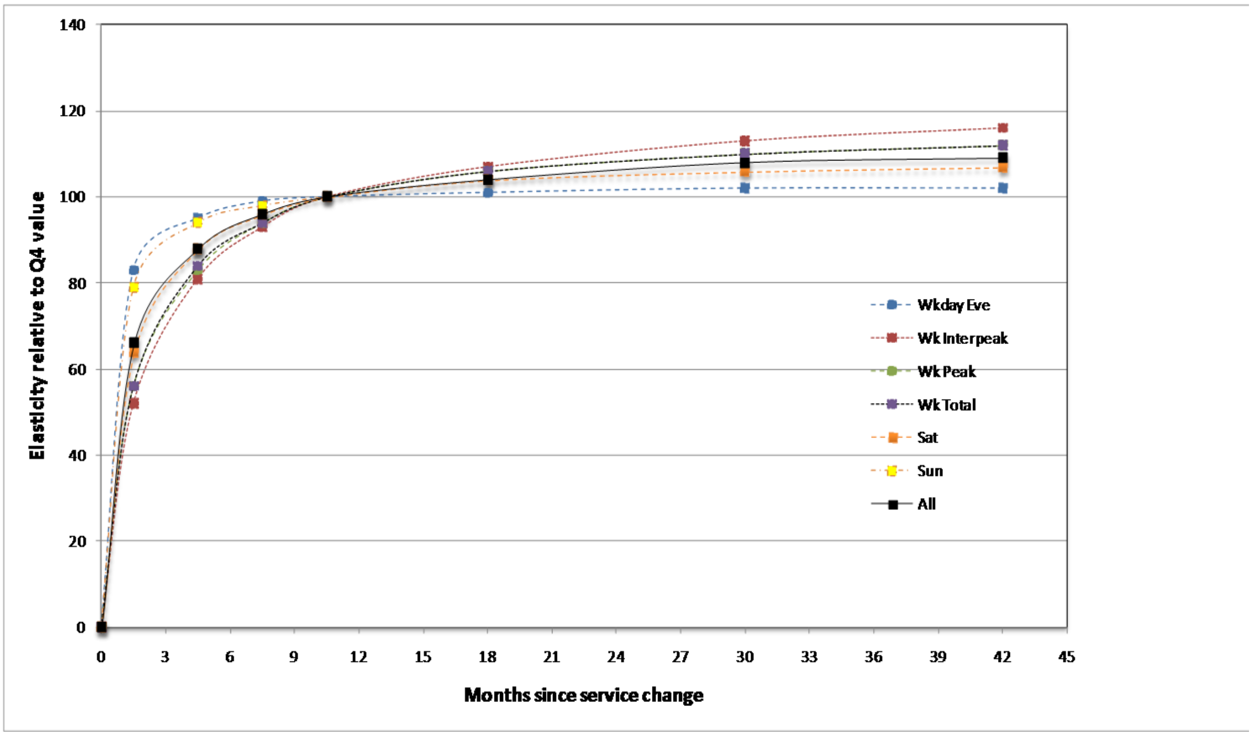
Over all time periods and routes, the average (adjusted) elasticity values relative to Q4 (=100) were:

Q1	66%
Q2	88%
Q3	96%
Q4	100%
Y1 (Q1–Q4) ave.	88%

Y2 (Q5–Q8) ave.	104%
Y3 (Q9–Q12) ave.	108%
Y4 (Q13–Q16) ave.	109%
Long run	113%.

Our judgement, given the variability between routes of the results for each quarter, is that the apparent differences in growth trends between the various time periods are most likely not significant. However, they do illustrate the range of growth trend results that might be expected.

Figure 4.4 Melbourne SmartBus elasticity ramp-up profile



4.8.5 Span Q4 elasticity results and 'drivers' – summary and commentary

For the service span assessments, we estimated Q4 'own period' elasticities, split between weekday evening schemes (30 cases) and weekend evening schemes (25 cases). Figure 4.5 provides a graphical summary of the results. We make the following comments:

- The mean value for all the weekday schemes was 0.65, and that for the weekend schemes was 0.95. From inspection of the two graphs, this difference is clearly significant.
- We also examined the weekday elasticity values to check whether their mean values differed significantly between service changes involving (i) evening changes only, (ii) evening changes predominantly, and (iii) both evening and early AM changes. The differences between these three mean values were small and not significant. Hence all the results for the weekday cases were considered in a single group.
- The weekend:weekday (evening) average elasticity ratio of 1.46 was very similar to that found in the SmartBus analyses for weekend:weekday (daily average) elasticity values of 1.44 (table 4.11).

- The relatively wide spread of results for the span schemes was considered to reflect the following factors:
  - The actual Q4 elasticity values were used in this case, rather than the 'smoothed' (saturation curve) values used for the SmartBus analyses.
  - In many of these cases, the evening (post 1800) service in the 'before' situation was minimal; so the elasticities were calculated for large (proportionately) service changes over three to four hours (say 1800–2200) from a minimal base service.
  - Given the relatively small quantum of services involved in each case (relative to the SmartBus routes), any inherent patronage variability was likely to have a relatively large effect on the results in any single quarter.

Given the relatively large samples of span schemes assessed, we were interested to examine whether elasticity values would be influenced by:

- the extent of the service increases in each case
- the absolute evening level of services (total trips), either before or after the service increase.

In regard to this first potential effect, we examined whether there was a significant relationship between the extent of the evening service increase (in terms of % increase in evening trips) and the resultant Q4 elasticity. The relationships are shown in figure 4.6. These analyses indicated a wide scatter in the individual results, but with very slight positive relationships for both weekday and weekend evening service increases: however, neither of these was statistically significant (different from zero).

In regard to the second potential effect above, inspection of the data also indicated no significant relationships between the level of service (either before or after the change) and the Q4 elasticity.

Figure 4.5 Melbourne service span elasticities (Q4) – distribution of results

Weekdays – mean 0.65 (30 cases) **Weekends – mean 0.95 (25 cases)**

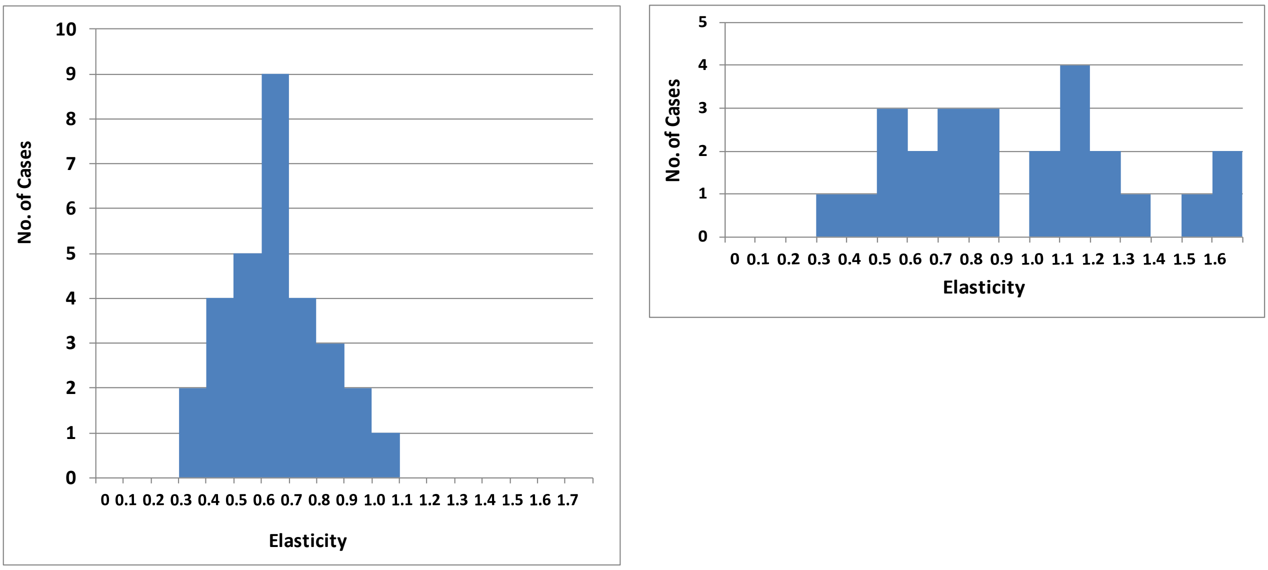
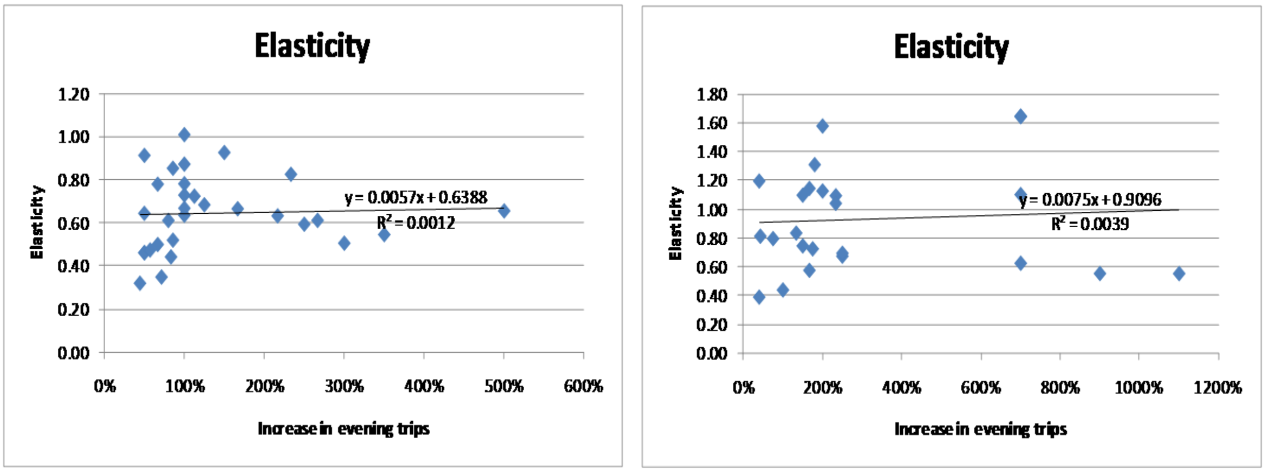


Figure 4.6 Melbourne service span elasticities (Q4) – variations with % service increase

Weekdays – mean 0.65 **Weekends – mean 0.95**



4.8.6 Span Q4 patronage performance

Table 4.12 presents key performance statistics for evening patronage measures for both the weekday and weekend (principally Saturday) services that were subject to span increases, for the fourth quarter (months 10–12) after these increases.

Findings of interest are as follows:

- **Passengers/day:** The weekday mean value was 107 passengers/day, with weekend service values being typically around 30% lower than weekday values.
- **Passengers/hour:** The pattern was similar to that for passengers/day (most of the increased services operated for four hours in the evenings).
- **Passengers/trip:** Here the values for the weekday and weekend services were closer, with the mean value being slightly above nine passengers/trip for both weekdays and weekends. On both day types, about half the routes averaged 7.5 or fewer evening passengers/trip.
- **Passengers/bus km:** Here the values for the weekday and weekend services were again fairly close, with the mean for both day types being around 0.5–0.6 passengers/bus km (with the weekend values slightly higher than the weekday values). About 25% of the routes had values below about 0.3, and 25% values above about 0.65. (These may be compared with average values for all Melbourne bus services, over all time periods, of around 1.0.)

Table 4.12 Span scheme – evening patronage performance statistics (Q4)[a]

Performance measures	Day	Mean	25%ile	50%ile	75%ile
Passengers/day	Weekday	106.6	63.8	88.0	148.1
	Weekend	79.7	32.8	55.1	103.4
Passengers/hour[b]	Weekday	27.3	16.7	22.0	37.0
	Weekend	20.6	8.2	13.8	25.9
Passengers/bus trip	Weekday	9.3	6.0	7.6	12.7
	Weekend	9.1	3.9	6.9	12.3
Passengers/bus km	Weekday	0.50	0.33	0.44	0.64
	Weekend	0.61	0.27	0.47	0.74

a) All figures relate to average evening (1800 onwards) patronage in the fourth quarter after the service change. Weekday figures relate to school term weekdays only.

b) 'Hour' represents the overall duration of evening services; eg if the last service operates at 21.30, then this counts as four hours of service duration (starting at 1800).

4.8.7 Span ramp-up profiles assessment

As for the ramp-up assessments for the SmartBus schemes (section 4.8.4), we made an assessment for the span schemes of how their evening 'own period' elasticity values varied over time from the service change. It was found that individual routes showed considerable variability in their trends: this reflected (at least in part) that for the span changes, no saturation curve analyses had been undertaken to smooth the quarterly data points, whereas such smoothing had been carried out for the SmartBus analyses.

Taking the means for each quarter of all the elasticity ratios (relative to Q4 = 100) gave the 'crude' results shown in table 4.13. While these average results were generally consistent with those from the SmartBus analyses (figure 4.4), inspection of the elasticity trend results for the individual routes shows that in many cases, results for some or all of the earlier periods (Q1–Q3) exceeded 100% and in a few cases were negative.

We would therefore recommend primary reliance on the SmartBus results on this topic, rather than any use of the results from the span analyses given here.

Table 4.13 Span schemes – mean elasticities relative to Q4 values (evening 'own period' elasticities)

Period	Weekday ratio (no. in sample)		Weekend ratio (no. in sample)	
Q1	63%	(30)	58%	(25)
Q2	89%	(30)	79%	(25)
Q3	99%	(30)	84%	(25)
Q4	100%	(30)	100%	(25)
Q5–Q8 (year 2)	106%	(30)	93%	(25)
Q9–Q12 (year 3)	120%	(17)	102%	(14)
Q13–Q16 (year 4)	115%	(4)	112%	(3)

4.8.8 Alternative elasticity measures (span schemes)

Earlier in the report (section 3.3), we discussed several alternative bases for estimating elasticities, which are particularly relevant when assessing the impacts of service changes over a single period of the day (eg evenings). All our assessments elsewhere in this report were focused on an 'own period' elasticity measure, applied to situations where services were varied either in just one period of the day (measure A in table 3.1) or in several periods of the day (measure C). Our assessments for the span schemes related to measure A, and those for the SmartBus schemes to measure C.

For the span schemes, we also attempted to estimate elasticities based on measures B1 and B2 (table 3.1). However, difficulties were found in deriving reasonably robust estimates for these two elasticity measures, because of the apparent effects of undefined external influences (not neutralised by use of control routes) on patronage. The following presents limited comparisons between the three measures for weekend span changes, for the seven cases for which we could derive reasonably robust estimates for all three measures.

For these seven cases, the **ratios** of elasticity values on measure B1 (evening total elasticity), measure B2 (daily elasticity) and measure A (evening own period elasticity) were as follows:

- Measure B1/measure A: mean ratio 1.29 (range 1.10–1.48)
- Measure B2/measure A: mean ratio 0.82 (range 0.47–1.36)
- Measure B1/measure B2: mean ratio 1.57.

We make the following comments:

- **Measure B1/measure A:** This represented the ratio between the total patronage generated by the enhanced evening service and the number of these passengers who made their trips in the evening period. Thus the mean ratio of 1.29 indicates that, for every 100 additional passengers generated in the evening from the enhanced evening services, another 29 (net) were generated prior to 1800. This result seems very plausible; for instance, with an improved evening service we could:
    - assume 50% of customers generated make their return trip entirely within the evening period (ie each generating two new evening boardings); and
    - assume the other 50% of new customers make their outward trip prior to the evening period, and their return trip in the evening (ie each generating one daytime boarding, one evening boarding).

  In this case, generation would be one daytime trip for three evening trips, ie a ratio for measure B/measure A of 1.33 (close to the 1.29 figure above).

  There appears to be very little research on this topic (in Australasia or internationally) with which these estimates may be compared. However, if taken at face value, they imply that any elasticity estimates derived in this report for evening-only service expansions (as for the span schemes) would need to be increased by around 30% to reflect the total patronage effects. For other periods of the day, lesser increase factors would be expected to be appropriate.
- **Measure B1/measure B2:** This represented the ratio of elasticities for evening service enhancements when calculated based on the total generation in patronage resulting from these enhancements relative to the % change in (B1) evening service levels and (B2) total daily service levels. The 1.57 ratio indicates that the elasticity value was substantially higher when calculated on the % change in evening service levels than if based on the % change in total daily service levels. The higher value for the measure based on evening service levels is typical, reflecting that average loadings are usually lower in the evenings than those averaged over the whole day. The distinction between the two measures is important, but often not apparent in the literature. Again, while the 1.57 ratio appears very plausible, there is little international evidence with which it can be compared.

5 Summary of patronage and service elasticity findings

5.1 Scope of chapter

This chapter summarises the findings on service elasticities and patronage ramp-up profiles from the assessments for the seven cities given in chapter 4, and discusses the conclusions that may be drawn from these assessments. It is arranged in the following sections:

- 5.2: Summary of assessment results
- 5.3: Discussion of findings – Q4 elasticity estimates
- 5.4: Discussion of findings – ramp-up profiles.

5.2 Summary of assessment results

Table 5.1 presents a summary of the Q4 elasticity estimates and the ramp-up profiles derived from the assessments in each of the seven cities covered.

The discussion of findings in the following two sections of the chapter focuses on the results for three of these cities, ie Melbourne, Adelaide and Brisbane. These three cities accounted for the great majority of all the service improvements examined, and generally had higher quality and longer time series of data than the other four cities.

Specific reasons for giving less weight to the results for the other four cities include:

- Auckland – only one scheme (interpeak/Saturday improvements) covered
  - very limited 'after' data series
- Dunedin – only one scheme covered
  - doubts about the suitability of the control services used (but no better alternatives available)
- Hamilton – only new routes/services assessed (no elasticity estimates possible)
  - trends somewhat erratic and possibly affected by external factors
- Perth – service changes assessed (rail feeder services, post-PM peak) not typical, difficult to generalise results
  - very limited (two or three quarters) 'after' data series.

5.3 Discussion of findings – Q4 elasticity estimates

5.3.1 Elasticity estimates, by time period

It is evident from the assessment that (as expected) the time period within which the service change takes place is a prime driver of the elasticity values. For the assessments in the three main centres analysed (Melbourne, Adelaide, Brisbane), table 5.2 sets out the mean Q4 elasticity values derived for the various time periods.

Table 5.1 Summary of patronage and elasticity assessments results, by city

	Scheme assessed	Q4 elasticity results[a]	Ramp-up results[b]	Notes
Auckland	Mt Eden Road frequency increases – interpeak (Feb 08), Saturday (Oct 08)	Interpeak c.0.5	Insufficient data	• Interpeak results reasonably robust • No data beyond first 12 months
Dunedin	Combined city routes – doubling of Sunday services, 2-hourly to hourly (July 2000)	Sunday c.0.45	Indicative results: • Q1 35%, Q2 65%, Q3 90% • Y2 110%, Y3 125%, Y4 135%, Y5 140%	• Results moderately robust in first year, increasingly uncertain thereafter • All ramp-up estimates beyond Q4 likely to be on high side
Hamilton	(A) New CBD (free) shuttle route (Apr 06)	Not applicable	(A) Indicative results (weekdays): Q1 50%, Q2 75%, Q3 90%, Y2 120%	(A) Results moderately robust
	(B) New Orbiter route (July 06)		(B) Results (weekdays): Q1 55%, Q2 80%, Q3 92%, Y2 111%	(B) Robust results
	(C) New Sunday services (Sept 08)		(C) Data for only 3 quarters – suggests close to saturation after Q2	(C) Indicative results only – insufficient data period
Perth	Northern Suburbs Rail feeder bus service frequency increases, 5 routes – early evening 1800–2100 (Aug/Oct 08)	Typical (evening) values around 0.4 to 0.5 for Q2 and Q3	Insufficient data	• Only 6–9 months 'after' patronage data in each case
Brisbane	Frequency improvements on 5 'BUZ' routes, evening, Saturday, Sunday (Nov 04–Feb 09)	Evening mean 0.59 (range 0.47–0.70): Saturday 0.73 (0.49–0.83); Sunday 0.74 (0.65–0.84)	Average results: • Q1 67%, Q2 90%, Q3 96% • Y2 104%, Y3 107%, Y4 109%	• Highly robust results – relatively narrow spread • Sat/Sun results very similar; evening elast. may be significantly lower
Adelaide	Frequency improvements on 8 interpeak routes, 3 evening routes and 7 Saturday/Sunday routes (Jan 03–Jan 08)	Interpeak mean 0.47 (range 0.35–0.61): evening 0.52 (range 0.40–0.70); Sat/Sun 0.61 (range 0.50–0.74)	Average results: • Q1 52%, Q2 80%, Q3 92% • Y2 110%, Y3 116%, Y4 120% • LR 131%	• Robust Q4 results – relatively narrow spread • Sat (3) and Sun (4) means very similar • Differences in means interpeak/ eve/ weekend appear to be insignificant

	Scheme assessed	Q4 elasticity results[a]	Ramp-up results[b]	Notes
				• Ramp-up results relate to 5 service changes only – considerably less robust
Melbourne	(A) SmartBus services, involving augmented (4 cases) or new (2 cases) routes, including enhanced frequencies (all time periods), priority measures, RTI etc (Aug 02–Apr 09)	Mean results (4 cases): • peak 0.30 (range 0.24–0.36) • interpeak 0.41 (0.38–0.47) • evening 0.87 (0.72–0.98) • Sat/Sun 0.64 (0.49–0.97)	(A) Average results: • Q1 66%, Q2 88%, Q3 96% • Y2 104%, Y3 108%, Y4 109% • LR 113%	• Highly robust results – relatively narrow spread • Sat/Sun results very similar; differences between other periods appear significant • Results adjusted for non-frequency components of improvements; represent frequency improvements across all time periods
	(B) Service span increases/ extensions of evening services – 30 weekday cases, 25 weekend cases (Sept 06–May 08)	(B) Mean results: weekday evenings 0.65 (range 0.35–1.01);weekend evenings 0.95 (range 0.39–1.64)	(B) Average results: • Weekday evening: Q1 63%, Q2 89%, Q3 99% • Weekend evening: Q1 58%, Q2 79%, Q3 84%	• (B) Individual scheme results not very robust (no smoothing), but mean Q4 results reasonably reliable • Ramp-up results also not very robust – particularly unreliable (not quoted) after first year

a) All elasticity results on 'own period' basis unless noted.

Unless otherwise mentioned, all ramp-up results given relate to Q4 = 100.

Table 5.2 Service elasticity (Q4) summary, by time period – Melbourne/Adelaide/Brisbane

Day	Time period	Q4 mean elasticity values[a]				Notes
		MEL SmartBus[b]	MEL Spans	ADL	BNE	
Weekday	Overall	0.44 (4)				
	Evening	0.87 (3)	0.65 (30)	0.52 (3)	0.59 (5)	
	Interpeak	0.41 (4)		0.47 (8)		
	Peak	0.30 (4)				
Sat/Sun[c]	Overall	0.64 (4)		0.61 (7)	0.73 (11)	MEL figures (overall, evening) indicate weekend values approx 50% greater than weekday values
	Evening		0.95 (25)			

a) Figures in brackets represent the number of service change cases making up the averages given.

b) Adjusted figures. Services improved across all time periods.

c) No significant differences between Saturday and Sunday results.

Comments on these results are as follows:

- In all three cities, the Saturday and Sunday elasticity mean estimates were almost identical, and certainly not significantly different:
  - Melbourne (SmartBus) Sat 0.66, Sun 0.60
  - Adelaide Sat 0.61, Sun 0.61
  - Brisbane Sat 0.73, Sun 0.74.

  On this basis, the Saturday and Sunday figures have been considered together in subsequent commentary.
- Considering elasticities averaged over the whole day, weekend elasticities were consistently greater than weekday elasticities. This result applied to all four of the Melbourne SmartBus routes: on average the weekend elasticity was some 45% greater than the weekday elasticity.
- Within weekdays, evening elasticities were consistently greater than interpeak values, which were in turn greater than peak values. Taking the SmartBus weekday average as 100, elasticities for each weekday time period were: peak 68%, interpeak 93%, evening 197%.
- Within weekends, the evidence again indicated that the evening elasticities were considerably higher than the all-day average: the table 5.2 results suggest that the weekend evening elasticity was around 50% higher than the weekend daily average.

5.3.2 Differences between cities

The table 5.2 results enabled some comparisons to be made across results for the three cities – for weekday interpeak (two sets of figures), weekday evening (four sets) and weekend overall (three sets):

- For the interpeak and weekend (overall) periods, our judgement was that the mean estimates for the different cities were not significantly different.

- For the weekday evening period, the indications were that the Melbourne (span), Adelaide and Brisbane estimates were not statistically different; but that the Melbourne SmartBus mean estimate was significantly higher than these three.[37]. This difference may reflect that a larger patronage response was to be expected in the SmartBus case, where services were improved throughout the day, relative to the other cases, where the improvements were to the evening services only.

Overall, given the different types of service improvements in each city and the spread of individual scheme results in each city, it was not possible to conclude that the elasticity values were significantly different in the three cities.

5.3.3 Differences between routes

This project did not attempt to 'explain' any differences found in elasticity values between routes. A priori, such differences might be expected, having regard to the differences in the market served by different routes (eg in terms of age profile, trip purpose, car availability, etc). However, in the absence of considerably more detailed analyses, we inclined to the view that much of the apparent spread in elasticity values within any given city/time period (eg see figure 4.5) reflected data variability and analysis imperfections, rather than underlying market differences. That is not to say that the 'true' elasticities were not affected by market characteristics; but only that the variations were probably less than the apparent variations in our elasticity estimates between routes.[38]

5.3.4 Effects of initial level of service

For any given market, it is 'conventionally' assumed that service elasticities vary with the (initial) level of service[39] (ie elasticities increase as the level of service decreases), and there is some empirical evidence to support this. For example, the proportionate increase in patronage (and hence the elasticity) for a service frequency change from two-hourly to hourly is generally considered to be greater than the proportionate change from a service every 10 minutes to every 5 minutes.

To test for any relationship between service elasticities and the initial level of service, the elasticity and initial service frequency were plotted for all the individual data points (service changes) in the three cities. Figure 5.1 shows the results, and also the regression lines for elasticity versus frequency for each time period. It is seen that the slopes of all the regression lines (for each time period) are shallow; in three cases they are positive, rather than the negative slopes expected, but appear to be not significantly different from zero.

This result reflected the relatively wide spread of the elasticity estimates at an individual service change level, especially for the Melbourne span schemes (which dominated in terms of the overall number of points in the chart). Hence, this evidence did not support the hypothesis that elasticities vary (in an inverse manner) with initial service frequencies.

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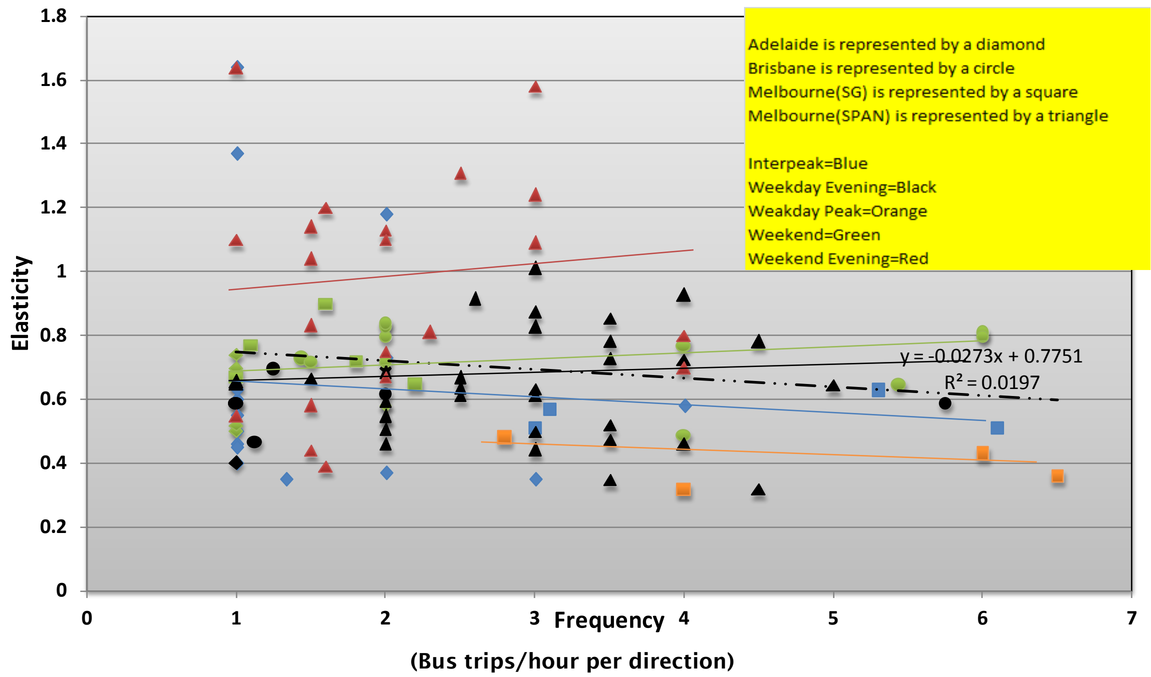
[37] This comment recognises the uncertainty in the SmartBus elasticity estimates, given the package of service features involved in the SmartBus case.

[38] This view tends to be supported by our Adelaide analysis, which indicated the spread of our elasticity results was considerably less than PTD's spread of values for the same service changes (the difference reflecting analysis methods), and the international evidence on fares elasticities (which is greater in quantity), which tended to indicate relatively consistent elasticity values across different markets (within a given time period).

[39] For example, Wallis (2004) indicated that service elasticities vary in broad proportion to headways (in inverse proportion to frequencies). This assumption is broadly consistent with that implicit in a constant generalised cost elasticity formulation, as used for instance in the NZ Bus Policy Model (Wallis et al 2012). Similarly EEM v2 (NZTA 2009) assumes that the user benefits of a given % change in frequency reduce as the frequency increases.

Figure 5.1 Service elasticity (Q4) versus initial frequency – Melbourne/Adelaide/Brisbane



5.3.5 Causes of elasticity differences, by time period

As noted earlier (section 5.3.1/table 5.2), there was clear evidence of differences in elasticity values by time period. What was less clear was the extent to which these differences reflected differences in the initial levels of service in each period, or were intrinsic features of the market in the different periods:

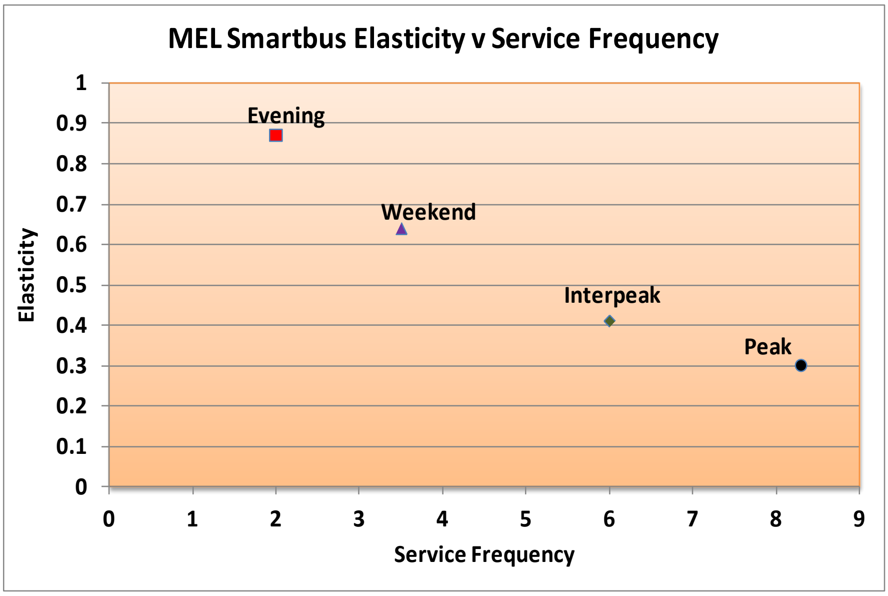
- The 'conventional wisdom', noted above, might indicate that the initial levels of service would be an important factor, despite this not being proved in our above analyses by time of day.
- The evidence on fares elasticities (where the fares are generally similar at all periods of the day) showed similar variations in elasticities by time of day to the service elasticities in table 5.2. This suggested the elasticity differences may have largely reflected intrinsic market differences.

In an attempt to shed further light on this issue, for the Melbourne SmartBus routes, we plotted the mean service elasticities (four routes) for each time period against the typical service frequency by period. The results are shown in figure 5.2. This shows a very clear correlation between service elasticity and frequency (by time period), very much of the type that would be 'conventionally' suggested within any given time period. The implication that could be drawn was that service frequency factors may have been the primary driver of service elasticity differences by time period, rather than any intrinsic market factors.

This can be no more than a hypothesis at this stage: the evident correlation does not necessarily imply causation. The quality and quantity of the data available from this project is not sufficient to either support or oppose this hypothesis with any confidence. This would be a matter requiring further research (with additional data).[40]

[40] As far as we are aware, this issue has not been addressed elsewhere in the international research literature.

Figure 5.2 Melbourne (MEL) SmartBus elasticity v service frequency



Bus trips/hour per direction

5.3.6 Effects of extent of service changes

Another question of interest was whether elasticity values would vary according to the extent of any service changes:

- One view is that passengers would hardly notice a small service change, but would respond more (proportionately) to a large change.
- The opposite view is that large changes would (proportionately) result in diminishing returns and hence lower elasticity values.

Our examination of this question used the most extensive datasets we had available – those for the Melbourne span schemes (30 weekday and 25 weekend schemes analysed). For this data, we examined how elasticity estimates varied with the percentage change in service frequency (bus trips per hour). The results were shown earlier in figure 4.6 and discussed in section 4.8.5. We concluded that no significant relationship was apparent between the elasticity and the extent of the service change, ie the constant elasticity assumption used in our assessments had not been disproved.[41]

5.3.7 Effects of direction of service change

The question addressed here is whether service elasticities are 'symmetric' with regard to service increases and decreases; ie would the elasticity values for service increases and decreases be the same?[42]

This question was examined in the case of the changes to the Adelaide route 155 (Saturday) services: these service levels were initially doubled and then subsequently halved 2.5 years later. The estimated

[41] However, the variability in the data available was such that no firm conclusions could be drawn.

[42] If a service was first increased and subsequently decreased back to its original level, with the resultant net patronage change being zero, this would imply that the elasticities (applying the elasticity functions defined in this report) for the service increases and decreases were equal.

elasticities were 0.65 for the service increase, 0.58 for the subsequent decrease (refer to section 4.7.3). This (very limited) sample was thus sensibly consistent with the hypothesis that service elasticity values are symmetric.

5.4 Discussion of findings – ramp-up profiles

5.4.1 Compilation of the evidence

The evidence on ramp-up profiles (relative to Q4 elasticity values) for all seven cities was summarised in table 5.1. As for the Q4 elasticity results discussed in the previous section, the most reliable ramp-up estimates were for the three cities (Brisbane, Adelaide, Melbourne): these estimates are therefore set out in table 5.3 and used as the key evidence in the following discussion of appropriate profiles.

5.4.2 Typical ramp-up profiles and comments

The ramp-up profile data for the three cities may be considered in the following four groups, as shown in table 5.3:

- **Melbourne spans:** While this source involved relatively large samples (30 weekday, 25 weekend service improvements), the quarterly/yearly estimates were 'unsmoothed' (ie no saturation curve was fitted) and hence prone to be erratic from period to period. The erratic nature of the results was greatest beyond Q4, and hence no results are given for Y2 onwards. For these reasons, this source was discounted in drawing conclusions.
- **Adelaide:** The Adelaide profile data was the average for only 5 of the 18 schemes assessed. The other schemes were set aside for a variety of reasons, including the shortness of the 'after' data series and some issues in fitting satisfactory saturation curves (refer to section 4.7.6). The profiles for the 5 schemes used still showed quite substantial variations between them, and thus the resultant average profile was assessed as only 'moderately' reliable.
- **Brisbane:** The Brisbane ramp-up profile was the average profile for all 16 schemes examined across the three time periods (weekday evening, Saturday, Sunday). It used smoothed elasticity estimates in all cases, and the profile results were similar across the three periods. The average profile derived was considered as 'most reliable'.
- **Melbourne SmartBus:** The Melbourne SmartBus profile shown was the average for the four SmartBus routes (for which elasticity estimates were made) across the six time periods analysed. It used smoothed elasticity estimates in all cases. Again, the average profile derived was considered as 'most reliable'.

Table 5.3 Summary of ramp-up results (Brisbane – BNE/Adelaide – ADL /Melbourne – MEL) (drawn from table 5.1)

City	Scheme	Period	Ramp-up factors (relative to Q4 = 100)								Notes
			Q1	Q2	Q3	Q4	Y2	Y3	Y4	LR	
Brisbane	All ('BUZ') – 16 schemes	All	67%	90%	96%	100%	104%	107%	109%	—	• 'Smoothed' data – most reliable
Adelaide	All – 5 schemes	All	52%	80%	92%	100%	110%	116%	120%	131%	• 'Smoothed' data – moderately reliable • Covers only 5 of the 18 ADL schemes assessed
Melbourne	SmartBus – 4 routes * 6 time periods	All	66%	88%	96%	100%	104%	108%	109%	113%	• 'Smoothed' data – most reliable
	Service span (evening) changes – 30 weekday, 25 weekend routes	Weekday	63%	89%	99%	100%	-	-	-	-	• Unsmoothed data – least reliable, particularly erratic beyond Q4
		Weekend	58%	79%	84%	100%	-	-	-	-	

In the light of the above appraisal, we took the view that a representative ramp-up profile was best based on the Brisbane and Melbourne SmartBus average profiles, because:

- these were both in the 'most reliable' category
- they had the largest useable samples of all the potential datasets
- the two profiles were very similar (relative to Q4), thus providing additional confidence in their representativeness.

Figure 5.3 shows the Melbourne SmartBus profile in graphic form (the Brisbane profile is almost identical). This represents a relatively 'sharp' profile, ie a rapid build-up in patronage within the first few months, with relatively little further growth beyond 12 months. Key features include the following:

- Overall patronage growth in the first year averaged around 88% of the Q4 value (and about 86% of the value by the end of Q4).
- By end Q1, patronage growth was approximately 75% of the end Q4 level; by end Q2 it was approximately 90% of the end Q2 level; and by end Q3 it was approximately 96% of this level.
- Further growth beyond the end of Q4 was much reduced – by around 4–5% within Y2, 2–3% within Y3, and around 1% or less in subsequent years.
- The long-run 'saturation' estimate (from the saturation curve analyses) was only 10–15% greater than the value at the end of the first year.[43]

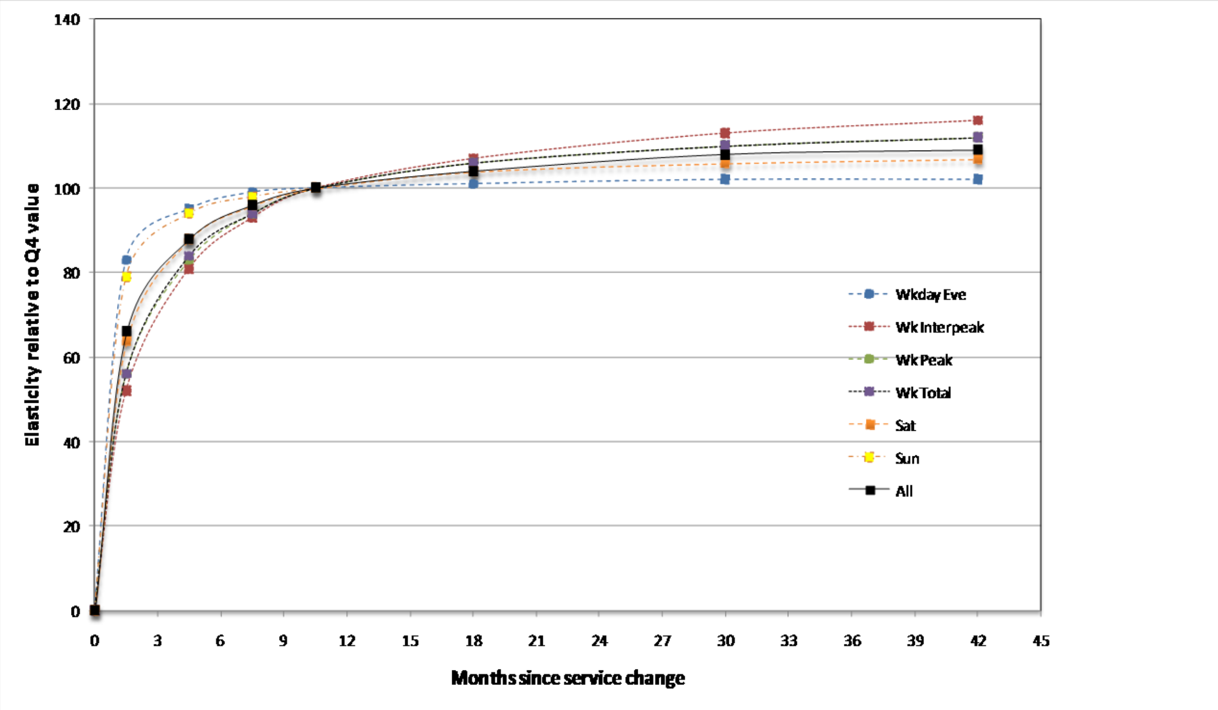
5.4.3 Potential factors influencing ramp-up profiles

Ideally, further analyses of the ramp-up profile data would have been undertaken, to estimate the influence that various factors had on the shape of the representative profile derived. Factors that might have been investigated could have included the city, the time period of the service change and the magnitude of the change. However, based on our inspection of the data it was evident that any such analyses would not have been successful, given the modest samples available, the uncertainties of the quarterly/annual estimates of patronage growth, and the apparent similarity of profiles (eg by time period).

We would, however, note that the TransLink Transit Authority (Queensland) has recently undertaken research to investigate ramp-up profiles for a wider range of PT improvement projects implemented in the south-east Queensland area over recent years (MRCagney 2012). The results from that project shed light on ramp-up profile differences by project type (eg major new infrastructure projects versus improvements to existing bus services).

[43] This result is very different from a common assumption that long-run service level elasticities are typically around twice the short run (c.12 month) values (eg Wallis 2004).

Figure 5.3 Melbourne SmartBus elasticity ramp-up profiles



6 Other effects of bus service improvements – market research review

6.1 Scope of chapter

This chapter summarises our appraisal of previous market research on traveller attitudes and perceptions relating to off-peak bus services, including previous/alternative means of travel and qualitative responses to service enhancements.

Rather than attempting to review market research evidence from all the seven centres covered in the earlier chapters of this report, our appraisal focused on evidence from Melbourne only: Melbourne has in recent years undertaken the most extensive market research programme of all the seven centres, particularly focusing on surveys of bus users following the implementation of service improvements.

The following summary is based on our review of nine reports/papers prepared since 2004 on the impacts of bus service improvements in Melbourne, five of which relate directly to the SmartBus routes. This review is reported in more detail in appendix I.

6.2 Prior mode of travel of users of new/improved services

In situations where new services were introduced in areas and at times where no (PT) service previously operated, only a minority (generally one-third or less) of the users of the service had previously made the trip in question by PT (of any sort). In situations where previous services were improved (maybe involving some rerouting), the majority of the users of the improved services were previously users of the service that had been replaced or upgraded.

The increases in patronage associated with new/improved services resulted from both 'new' passengers (for the trip in question), and 'old' passengers making additional trips. The balance between these sources of increased patronage depended very much on the nature of the service change, and in particular, on the extent to which it served new catchment areas and provided for new PT trip opportunities.

6.3 Alternative means of travel (if specific PT service not available)

Similar to the 'prior mode' comments above, the next-best alternative for passengers if the specific bus service was not available depended very much on whether there were other PT services that would enable them to make the trip in question. In most Melbourne suburban situations, the majority of passengers would use another PT service as their next-best alternative. Not surprisingly, the proportion using another PT service tended to be higher in the inner suburban areas than in the outer areas.

For those passengers who would **not** have used another PT service, typical alternative mode shares were as follows:

- car driver c.30–40%
- car passenger (lift) c.15–25%
- walk/cycle c.10–20%

- taxi/other c.5–15%
- not make trip c.10–20%.

These proportions were influenced by the specific situation, but were generally consistent with results from market research elsewhere.

6.4 Desired service improvements

For typical low-frequency suburban bus services, users' highest priority aspects for service improvements to increase patronage were enhanced service frequencies and extended service hours (to run in evenings and weekends). This finding was consistent with the relatively high off-peak service frequency elasticities reported in the previous chapter.

Other priority aspects included: more direct services (following the main roads), improved reliability, improved bus stops, real-time passenger information and stop-specific timetables.

For PT services to attract current non-users who had access to a car, key aspects for improvement were:

- more frequent services
- services to better match required origins (home) and destinations
- more/better information and marketing of services.

6.5 User response to service improvements

The Melbourne SmartBus market research indicated that those features of the services that most influenced a person's decision to use the upgraded services were: improved frequencies, faster travel/direct routings, longer service hours, and stop-specific timetables/real-time information. These features were also those for which SmartBus users expressed the highest levels of satisfaction. These findings for improved services are generally consistent with the priority improvements desired by users of 'unimproved' services (above).

The evidence indicates that:

- a substantial proportion of new passengers using improved PT (particularly suburban bus) services tend to be people with limited mobility options, who are most likely to be experiencing a significant degree of social exclusion
- the improved PT services are likely to promote increased mobility, accessibility and self-reliance, providing better access to employment, health services and leisure activities – thus contributing to a reduction in social exclusion.

7 Summary, conclusions and recommendations

7.1 Summary of findings and conclusions – service elasticity aspects

This section draws on the material from sections 5.3 and 5.4 in particular to present a summary of the project findings and conclusions relating to service frequency elasticities.

7.1.1 Best-estimate Q4 elasticity values

The project findings indicated that the primary differentiator of elasticity (Q4) values was the day type/time period in which the service operated. Within a given day/time period, there was no clear evidence of significant differences in elasticity values between centres, by initial level of service or by other route or market characteristics. On this basis, it was possible and helpful to draw general conclusions (based on the evidence from the three major centres focused on in chapter 5; ie Melbourne, Adelaide and Brisbane) on typical (Q4) elasticities by day type/time period, as set out in table 7.1.

In regard to these typical values, it should be noted that:

- The patronage changes assessed were those occurring only in the period in which the services were changed. To that extent they are likely to underestimate the total patronage impacts and hence the elasticities, especially in the case of evening service changes. The Melbourne span (evening) appraisal indicated that the 'own period' elasticities may need to be increased in the order of 30% to represent the total patronage effects (refer to section 4.8.8).
- The typical values given were derived primarily from situations in which services had been changed only in the time period in question. For situations in which services were improved at all time periods (such as the Melbourne SmartBus cases), higher elasticities might be expected.[44]

Table 7.1 Typical service frequency elasticity values (Q4), by day type/time period

Day type	Time period	Typical Q4 elasticity ('own period')[a]
Weekday	Peak	0.25–0.35
	Interpeak	0.4–0.5
	Evening	0.5–0.7
	Overall	0.4–0.5
Saturday/Sunday	Overall	0.6–0.75
	Evening	0.8–1.1

a) Relates to service changes in single period only and patronage changes only in that period (refer to text).

7.1.2 Elasticity trends over time

The project analyses all showed generally similar ramp-up profiles of patronage and elasticity trends over time following a service change. While the profiles obtained appeared to show some differences between

[44] This may explain why the Melbourne SmartBus weekday evening elasticity estimate appeared to be substantially greater than the three other weekday evening estimates.

day types/time periods and routes, these differences were not significant (unsurprising, given the small samples with reasonably reliable data).

The typical ramp-up profile (figure 5.3) was characterised by the following:

- By end Q1, patronage growth was approximately 75% of the end Q4 level; by end Q2 it was approximately 90% of the end Q4 level; and by end Q3 it was approximately 96% of this level.
- Average patronage growth in the first 12 months was about 86% of the growth by the end of Q4.
- Further growth beyond the end of Q4 was much reduced – further growth was around 4–5% within Y2, 2–3% within Y3, and around 1% or less in subsequent years.
- The long-run ‘saturation’ estimate (from the saturation curve analyses) was only 10–15% greater than the value at the end of the first year.

This ramp-up profile was very much ‘sharper’ than is commonly stated in the literature; ie the patronage growth rate was higher in the early months but relatively lower subsequently. Most of the international evidence suggests that ‘long-run’ elasticities (over a period of 7+ years) are between 50% and 100% greater than ‘short-run’ elasticities (after about 12 months)[45], whereas the project saturation values (ie long-run) were in the order of only 10–15% greater than the values after 12 months.

Particularly given this difference, further research on ramp-up profiles would be desirable. Some recent evidence indicates that ramp-up profiles for some other scheme types (eg new routes, major infrastructure projects) are significantly ‘flatter’ (more gradual) than those we have established for frequency improvements to existing routes.[46]

7.1.3 Other elasticity dimensions

Table 7.2 summarises the project findings in relation to the various other ‘dimensions’ of service frequency elasticities, additional to those addressed in the preceding two subsections.

In support of the findings in this table, we make the following additional comments:

- The highest priority for further investigation of service elasticity values is the extent of their variation with (a) day type/time period; and (b) initial level of service (frequency). This project’s evidence on the relative importance of these dimensions in ‘driving’ elasticity values was inconclusive.
- Subject to resolution of this point, there appears to be a strong consistency in elasticity values across routes and cities (for a given day type/time period and initial frequency). This provides confidence regarding the transferability of the project values between cities and routes.

[45] Refer to table 2.1. Wallis (2004) found that the weight of international evidence indicated that long-run service level elasticities were typically about double the short-run values.

[46] The TransLink Transit Authority, Queensland has recently undertaken analyses of a wide range of schemes implemented over the last 10 years to establish ramp-up profiles for different scheme types (refer to MRCagney 2012).

Table 7.2 Service elasticity findings – 'other' dimensions

Dimension	Findings	Notes, comments
Initial level of service	Little evidence of differences by initial service frequency (see fig. 5.1)	This was a surprising result: while the international evidence appears to be very limited (table 2.1), generalised cost theory would suggest that elasticities would reduce as frequencies increase, and there is some empirical support for this (Wallis 2004).
Day type/time period	Clear differences between weekday/weekend and peak/ interpeak/ evening (see table 7.1)	It remains unclear to what extent the observed differences by day type/time period reflected (i) the different frequencies prevalent by period and/or (ii) underlying characteristics of the market at different periods (refer to section 5.3.5).
Extent of service change	No evidence of significant differences by extent of service change	Refer to section 4.8.5/figure 4.6. There is minimal international evidence on this aspect.
Direction of service change	Evidence (limited) indicated no significant differences for increase v decrease in services	Evidence based on only one case of service increase followed by decrease. There is minimal international evidence on this aspect.
Service type and market demographic etc factors	For a given time period, there was a strong consistency of values both within cities (by route) and between cities	The results indicated that any differences by service type, market, etc were likely to be second order. This conclusion was very encouraging in terms of the transferability of values between cities and routes.

7.2 Summary of findings and conclusions – other market impacts of bus service improvements

In addition to the quantitative market response (service elasticity) analyses, the project involved a more qualitative appraisal of the effects of off-peak bus service improvements on mode choice, on enhancing travel opportunities, and on attitudes and perceptions about the services. This appraisal focused on review of the extensive market research evidence from Melbourne, largely based on market responses to the bus service improvements that have been implemented in recent years.

The main findings from this market research programme were as follows:

- **Previous travel mode of users of new/improved services:** The previous travel mode for the trip in question depended very much on whether any alternative PT services could previously cater for the trip. Where alterative services previously operated, the majority of users of any new/improved services would have used these alternatives; where suitable alternatives had not previously existed, only a small proportion of the users of the new/improved services would have made the trip by PT.
- **Alternative means of travel:** As above, the next-best alternative for passengers, if their specific new/improved service was not available, would depend very much on whether other PT services were suitable for the trip in question. For those passengers who would **not** have used another PT service, typical alternative mode shares were as follows:
  - car driver c.30–40%
  - car passenger (lift) c.15–25%
  - walk/cycle c.10–20%
  - taxi/other c.5–15%
  - not make trip c.10–20%.

These proportions were influenced by the specific situation, but were generally consistent with results from market research elsewhere.

- **Desired service improvements:** For typical low-frequency (unimproved) suburban bus services, users' highest priority aspects for service improvements to increase patronage were good service frequencies and extended service hours (to run in evenings and weekends). This finding was consistent with the relatively high off-peak service frequency elasticities reported above. Other priority aspects included: more direct services (following the main roads), improved reliability, improved bus stops, real-time passenger information and stop-specific timetables.

  For PT services to attract current non-users who had access to a car, key aspects for improvement were:

  - more frequent services
  - services to better match required origins (home) and destinations
  - more/better information and marketing of services.

- **User response to service improvements:** The Melbourne SmartBus market research indicated that those feature of the services that most influenced people's decision to use the improved services were: the improved frequencies, faster travel/direct routings, longer service hours, and stop-specific timetables/real-time information. These features were also those for which SmartBus users expressed the highest levels of satisfaction. These findings for improved services are generally consistent with the improvement priorities expressed by users of 'unimproved' services (above).

  The evidence indicated that a substantial proportion of new passengers using improved PT (particularly suburban bus) services tended to be people with limited travel options. The improved PT services are likely to promote increased mobility, accessibility, and self-reliance, providing better access to employment, health services and leisure activities, and thus contributing to reduced social exclusion.

7.3 Recommendations

7.3.1 Application of project findings in the New Zealand research and policy context

The project was highly successful in meeting its objectives, in particular through providing much-improved Australasian evidence on bus service frequency elasticities for the various (weekday and weekend) off-peak periods, both in the shorter run and progressively over time. It has made a substantial contribution to filling what was a significant knowledge gap in the body of research evidence, both in an Australasian-specific context and more widely internationally.

In the New Zealand context, we envisage the project's findings having applications, in the short/medium term, to:

- the efforts of regional authorities (in particular) to improve off-peak PT services, and to forecast the market (patronage) and financial impacts of such improvements
- the NZTA's ongoing research to develop better evidence on urban PT demand elasticities for application in PT planning and policy analysis in New Zealand.

7.3.2 Further research priorities – market response to service frequency improvements

For a given day type/time period and initial service frequency, the project findings have indicated a strong consistency in frequency elasticity values, across cities, across routes, by the extent and direction of service changes, and over time from the service change. This provides confidence regarding the transferability of the project estimates between cities, routes and situations (at least within Australasia, but potentially more widely).

Aspects of the market response to service frequency improvements that would warrant priority for future research are:

- the relative impacts of (i) the day type/time period; and (ii) the initial service frequency, on elasticity values
- the impacts of service changes in one time period (eg weekday evening) on patronage in other time periods (eg weekday daytime/interpeak)
- the 'synergy' effects on patronage, and hence elasticities, of improving services 'across the board' (eg through the whole weekday) rather than in just a single time period (eg weekday evening).

Research on each (or all) of these aspects would substantially improve understanding of service elasticities in a range of situations, and hence be of considerable value to PT service planners/analysts in New Zealand, Australia and internationally. Such research would not necessarily have to be based on Australasian evidence to be useful in the Australasian context.

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Appendix A: Impacts of service improvements – international review

A1 Introduction

This appendix does not attempt a comprehensive documentation and appraisal of all the international evidence on urban bus service frequency elasticities in general: this topic is covered in an earlier NZTA research report (Wallis 2004) 'Review of passenger transport demand elasticities', *Transfund NZ research report 248*. Rather its emphasis is on disaggregate evidence (elasticities) relating to key market dimensions and issues, which are not extensively covered in the existing international literature but are of particular interest to this project. Key dimensions examined included:

- variations in responses between different off-peak periods (principally weekday interpeak, weekday evening, Saturday, Sunday)
- evaluation of responses over time following a service change (the initial 'ramp-up' of responses and subsequent changes over five or more years)
- variations in responses according to the initial level of service
- impacts of service changes in one time period on patronage in other periods of the day/week
- differences between impacts on a route basis and on a wider corridor and network basis
- evidence on the prior behaviour (mode of travel, etc) of 'new' bus passengers attracted by improved services.

The focus of this project was on the effects on patronage and traveller behaviour (choice of mode, etc) of improvements to metropolitan/urban bus services outside peak periods. While all types of off-peak bus service improvements were of relevance, particular attention was given to improvements in service frequencies (headways) on existing routes: for such improvements, it was possible to derive service frequency elasticities[47], which might potentially be transferable to frequency improvements in other areas and situations; whereas it was more difficult to generalise and transfer the impacts of other types of service improvements (eg area or corridor-wide network restructuring).

The international literature on the patronage effects of improvements in urban bus service frequencies is significant in volume, but not as extensive as might have been expected[48]. It provides a modest number of urban bus service frequency elasticity estimates for the overall market, with only a few of these being disaggregated by key dimensions (eg long vs short run, day of week/period of day).

We note two further points here:

- Most of the international literature is based on studies of actual behaviour ('revealed preference' (RP), usually using 'before and after' analyses or econometric analysis of time series data on patronage and various causal variables.

[47] The service frequency elasticity represents the proportion change in patronage divided by the proportionate change in service frequency (bus trips per hour). Elasticity concepts and measures are discussed in more detail elsewhere in the project.

[48] One of the major international publications on factors affecting the demand for public transport (Balcombe et al 2004) gives some four pages to the evidence on the 'effects of service intervals', as compared with some 50 pages to the evidence on the effects of fare changes.

- Some of the literature is based on stated intentions of how people say they would respond to changes in services (stated preference (SP)). This review focuses on the RP evidence, as providing (in general) a more reliable guide than SP evidence.

A2 Summary of international evidence

A2.1 Disaggregated service frequency elasticity values – evidence and conclusions

The work undertaken included a detailed review of the key international and New Zealand sources that provide estimates of service frequency elasticity values for urban bus (and in some cases tram or train) services.

The review is presented in detail in annex AA of this appendix (table AA.1 in particular). As noted in section A1, the primary focus of the review was on disaggregate elasticity evidence relating to key market dimensions and aspects. We make the following comments:

- Almost all the literature covered has derived elasticity values from analysis of changes in actual market behaviour (ie RP rather than SP sources).
- Where possible, our review was based on appraisal of the original studies, rather than consolidated review articles.
- However, we did not generally attempt to examine the original data sets used in the studies, and therefore accepted the elasticity values derived by the original authors.
- One implication of this was that we implicitly had to accept the modelling methods and the definitions of the elasticities used in the original studies; different studies use different modelling methods and elasticity definitions, and hence the results quoted across the full range of studies will not in general be consistent. We note in particular that various different formulations for calculating elasticities are common in the literature[49].

Table A.1 presents a summary of the international evidence and our overall conclusions for each disaggregation dimension (or aspect); this summary draws on the detailed review material in annex AA.

The evidence is disaggregated by the following aspects:

A Changes over time from service change (short, medium and long-run impacts)

B Changes by time of day and day of week (weekday/Saturday/Sunday)

C Changes by market segment, specifically by:

- passenger type (adults, pensioners, children, etc)
- CBD v non-CBD oriented travel
- trip distance

D Type of region or area

E Initial service frequency

We note that, with the exception of item A (changes over time), the extent of evidence on each of these aspects is very sparse, in each case being based on a maximum of four separate studies.

[49] Refer Wallis (2004, appendix L) for further discussion on this point.

It was originally intended that we would examine the disaggregated evidence on the following additional three aspects:

1 Variations in elasticity responses according to the extent and direction (increase/decrease) of service changes

2 Impacts of service changes in one time period (or day type) on patronage at other time periods

3 Differences between impacts on patronage on a single route and impacts on the overall network (allowing for switching between routes).

However, we were unable to identify any worthwhile evidence on these three important aspects.

A2.2 Previous travel modes – evidence and conclusions

Annex AE provides a summary of the international and New Zealand evidence on the previous travel modes of additional public transport (PT) trips attracted as a result of service improvements. It focuses particularly on evidence relating to:

- bus services
- off-peak periods (where available)
- enhancements to existing services rather than the introduction of new mode or service types.

The relevant New Zealand and international evidence (set out in full in table AE.1) focuses on three groups of bus service enhancement schemes:

- various New Zealand schemes (including one ferry scheme), mostly involving the introduction of new routes
- the Adelaide 'TransitLink' services, which primarily involved the introduction of limited stop services to supplement the conventional routes.
- an extensive set of bus service improvements in Norway, including service frequency increases. These trials were extensively monitored through the Norwegian government and the evaluation results should be regarded as of high quality.

Table A.2 provides a summarised version of this evidence, focusing on the previous modes of new bus users for each of the three groups of services. Key findings include:

- In the two Australasian cases, between half and two-thirds of the new PT trips were previously made by car (the proportion in the Norwegian cases appears somewhat lower, most likely reflecting the differences in the areas and markets served).
- The split of these previous car trips between car driver and car passenger was fairly even, with the car passenger share of the car total varying about 30% and 60%. (This result implies a greater propensity for car passengers to switch to PT than for car drivers, given the relative 'base' mode shares for car drivers and car passengers.)
- The proportion of new PT trips that were previously made by walking or cycling is typically around one-third.
- There is conflicting evidence on the proportion of completely new ('pure generated') trips, ie cases where the improved PT service resulted in a new trip that would not otherwise have been made (even to a different destination). We believe this conflict largely reflects differences in survey methods. We consider that the Norwegian trial project study is likely to give the most reliable results, indicating a 'new trips' share of around 5%.

Table A.1 Service level elasticities – summary of international evidence

Aspect	Reference/Service	Summary of evidence	Overall conclusions
A Changes over time	MRCagney (2009) (Aust metro bus services)	Elast relative to 9–12 months values: • 0–3 months = 63% • 3–6 months = 94% • 6–9 months = 101%	• Impacts in first 12 months Elast values relative to 9–12 months: - 0–3 months 60%–85% - 3–6 months 80%–95% - 6–9 months 90%–100%. • Impacts in medium term (beyond 12 months) Elast value relative to 9–12 month results: - 2–4 years 110%–115%. • Short/medium/long run values (SR: within 12 months, LR = beyond 7 years or ultimate equilibrium) - LR:SR ratios in range 1.3 to 2.3 (favoured range 1.5 to 2.0).
	BAH (2002) NZ metro bus services	Ratios 3 months:12 months elast values: • AKL route 007 86% • CHC Orbiter weekday 74%, Saturday 83%, Sunday 80% Ratios 3 months:8 months elast value: • CHC Lyttleton weekday 62%, Sunday 94% Longer run elast rel to 9–12 month results: • AKL route 007: 24 months 111%, 36 months 111%, 48 months 114%	
	Oxera (2000) GB bus services	LR:SR elast range from around 0.9 to 2.3	
	Oxera (2005) GB rail	Time period to achieve 90% of ultimate patronage response (using rigorous statistical modelling methods) ranged from 1.0 to 4.7 years.	
	Dargay and Hanly (1999) GB bus	Elast ratios LR (when adjustment process completed): SR (within 1 year) generally in range 1.5–2.0. National level results give LR (within 7 years): SR (within 1 year) ratio of around 2.2.	
	Dargay and Hanly (2002) GB bus	LR:SR elast ratios generally in range 1.7 to 2.1.	
	Preston (1998) GB bus	LR: SR elast ratios generally in range 1.3 to 2.0.	
	De Rus (1990) Spain urban bus	MR:SR elast ratios around 1.5. Static model elast results generally fall between SR and MR values.	
	Holmgren (2007) various	LR:SR elast ratios around 1.3.	

Aspect	Reference/Service	Summary of evidence	Overall conclusions
B Time of day and week	Preston (1998) GB bus	Best estimate SR values: Interpeak 0.17, evening 0.35, peak 0.38, Saturday 0.52, Sunday 1.05.	No clear conclusions from the limited evidence: • Weight of evidence suggests off-peak elast greater than peak values, and evening/weekend elast greater than inter-peak values – but considerable uncertainty. • Results likely to be confounded by typical frequency levels differing between time periods (refer aspect E).
	Preston and James (2000) GB metro/ urban bus	Off-peak (interpeak?) values between 1.0 and 3.0 times peak values	
	Wilson (2001) Adelaide bus	Best estimate SR values (mean values from samples, 7–11 routes); weekday evening 0.46, Saturday 0.49, Sunday 0.20.	
	Hensher (2008)	Off-peak elast greater than peak elast.	
C Market segment: C1 Passenger type	Preston and James (2000) GB metro/ urban bus	Elast for adult pax greater than that for other pax types	No clear conclusions from the limited evidence.
	Brown and Singleton (1980) Melbourne tram	Elast for pensioner pax greater than that for other pax types	
	Cheung et al (1985) Netherlands, week-end urban services	Elast for older people (>45 years) greater than that for younger people.	
C2 CBD v non-CBD trips	Preston and James (2000) GB metro/urban bus	In peak periods, elast for CBD trips greater than for non-CBD trips. In off-peak periods, elast for CBD trips less than for non-CBD trips.	No clear conclusions from the limited evidence.
C3 Trip distance	Brown and Singleton (1980) Melbourne tram	Mixed evidence on variations in elast with trip distance.	No clear conclusions from the limited evidence.
	Hensher (2008) various	Elast values similar for passenger trips and passenger km (indicating that no great differences in elast values by trip distance).	

Aspect	Reference/Service	Summary of evidence	Overall conclusions
D Type of region/area:			
D1 Metropolitan vs other areas	Dargay and Hanly (1999; 2002) GB bus	Elast for services in shire counties around twice those for metro areas	Reasonably strong evidence that elast values in smaller urban centres and rural/semi-rural areas are higher than in metro areas. However this result may reflect the relative service levels rather than intrinsic market differences.
	Oxera (2008) GB bus	Elast for services in other GB regions greater than for London.	
D2 Urban densities and types of development	Hensher (2008) various	Found no significant differences in elast values between USA/Australasia (low-density, car-dependent cities) and other, mostly EU (high density, less car dependence).	Cannot draw conclusions with confidence from the limited evidence.
E Initial service frequency	Cheung et al (1985) Netherlands, week-end urban services	Elast values for lower frequency services (<1/hour) were up to 0.9, for higher frequency services (>2/hour) zero to 0.2.	There is surprisingly little evidence on this aspect. The best source of evidence (Cheung et al) is consistent with expectations that elast values would be substantially lower for higher frequency services than for lower frequency services.
	Renolen and Kjorstad (nd) Norway bus services	Analysis of daily PT trips rates by service frequency suggests that 'elasticity' value (% trip rate change: % service change) increases with base service frequency. This is contrary to expectations – but seems likely to reflect self-selection effects rather than expected service elasticities.	

Table A.2 Previous travel modes of new bus users – summary

Project/scope	Proportions of new users by previous modes		
	Car driver/car passenger[(a)]	Walk/cycle	Did not travel
New Zealand – bus service enhancements	50%–66% (20%, 29% CD in 2 cases)	27%–41%	N/a
Adelaide – TransitLink services	56% peak (33% CD, 23% CP) 58% interpeak (42% CD, 16% CP)	N/A	37% peak 34% interpeak
Norway – various trial projects	27%–50% overall, 44% increased service frequency	27%–51% overall 33% increased service frequency	c.6% overall

Source: Summary from table AE.1 for new bus users.

Notes: (a) CD = car driver, CP = car passenger.

Annex AA: Detailed review of international evidence

AA.1 Detailed review

Table AA.1 provides a summary and review of each of the key international (including New Zealand) sources identified that provide estimates of service frequency elasticity values for urban bus (and in some cases tram and train) services.

For each reference source, the table summarises the evidence under the following headings:

- Country/city
- Key variables
- Type and extent of service changes
- Data set and years to which this relates
- Analysis methodology
- Market segments analysed
- Elasticity values obtained
- Additional comments.

This detailed table is drawn on for the appraisal in section A.2 of service elasticity values by various disaggregation dimensions or aspects.

Section AA.2 provides the full details of the various reference sources used in compiling the information given in table AA.1.

Table AA.1 Bus service level elasticity studies

City/country	References	Key variables	Type/extent of service changes	Data set/ period	Methodology	Market segments	Elasticity values	Comments
Australia – ADL, BNE, MEL	MRCagney (2009).	Patronage (by route) related to bus trips/hour (by route)	Frequency increases on individual bus routes	Monthly patronage data by route, 2004–2009.	Before/after monthly comparisons by route, adjusted for control route changes. Elast calculated by month as % change route patronage: % change route frequency.	Weekday interpeak period (9am–2pm).	Values for months 9–12 average, relative to same period 12 months earlier: • ADL (12 routes): mean 0.31, range 0.05–1.11 (only one result above 0.62). • BNE (4 routes): mean 0.45, range 0.36–0.50. • MEL (1 route): 0.25. Overall (17 routes): mean 0.34 (12 with-in range 0.15–0.62). Average elast values for earlier periods rel to 9–12 months ave: • 0–3 months 64% • 3–6 months 94% • 6–9 months 101% • 9–12 months 100%.	Elast values available by month over first 12 months of increased services. Values given beyond 12 months are dubious because of apparent inconsistency in estimation methods. No investigations included of possible patronage effects on competing routes or other time periods.
Britain	Oxera (2000), cited in Balcombe et al (2004)				Model-based estimates(?)	All	SR and LR values (timescales undefined) for bus services by region: • London SR 0.30, LR 0.26 • Other regions SR 0.41, LR 0.95 • NE region SR 0.34, LR 0.32.	
Britain	Dargay and Hanly (1999), also cited in Balcombe et al (2004)	Bus trips pa/capita related to bus km pa/capita	Aggregate service (bus km) changes	Annual patronage data by region, 1985–1996 period; national data	Econometric modelling, annual basis, various model formulations. Related bus trips/capita to bus	All	SR and LR values for bus services by region: • All regions (1): SR 0.26, LR 0.36 • All regions (2): SR 0.46, LR 0.74	SR defined as effects 'within 1 year of (service) change'; LR as 'total response to change over time, when adjustment process is

City/country	References	Key variables	Type/extent of service changes	Data set/ period	Methodology	Market segments	Elasticity values	Comments
				1977–1996	km/capita, fares, income, motoring costs, car ownership, etc. Dynamic model structure, allowing estimation of adjustment process over time		• All regions (3): SR 0.43, LR 0.81 • Met areas (1): SR 0.27, LR 0.24 • Met areas (2): SR 0.35, LR 0.71 • Shire counties: SR 0.64, LR 0.87 • English counties (1): SR 0.45, LR 0.75 • English counties (2): SR 0.42, LR 0.79	complete'. Notes that national level results indicate SR elast (within 1 year) of around 0.4, LR elast (within 7 years) of 0.9.
Britain -Metro areas	Preston (1998) cited in Balcombe et al (2004)				Econometric modelling (?)	Five segments by time period	Peaks: SR 0.38, LR 0.58 Interpeak: SR 0.17, LR 0.30 Evening: SR 0.35, LR 1.95 Saturday: SR 0.52, LR 0.67 Sunday: SR 1.05, LR 1.61	'Peak' periods include early AM services. Main finding was that demand in evenings and Sundays is 'sensitive' to service levels, demand in interpeak is 'insensitive'.
UK – 23 cities/towns	Preston and James (2000), cited in Balcombe et al (2004)	Bus patronage pa related to average wait time (headway)			Relationships between bus patronage and average wait time (headway).	Segmented by: • total v adult passengers • peak vs off-peak • town centre vs other travel.	Following are elast values wrt wait time: • Total ave -0.64, adult ave -0.74 • Time period: off-peak between 1.0 and 3.0 times peak. Destination: town centre trips c.1.5 times other trips peak; c.0.65 times other trips off=peak.	SR values?? Not clear whether waiting times are derived as proportional to headways, therefore results represent headway or frequency elasticities (assumed to be the case).

City/country	References	Key variables	Type/extent of service changes	Data set/ period	Methodology	Market segments	Elasticity values	Comments
England – 46 counties	Dargay and Hanly (2002)	Bus patronage/ capita relates to bus km pa/capita		County level bus patronage (operators over 50 vehicles), annual 1987/88–1996/97. Also bus km/cap, ave fare/trip, income/cap, motoring costs, demographic variables.	Econometric modelling (county level, annual data). Dynamic, partial adjustment, model. Related bus patronage pa to dependent variables. Pooled data: modelled for same/different fare elasticities by county, fare elast fixed or proportional to fare level.	All bus travel	Preferred model with fare elast differing by county and variable with fare level: SR 0.42, LR 0.79 Other models: SR 0.48 to 0.49 LR 0.83 to 1.03 Split between metropolitan and shire counties: Met SR 0.36, LR 0.73 Shire SR 0.72, LR 0.97 Between 48% and 58% of total adjustment (all sources) estimated to occur within first year following changes.	This study uses similar, but slightly different data set to that in Dargay and Hanly (1999), and also slightly different model formulations. The results are generally similar.
Various, mostly UK	Balcombe et al (2004). Also Paulley et al (2006) has same material	Various	Various	Various	Various	Various	Various	Review of international evidence, with a UK focus – often referred to as DfPT. All relevant studies have been included individually elsewhere in this table.
Various	Holmgren (2007)	Patronage/capita related to bus km	Various (not defined)	Meta-analysis (58 studies with demand elasticities for local bus services wrt vehicle km).	General linear meta-analysis model, including variables to distinguish between log-linear, linear, semi-log and complete demand models in	Various- differentiated between the different bases used in the original models, eg: • SR v LR • exogenous	SR (reference) elast 1.05, LR 1.38 Elast with x-section data higher than time series data (reflects LR v SR effect).	Definition of LR v SR unclear. Found service elast not affected but whether veh km treated as exogenous or endogenous (although fare elast does appear to be

City/country	References	Key variables	Type/extent of service changes	Data set/ period	Methodology	Market segments	Elasticity values	Comments
					the original elasticity estimation. Used step-wise regression to eliminate insignificant variables.	vs endogenous variables • time series vs cross-section vs panel data • American/Australian vs other countries • omission of certain dependent variables.		affected by this).
Britain	Oxera (2005)	Rail patronage, related to rail fares, journey times, service delays	No specified – uses generalised journey time (GJT)	British Rail ticket sales data, 4-weekly 1995/96-1999/00, annual 1992-2001	Emphasis on analysing lagged effects. Used partial auto-correlation function (PACF) to identify significant lag effects. Then applied error correction model with 4-monthly data to explore potential explanatory variables and their lag patterns.	Long vs short distance, London v other trips	For fare elasticities, identified 3 elasticities (1 period, 1 year, LR) and time taken for 90% of ultimate (LR) patronage adjustment. For various market segments, found times for 90% adjustment in range 1.0 years to 4.7 years.	Study results of interest, as one of few studies to examine/report on elasticity responses over time using rigorous analysis methods. Does not quote any service elasticities over time.
Norway	Renolen H and Kjorstad KN (nd))	PT trips/day related to service frequency		Norwegian National Travel Survey	Cross-sectional analysis of relationships between PT trips/day against	All	Daily PT trip rates v service headways: • Up to 15 mins: 0.53 • 20–30 mins: 0.35	Application of these results to estimate elasticity values against frequency level gives the

City/country	References	Key variables	Type/extent of service changes	Data set/ period	Methodology	Market segments	Elasticity values	Comments
					service frequency near place of residence		• 60 mins: 0.25 • 120 mins: 0.22 • Less frequent: 0.16	following (approx): • 120 to 60 mins: 0.15 • 60 to 25 mins: 0.30 • 25 to 12 mins: 0.50. Most likely these results will incorporate a self-selection effect. Report notes that increasing frequencies was generally the most desired single improvement to PT services.
Spain	De Rus (1990)	Bus trips/month related to fares and bus km	Bus trips. fares by ordinary/ multi-trip tickets, bus km, time trend.	11 medium-size Spanish cities (pop 110–740k). Local bus data by month, 1980–88. Monthly pax trips, fare revenues, fares, bus km.	Log-log model, with dynamic (geometric log) structure to account for delayed adjustments.	For some cities, separated cash from multi-trip tickets.	Dynamic (auto-regressive) model, giving service elast by city: SR 0.26 to 1.54 MR 0.39 to 1.88 On average MR/SR elast ratio = 1.54 Static model: service elast 0.34 to 1.26, generally between dynamic SR and MR values.	Paper gives no information on how MR is defined or on profile of lagged response effects.
Various	Hensher (2008)	Various	Various	Meta study of sources of variations in PT fare and	Range of regression models, controlling for heteroskedasticity,	All. Divided where available between bus/train,	Analyses in relation to bus headways indicate that: • Off-peak > peak • No apparent difference in	Appears not to have addressed elapsed time (SR/MR/LR) of impact

City/country	References	Key variables	Type/extent of service changes	Data set/ period	Methodology	Market segments	Elasticity values	Comments
				service elast, with focus on 21 studies of headway elasticities	eliminating insignificant variables.	peak/off-peak, etc.	elast between pax trips and pax km • No apparent elast difference between USA/Australia and elsewhere (EU etc).	
Melbourne, Australia	Brown and Singleton (1980)	Patronage (tram) related to service km operated.		Time series up to 1979/80. Included fares (real), service km.	Econometric time series analysis, annual data, deriving elasticities wrt service km.	All tram users. Also split by trip distance (1 mile sections) and adult / child/pensioner.	All; 0.83. Generally pensioner elast greater than adult elast. Mixed evidence on variations in elast wrt trip distance.	Essentially static/short-medium run values.
Auckland/Christchurch, New Zealand	Booz Allen Hamilton (2001)	Patronage by route relative to bus trips operated.	Service increases on existing routes, also route extensions (Orbiter).	'Before' data for 3 months prior to service change; 'after' data for 3 monthly periods ending 3 months, 12 months, 24 months after service change.	Before vs after comparisons, adjusted for patronage trends (control routes) and estimated abstraction from other services.	All – by weekday/ Saturday/Sunday .	AKL 007 Crosstown service – service elast: • 3 months: 0.62 • 12 months: 0.72 • 24 months: 0.80 • 36 months: 0.80 • 48 months: 0.82. CHC Lyttleton service elast: weekday 3 months 0.36, 8 months 0.58; Sunday 3 months 0.16, 8 months 0.17. CHC Orbiter (included completion of loop): Weekday 3 months 0.58, 12 months 0.78; Saturday 3 months 0.55, 12 months 0.66; Sunday 3 months 0.70, 12 months 0.87.	Useful results in terms of patronage impacts over time from service frequency increases.
Netherlands	Cheung et al (1985), cited in Booz Allen	Patronage related to service levels.			Before/after analysis of weekend service frequency changes	Weekend services	Service elast vary with initial service frequency: Higher frequency (2+/hour): elast zero to 0.2; lower	Regional services (responses may differ from local/urban

City/country	References	Key variables	Type/extent of service changes	Data set/ period	Methodology	Market segments	Elasticity values	Comments
	Hamilton (1998)				on regional bus services.		frequency (<1/hour) elast up to 0.9.	services).
Adelaide, Australia	Wilson (2001)	Patronage related to services (trips)	Range of service frequency improvements following new contracts in April 2000 - mainly Saturday and Sunday, some weekday.	Before/after analyses – B data 6 months October 1999–March 2000; A data same period 12 months later.	Before/after comparisons, adjusted for control of unimproved routes.	Weekday, Saturday, Sunday	Service frequency (trips) elast: • Weekday mean 0.46, range -0.31 to 1.90 (sample 11) • Saturday mean 0.49, range -0.34 to 1.35 (sample 10) • Sunday mean 0.20, range 0.16 to 0.34 (sample 7).	Very large spread of results for each time period – doubts as to significance of differences. Majority of weekday changes related to evening services, others to interpeak services: most of service changes were small, contributing to wide spread of results. 'Go Zone' concept introduced at same time(?) and appears to have contributed to impacts, with elasticity values generally higher in Go Zone areas.

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Annex AB: Summary of evidence from Transfund NZ research report 248

An earlier research report prepared as part of the (then) Transfund NZ research programme involved an extensive international 'Review of passenger transport demand elasticities' (Wallis 2004). This annex reproduces the appendix from that report, which addresses the international evidence on elasticities of PT demand with respect to service levels (the evidence reproduced below is specific to the bus mode – the original report also covered the rail mode and PT services in general).

AB.1 Introduction

This appendix provides an overview of the evidence from New Zealand, Australia and internationally on the effects of changes in service levels on PT patronage (ie direct elasticities). It does not examine any cross-modal effects. Evidence is categorised into that specific to bus, rail and to PT in general. Tables B1 to B6 summarise the ranges of elasticities by these modes[50].

Vehicle kilometres operated is generally used as a useful proxy measure of service levels and, although it is a fairly crude approximation as many factors make up the level of service, it is the most readily available aggregate measure.

Vehicle kilometres operated can reflect a number of factors that should be considered when examining the estimates including:

- average frequency of service during a given period. For a fixed length route and fixed period of operation, frequency is directly proportional to vehicle km

[50] The detailed tables from the report are not included here.

- length of day or week over which a service operates. Expanding the schedule on a fixed route to cover a longer period at the same frequency, eg in the evenings, would produce an increase in vehicle km
- route length and network density. Increased vehicle km (at a network level) may also reflect extensions of routes and/or additional routes, thus increasing accessibility (ie shorter walking distances).

Elasticities derived from network-wide vehicle km statistics (the usual source) may thus encompass all three effects, although the average frequency of service during a given period is likely to be the predominant element.

Also, for service levels in particular, there is a 'cause and effect' relationship with patronage: increases to services tend to produce increases in patronage; but exogenous increases in patronage also tend to result in increases in services. This effect is difficult to exclude from the calculations, although before and after studies of specific service changes are thought likely to give the best results. Therefore, we have placed greater weight on our conclusions from before and after studies (where available).

AB.2 International evidence – bus service levels

AB.2.1 Overall estimates

Short run (SR)

Table B1[51] summarises evidence on bus service elasticities, where service is measured in terms of vehicle kilometres. Although not explicitly stated in most cases, most of the values given would appear to be SR estimates based on the analytical technique applied, such as unlagged time series and before and after studies. Typical SR values found in the literature appear to range from 0.2 to 0.6. However, they tend to vary widely between studies. Some key studies included:

- Balcombe et al (2004) estimated an average SR value of 0.38 based on a review of the empirical literature (values ranged from 0.10 to 0.74).
- Dargay and Hanly (1999) estimated a short run value of 0.4 in their study of UK buses.
- In Europe, ISOTOPE (1996) estimated an overall value of 0.41.
- In Germany, Fitzroy and Smith (1998) derived a value of 0.65.
- De Rus (1990) found service km elasticities ranged from 0.34 to 1.26 based on an analysis of 11 Spanish cities.
- In the USA, Pratt et al (2000) observed much higher elasticities which typically ranged from 0.6 to 1.0 (although the time horizon was not specified).

Medium run (MR) and long run (LR)

Dargay and Hanly (1999) and Balcombe et al (2004) concluded that MR to LR estimates are approaching twice the SR estimates. This relationship is consistent with that found for fare levels, as noted by Dargay and Hanly in their analysis.

AB.2.2 Disaggregate estimates

In general, although estimates varied from study to study, the following conclusions can be drawn:

- **Service frequency.** Elasticities for low frequency services were greater than for high frequency services. Chung (cited in Booz Allen Hamilton 1998) found elasticities for lower frequency services were up to four times greater than high frequency services.

- **Trip purpose and time of day/week**. While no robust elasticity estimates were found for the various travel purposes, elasticities for the off-peak were generally found to be greater than the peak. For example, Lago et al (1981) found an average peak elasticity of 0.33 and an off-peak estimate of 0.63, compared to Rendle et al (1978) who observed a peak estimate as low as 0.11 and a similar off-peak estimate of 0.62. Elasticities were also found to be lowest during the weekday inter-peak period, higher during the weekday and evening periods, and highest at weekends (Preston 1998, cited in Dargay and Hanly 1999). These differences in part reflect the service frequency effect (above) and in part the different traveller/trip purpose characteristics at the different periods.
- **City size.** Elasticities tend to be higher in larger centres. ISOTOPE (1996) reported that demand was more elastic in larger cities (0.49) than in smaller cities (0.33). The author attributes this to competition with other transport modes occurring in larger cities. The report also suggests that service is valued more highly in larger cities because of higher income levels, and thus higher values of time.
- **Urban and suburban.** Allen (cited in Pratt et al 2000) revealed a higher elasticity for local suburban services compared with urban services.

AB.3 Australian and New Zealand evidence – bus service levels

AB.3.1 Overall estimates

Short run (SR)

The results detailed in table B4 show a considerable range of Australian and New Zealand bus elasticity values. A typical SR value appears to be around 0.5 to 0.6, which is generally comparable to the international evidence discussed in section B2.

Australia. Earlier analysis in Australia by BTE (1977), Brown and Singleton (1980), and Shepherd (1973) found elasticity estimates towards the higher end of the range (ie values ranged from 0.6 to 1.2 depending on the study).

New Zealand. A number of studies undertaken in New Zealand revealed results of a similar order of magnitude. Key findings included:

- Wallis and Yates (1990) undertook a time series analysis based on data from seven urban centres and estimated average values ranging from 0.48 to 0.54, with a wider variation apparent between individual centres.
- Research by Galt and Eyre (1987) estimated values as high as 1.0 (passenger trips) and 1.3 (passenger km) in their analysis of 26 urban centres throughout New Zealand.

AB.3.2 Disaggregate estimates

Based on the relatively limited literature which examined the variation in elasticities by market segment, the following conclusions could be formulated:

- **Service frequency.** Based on a review of the empirical literature, Booz Allen Hamilton (1998) concluded elasticities were much lower than average for frequent services (ie 0.1 to 0.2 for services at least every 10 minutes), and generally increasee for less frequent services (ie in the order of 0.8 for service frequencies worse than hourly).
- **Time of week.** Two studies (Wilson 2001, Booz Allen Hamilton 2002) found that service elasticities for weekend travel were less than half those for weekday travel. However these results are contrary to UK evidence (section AB2.2), and also contrary to the general finding that elasticities are generally higher for lower frequency services.

AB.4 Conclusions

AB.4.1 Overall estimates

The New Zealand, Australian and international evidence on overall service level elasticities shows a wide range, with SR values ranging as low as 0.1 and as high as 0.9 or even higher. This wide range in part reflects the wide range of circumstances examined, particularly in terms of base frequency levels.

Making allowances for base frequency levels, no strong evidence of significant differences exists in service elasticities for bus versus rail services. We therefore assume equal elasticities.

Based on typical New Zealand urban bus service frequencies (20-30 minutes), we would recommend an SR service frequency central estimate of 0.35, with a typical range of 0.20 to 0.50.

These estimates are noted to vary broadly in proportion to the service frequency, for frequencies of up to about 1 hour.

For long-run estimates, the above service elasticities are expected to be approximately doubled.

AB.4.2 Disaggregate estimates

The international evidence on disaggregated service level elasticities is somewhat limited, and that for New Zealand and Australia even more so. Based primarily on the international evidence, the following conclusions on disaggregated service elasticity values are drawn:

- Service elasticities vary broadly in proportion to base service frequencies (as above). Typical values would be 0.1 to 0.2 for 5–10 minute frequency services increasing to around 0.8 for hourly services, with lesser rates of increase for even less frequent services.
- Elasticities are substantially higher than average for shorter trips, particularly when walking is a ready alternative.
- Elasticities are typically lowest for peak trips, higher for weekday off-peak trips, and highest for weekend trips. (This result arises both from the frequency effect and the different market segments and trip purposes involved.) However some studies have reached different conclusions.
- The limited evidence indicates that elasticity values are largely independent of the magnitude of any service change or its direction (increase or decrease).

AB.5 References

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Wallis, IP and P Yates (1990) *Public transport patronage trends in New Zealand. Where are all the passengers going*? ATRF document. 19pp.

Wilson, TJ (2001) Patronage increases from April 2000 bus service improvements. Internal memo, SA Passenger Transport Board.

Annex AC: Summary of North American evidence

AC.1 Introduction

This annex summarises the relevant evidence on bus service frequency elasticities taken from the key USA report on the topic, prepared for the USA Transportation Research Board as part of the Transit Cooperative Research Program (TCRP 2004). The report draws together USA and (to a lesser extent) Canadian research on the topic: much of the research evidence presented relates to experience from the 1960s and 1970s (but noting that such evidence is still likely to be largely valid).

AC.2 Response by market segment—overview

- Service frequency elasticities are highest where:
  - prior services are infrequent (<3 trips per hour)
  - routes serve middle/upper income areas

- it is an off-peak rather than peak period
- trips are relatively short (walking is an alternative).

AC.3 Response by base service level

- Table AC.1 suggests higher service frequency elasticities when the initial frequencies are lower.
- This is as expected (based on a generalised cost formulation), but the effects may be confounded by time period/trip purpose effects (see below).

AC.4 Effects by time period/trip purpose

- Table AC.3 indicates that elasticities may be higher at off-peak than peak periods, although the evidence is not conclusive.
- Table AC.4 gives some indications of lower off-peak elasticities.
- In both cases the results are likely to be confounded by the differing base service levels in the different periods (see above).

AC.5 Network effects

- The overall system elasticities resulting from service frequency changes on a single route are often much lower than the individual route elasticities, due to passengers switching to/from alternative routes.
- Such an example is given in table AC.4, based on a situation where service frequencies were reduced and a before/after survey was undertaken of passengers. For the majority of the market (work and school trips), it is seen that the total transit elasticities are much lower than the individual route elasticities, indicating that most of the passengers affected by the service reduction transferred to alternative routes.

AC.6 Alternative modes

- For those new transit passengers attracted as a result of service frequency increases, the weight of evidence indicates that one-third to one-half of these would otherwise have made the trip as car drivers.
- Table AC.2 shows some typical results for such situations.

AC.7 Temporal effects

- Changes in service frequency in a given time period may also affect patronage in other periods.
- This is perhaps particularly true in relation to evening services. Improvements in evening services may well result in increased patronage in earlier periods of the day.
- There is also evidence of similar effects in relation to weekend services. Increases in weekend services may result in increased patronage on weekday services.

AC.8 Time lag effects

- The time taken for patronage gains to stabilise in response to service frequency improvements seems to vary:
  - Massachusetts Experiments (1960s):
    - patronage on some services stabilised within the first month

    - o on other services it took at least 9–12 months (eg the fourth quarter patronage increase was some 50% greater than the increase that occurred within the first quarter)
  - Portland, Oregon service increases:
    - o in suburban areas, patronage stabilised after 1–5 months
    - o in urban areas, patronage stabilised after 8–10 months.
- The indications are that, for frequency changes, patronage stabilises significantly sooner than for new routes (typically two to three years).

Table AC.1 Bus route headway elasticities stratified by original service level

Original service level (headway)	No. of observations	Arc (mid-point) elasticity	Standard deviation
Less than 10 minutes	7	-0.22	±0.10
10 to 50 minutes	6	-0.46	±0.18
Greater than 50 minutes	10	-0.58	±0.19
All observations	23	-0.44	±0.22

Source: Lago et al (1981)

Table AC.2 Prior travel modes of transit users attracted by increased frequency

Bus users attracted by various Massachusetts Bus frequency increases	
Prior mode	**Percentage**
Own car	18 – 67
Carpool	11 – 29
Train	0 – 11
Taxi	0 – 7
Walking	0 – 11

Source: Mass Transportation Commission et al (1964), cited in TCRP (2004)

Table AC.3 Bus headway elasticities stratified by time of day

Time period	No of observations	Arc (mid-point) elasticity	Standard deviation
Peak hours	3	-0.37	±0.19
Off-peak hours	9	-0.46	±0.26
Weekends	4	-0.38	±0.17
All hours	7	-0.47	±0.21

Source: Mayworm et al (1980)

Table AC.4 Headway elasticities for Mt Pleasant trolley bus route panelists, Toronto

		Headway elasticities		
Trip purpose	**Time period**	**Mt Pleasant**	**Total transit**	**Total trips**
Work and school trips	All periods	-0.40	-0.06	0.00
Non-work and non-school trips	All periods	-0.40	-0.40	-0.29

Trip purpose	Time period	Headway elasticities		
		Mt Pleasant	Total transit	Total trips
All purposes	Peak periods	-0.47	-0.15	-0.10
All purposes	Off-peak period	-0.29	0.00	-0.10

AC.9 References

Lago, AM, PD Mayworm and JM McEnroe (1981) Transit ridership responsiveness to fare changes. *Traffic Quarterly 35*, no.1: 117–142.

Mayworm, P, AM Lago and JM McEnroe (1980) Patronage impacts of changes in transit fares and services. *UMTA US DoT report RR135-1*.

TCRP (2004) Traveler response to transportation system changes, chapter 9: transit scheduling and frequency. *TCRP report 95*. Transit Cooperative Research Program, Transportation Research Board.

Annex AD: Previous Adelaide analyses

AD.1 Introduction

The competitive tendering of bus services in Adelaide commenced in 1996/97 and since April 2000 all bus services have been operated under contract by private operators selected through a competitive tendering process.

Since that time, many service improvements have been made, often by changes to the network and frequencies without additional funding being made available. The types of improvements have included:

- increased weekday interpeak frequencies
- increased evening frequencies
- increased weekend frequencies
- increased peak frequencies (mostly quite recently, as previously service changes were largely undertaken in a 'cost neutral' environment)
- route extensions
- changes to the route network
- introduction of Go Zones[51].

In general, the service changes have been initiated by the operator concerned, for approval by the state government authority[52].

[51] 'Go Zones' comprise sections of route along which at least a 15-minute service is provided during the day on weekdays, and at least a 30-minute service is provided on weekends and evenings until 10pm. These routes are clearly marked with red bus stops and marketing material.

[52] Initially the SA Passenger Transport Board (PTB), subsequently the Public Transport Division (PTD) of the SA Department of Transport, Energy and Infrastructure, and now the Public Transport Services Division of the SA Department of Planning, Transport and Infrastructure (DPTI).

The changes have generally been successful in increasing patronage. Prior to 2000, Adelaide bus patronage had been declining for many years, at an average rate of 2%–3% pa. Since 2000, this trend has been reversed, with average increases of a similar amount (ie increases in the order of 5% pa relative to the previous downward trend) (Bray and Wallis 2007).

Since the start of the new contracts in April 2000, PTB/PTD has been monitoring patronage on a continuing basis, by individual trip, and has produced a number of papers/memoranda examining the impacts of specific service changes (on a route or route group basis) on patronage. This annex provides a summary of the most relevant findings from these papers.

In regard to these papers, it should be noted that:

- The service changes assessed involved many different types of changes (as noted above), not just service frequency changes.
- In many of the cases, data on the change in bus trips or bus kilometres was not readily available.
- Most of the analyses were split by weekday/Saturday/Sunday, but a further breakdown by time period of the weekday service and patronage changes was often not available.

AD.2 Service changes, year 2000

PTB undertook analyses of service frequency (weekday, Saturday, Sunday) improvements implemented in year 2000, at the start of the new contracts. Patronage for the six months October 2000 – March 2001 (ie starting some five months after the service changes) was compared with the corresponding patronage for the equivalent period 12 months earlier. The results were adjusted for underlying trends by using patronage changes on the unimproved routes as 'controls'.

Table AD.1 presents a summary of the findings from the PTB analyses (Wilson 2001). Additional comments that should be noted:

- The elasticities derived from these analyses effectively represent figures averaged over the period 6–11 months after the service changes.
- The majority of the service changes involved changes other than frequencies. A substantial proportion of them involved replacement of one-way loop routes (evenings and weekends) with either two-way loops or with two separate services covering a similar area. A substantial proportion also involved the introduction of Go Zones.
- The weekday elasticity results were calculated over all weekday services. If they were re-estimated over only the period of the day affected (mostly evenings), the calculated elasticities would be higher, perhaps by a factor of two to three (reflecting the relative average loading levels on evening services relative to weekday services overall).
- The evidence indicated that service changes associated with the introduction of Go Zones had generally higher elasticities than other changes.

AD.3 Service changes 2000 to 2005

PTD compared patronage by route group (including rail and tram services) in March 2005 against the equivalent figures for March 2000 (ie just prior to the introduction of the new contracts). Route groups were divided into four categories, according to the extent of any service improvements over the period. The results for each level of improvements are summarised in table AD.2 (Wilson 2005).

Table AD.1 Impacts of Adelaide service frequency changes year 2000

Day/type	Sample size[a]	Average service level increase[b]	Patronage change[c]		Mean elasticity value[d]	Elasticity range	Notes
			Unadjusted	Adjusted			
Weekday	11	+7.4%	7.8% ave (-3.1%–13.0% range)	3.4% ave (-7.5%–8.6% range)	0.46	-0.31 to 1.90	Mostly evening services, some interpeak services. Most service changes were small. Elasticity for evening service improvements considered on stand-alone basis would be substantially higher than this, given their lower-than-average patronage. Average elasticities were 0.79 for route groups (5) with Go Zones, close to zero for other (6) route groups.
Saturday	10	+20.2%	13.2% ave (3.5%–35.6% range	13.2% ave (-3.3%–28.8% range)	0.49	-0.34 to 1.35	Average elasticity for route groups (4) with Go Zones was 0.60, average for other route groups (6) was 0.42.
Sunday	7	+66%	21.7% ave (9.7%–39.7% range	13.5% ave (1.5%–31.5% range)	0.20	0.16 to 0.34	Average elasticity for improvements[d] involving Go Zones was 0.30, that not involving Go Zones (3) was 0.16.

Source: Wilson (2001).

[a] Represents the number of distinct routes/route groups for which service changes were analysed.

[b] Represents the average daily change in bus trips (or bus km) for route groups analysed.

[c] Unadjusted figures are direct year-to-year comparisons; adjusted figures allow for changes on control (unimproved) route groups.

[d] Represents unweighted mean of results for sample.

Table AD.2 Patronage changes 2000 to 2005 by extent of service improvements

Improvement category	No. of route groups	No. of new Go Zones	Average patronage change 2000 to 2005	Comments
'Substantial'	21	10	+28%	Patronage changes range +9% to +76%. Includes 3 rail lines.
'Minor'	10	2	+8%	Patronage changes range -3% to +26%. Includes tram line.
'Little/none'	23	2	-0.5%	Patronage changes range -34% to +15%. Includes one rail line.
'Decrease'	3	-	-19%	Patronage changes -36% to -5%.

Source: Wilson (2005).

The table shows clear correlation between the extent of improvements undertaken and the growth in patronage, within each category. It is also notable that, for the category with little or no service changes, the average change in patronage over the period was very close to zero: this strongly suggests that the 'underlying' patronage trend over this period was close to zero, and that all the patronage gains in the 'substantial' and 'minor' categories were the result of the service improvements undertaken.

It is not possible to derive service elasticities from this data source, as no figures are given on the extent of the service improvements involved.

AD.4 Service changes 2000 to 2007

This assessment was essentially an extension of the analyses by route group from 2000 to 2005, given in the previous section, to cover two further years to March 2007 (SA DTEI 2007). This assessment covered some 90% of the Adelaide bus network, and showed the following overall patronage increases over the seven-year period[53]:

- weekday – 14%
- Saturday – 23%.
- Sunday – 72%
- overall – 16%.

The SA DTEI paper (2007) notes that:

- Operators are given incentive payments to encourage then to increase patronage. They have the flexibility to change routes and frequencies, subject to PTD approval.
- The rate of service changes has been much greater than when the system was operated by government.
- This has been successful in reversing the downward patronage trend prior to 2000.
- The service changes have largely been made in a 'cost neutral' environment with regard to service kilometres provided and the total fleet size. Improvements have been largely funded by reductions in poorly-patronised services, with resources being redeployed to where they are likely to attract higher patronage.

[53] As noted in table AD.1, the proportionate increases in service levels were much greater on Sundays than Saturdays, which were in turn greater than for weekdays overall.

- The majority of improvements have thus occurred during the weekday early AM, interpeak and evening periods, and at weekends. Some minor weekday peak improvements have been achieved through clever timetabling.

The main types of changes made were described as follows:

- **Go Zones.** These have been progressively introduced since April 2000 (refer section AD.1).
- **Frequency improvements.** These have ranged from minor to major, with relatively few improvements at peak times due to the non-availability and cost of providing additional buses. Typical interpeak improvements may be changing from a 20-minute to a 15-minute service, or from a 40 or 60 to a 30-minute service. At night and on Sundays in many cases frequencies have improved from no service to hourly or from hourly to half-hourly. (It is believed that improvements at night and on weekends can assist patronage increases on weekdays at peak or inter-peak times, as people become accustomed to a service they can depend on at all times. People who purchase cars because their bus service is poor at night or on weekends may be likely to abandon PT altogether.)
- **Replacement of different networks.** In 1992 night and weekend services in Adelaide were cut drastically, and in many cases a different network introduced at those times to minimise use of resources. That arrangement was extremely confusing for the public, and has been progressively discontinued since 2000, with significant positive results. Some of these results can be seen by the substantial patronage increases that have occurred on Sundays, when many services were improved from 'extremely poor' in 2000 to 'acceptable' levels in 2007.
- **Improved cross-suburban links,** including often replacing an old local route and an old radial route with one through route which increases the availability of the cross-suburban access.
- Changes designed to **reduce the need for passengers to transfer.**
- **General network changes** – designed to facilitate much of the above.

AD.5 References

Bray, DJ and IP Wallis (2007) Adelaide bus service reforms – impacts, achievements and lessons. *Paper to 10th international conference on Competition and Ownership in Passenger Transport*, Hamilton Island, Australia.

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Annex AE: Evidence on previous travel modes of new bus service users

AE.1 Introduction

One of the aspects of the project case studies was to investigate the previous modes of additional PT (bus) trips attracted as a result of service improvements. While very limited (no?) evidence was available on this topic from the selected case studies, this appendix provides a summary of the international (including New Zealand) evidence on the topic from other studies.

The focus of this appendix is on the previous travel patterns of those people attracted to use PT/bus services as a result of service enhancements, and in particular evidence relating to:

- bus services
- off-peak periods (where available)
- enhancements to existing services rather than the introduction of new mode or service types.

AE.2 The evidence

The relevant New Zealand and international evidence is set out in table AE.1. This evidence focuses on three groups of bus service enhancement schemes:

- Various New Zealand schemes (including one ferry scheme), mostly involving the introduction of new routes.
- The Adelaide 'TransitLink' services, which primarily involved the introduction of limited stop services to supplement the conventional routes.
- An extensive set of bus service improvements in Norway, including service frequency increases. These trials were extensively monitored through the Norwegian government, and the evaluation results should be regarded as of high quality.

Table AE.1 shows, in proportionate terms, for each scheme:

- the previous modes of all users of the enhanced services; and
- the previous modes of those users who did not previously travel by PT for the trip in question (figures shown in brackets).

Table AE.2 provides a summarised version of this evidence, focusing on the previous modes of new bus users for each of the three groups of services.

AE.3 Summary and commentary

AE.3.1 Evidence on previous modes

Car users:

- In most of the cases (New Zealand, Adelaide), between one-half and two-thirds of the new bus service users would otherwise have travelled as car driver or passenger for the trip in question. For the Norwegian trials, the car driver/passenger proportion appears to be rather lower (44% for the trials of increased bus service frequency).

- The split of this group between car drivers and car passengers appears to vary substantially between the different schemes: for the Adelaide and New Zealand schemes, the car driver: car passenger ratios vary between 40:60 (Christchurch Orbiter) and 72:28 (Adelaide interpeak).
- The Adelaide data is the only source of separate peak versus off-peak (interpeak) splits: these indicate that the proportion of car users (drivers and passengers) is similar in both periods, but weighted more towards car drivers in the interpeak.

Walk/cycle:

- The New Zealand and Norwegian data give a fairly consistent picture in terms of the proportions otherwise walking or cycling, at between 27% and 51% in all cases[54]. The typical figure for bus service frequency enhancements appears to be towards the middle of this range.
- The New Zealand data indicate similar proportions of walking and cycling for the Christchurch Orbiter, but elsewhere walking dominates.

Did not travel:

- The Adelaide schemes and the Norwegian schemes appear to give very different results in this aspect: for Adelaide, the survey results indicate that around 35% of the new trips would not otherwise have taken place (similar proportions in peak and inter-peak periods), whereas the corresponding figure for the Norwegian schemes is around 6%[55]. The Christchurch Orbiter survey identified a minimum of around 3% of new users who would otherwise not have made the trip in question.
- We suspect that these large differences result in part from inconsistent definitions in the various surveys. We suggest that Norwegian results are likely to be more reliable, as these trial schemes were evaluated carefully within a well-designed framework covering all behavioural responses.

AE.3.2 Other market segmentation

- Time periods. The evidence base on previous travel modes by different periods of the day or trip purposes is very limited: the main source we have identified is for the Adelaide TransitLink schemes, as outlined in table AE.1 and discussed above.
- Short run and long run. We have not been able to identify any evidence on the differences in previous mode in the short run and long run after scheme implementation. All the data given in this appendix reflects shorter run effects (ie within one year).

Table AE.1 Previous mode of travel by bus users after the implementation of service enhancements

<table>
<tr><th rowspan="2">Project</th><th colspan="8">Proportions of market by previous mode[a]</th></tr>
<tr><th>Car driver</th><th>Car passenger</th><th>Did not travel</th><th>Walk/ cycle</th><th>Other</th><th>Total new PT market</th><th>Existing PT users</th><th>Overall total</th></tr>
<tr><td colspan="9">New Zealand services</td></tr>
<tr><td>AKL link[b]</td><td colspan="2">41[c]
(58)</td><td>-
(-)</td><td>29
(41)</td><td>1
(1)</td><td>71
(100)</td><td>29</td><td>100</td></tr>
<tr><td>AKL route 007 (Crosstown)</td><td>(29)</td><td>(31)</td><td>(-)</td><td>(27)[d]</td><td>(12)[e]</td><td>(100)</td><td></td><td></td></tr>
</table>

[54] It appears that walking and/or cycling was not offered as an option in the Adelaide surveys, which may reflect that most of the trips concerned were relatively long.

[55] This category was not covered in most of the New Zealand cases.

Project	Proportions of market by previous mode[a]							
	Car driver	Car passenger	Did not travel	Walk/ cycle	Other	Total new PT market	Existing PT users	Overall total
AKL Half Moon Bay ferry	(43)	(40)	(-)	(-)	(17)[f]	(100)		
CHC Orbiter bus route[b]	13	20[hi]	2	23[g]	7	65		
	(20)	(30)		(35)	(15)	(100)		
Adelaide TransitLink services								
Peak: TL2	7.5	4.5	4.0		3.0	19.0	81.0	100.0
TL3	8.4	4.6	12.0		2.0	27.0	73.0	100.0
TL4	5.9	5.1	5.0		1.0	17.0	83.0	100.0
TL5	4.1	3.9	5.0		1.0	13.0	87.0	100.0
TL10	12.0	12.0			-	24.0	76.0	100.0
Average peak	6.6	4.6	7.4		1.4	20.0	80.0	100.0
	(33)	(23)	(37)		(7)	(100)		
Interpeak :TL2	13.7	4.3	8.0		1.0	27.0	73.0	100.0
TL3	11.5	5.5	11.0		2.0	30.0	70.0	100.0
TL4	8.1	2.9	6.0		2.0	19.0	81.0	100.0
TL10	11.0	8.0			2.0	21.0	79.0	100.0
Average interpeak	10.3	3.9	8.3		1.7	24.3	75.7	100.0
	(42)	(16)	(34)		(7)	(100)		
Norway trials								
Service routes	22		4	32	5	63	37	100
	(35)		(6)	(51)	(8)	(100)		
Smaller buses	13		3	23	9	48	52	100
	(27)		(6)	(48)	(19)	(100)		
Express service	15		?	8	?	30	70	100
	(50)		(?)	(27)	(?)	(100)		
Increased frequency	9		?	7	?	21	79	100
	(44)		(?)	(33)	(?)	(100)		
Service route/smaller buses:								
Urban trials	10		3	17	5	36	64	100
	(28)		(8)	(47)	(14)	(100)		
Local/regional trials	28		3	39	10	80	20	100
	(35)		(4)	(49)	(12)	(100)		

Sources: Australian and Norway data: Booz Allen Hamilton (2000)

NZ data: Booz Allen Hamilton (2002).

[a] Unbracketed figures are previous mode proportions of total PT trips (after service enhancements). Bracketed figures are previous mode proportion of total new PT trips.

[b] Results after adjustment for multiple responses to survey questions.

[c] Includes 3% (4%) car pool.

[(d)] Comprises 23% walk, 4% cycle.

[(e)] Includes 7% taxi.

[(f)] Includes 10% taxi.

[(g)] Comprises 11% (17%) walk, 12% (18%) cycle.

[(h)] Some two-thirds of these car passenger trips involved another person making a specific 'serve passenger' trip as a car driver, thus contributing to a further reduction in car traffic.

Table AE.2 Previous travel modes of new bus users – summary

Project/scope	Proportions of new users by previous modes		
	Car driver (CD)/car passenger (CP)	Walk/cycle	Did not travel
New Zealand – bus service enhancements	50%–66% (20%, 29% CD in 2 cases)	27%–41%	N/a
Adelaide – TransitLink services	56% peak (33% CD, 23% CP) 58% interpeak (42% CD, 16% CP)	N/A	37% peak 34% interpeak
Norway – various trial projects	27%–50% overall, 44% increased service frequency	27%–51% overall 33% increased service frequency	c.6% overall

Source: Summary from table AE.1 for new bus users.

AE.4 References

Booz Allen Hamilton (2000) Effects of public transport system changes on mode switching and road traffic levels. *Transfund NZ research report 179*.

Booz Allen Hamilton (2002) Analysis of patronage data from public transport case studies. *Transfund NZ research report 223*.

Appendix B: Service elasticity assessments – Auckland

B1 Introduction

This appendix focuses on service frequency enhancements to the Three Kings bus routes along Mt Eden Road in Auckland (New Zealand).

The service frequency enhancements were introduced as follows:

- Weekday interpeak (0900–1500) services, from 10 February 2008: typical headways reduced from about 12 minutes to about 9 minutes[56].
- Saturday services, from 18 October 2008: average headways reduced from about 20 minutes to around 15 minutes[57].

B2 Data sources

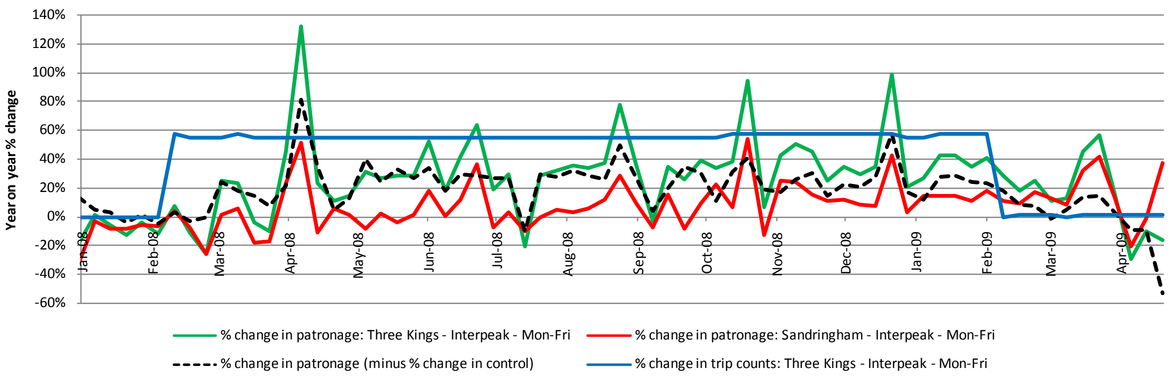
The operator (NZ Bus) provided total weekday and Saturday patronage, on a weekly basis between 31 December 2006 and 23 April 2009 for the Three Kings routes.

It also provided total weekday and Saturday patronage, on the same basis, for the Sandringham route, to be used as a control.

B3 Graphical analysis

Figures B.1 and B.2 show a clear relationship between growth in service levels (ie the blue line) and growth in patronage after adjustment for the control (ie the dotted line).

Figure B.1 – Mt Eden Road, interpeak, Mon–Fri – patronage growth with and without control adjustment



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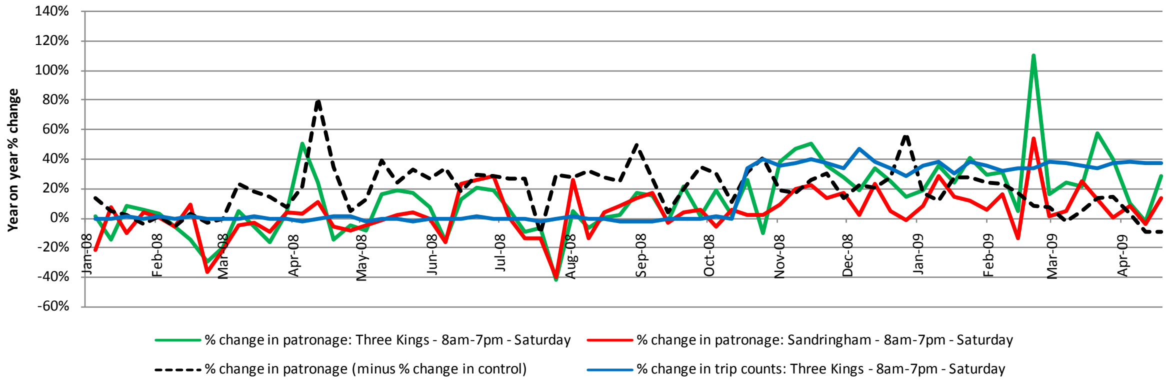
[56] However, there were a few exceptions to this for outbound services between 1400 and 1500 hours, headway fell from ~30 min to ~20 min; for inbound services between 0900 and 1000 hours, there were no initial services but two services were added, creating a headway of about 20 minutes

[57] There was a single exception to this for outbound services between 0900 and 1000 hours, headway fell from ~60 min to ~30 min.

Figure B.2 Mt Eden Road, Saturday – patronage growth with and without control adjustment



B4 Econometric analysis

B4.1 Weekday interpeak services

Table B.1 (at end of this appendix) shows the results of econometric analyses of the impacts of the service enhancement on patronage growth. The preferred model in table B.1 is model D, followed closely by model C.

Models A and B were estimated, but were not preferred. Models A and B regress patronage growth on service enhancement. However, a large portion of this patronage growth is most likely due to other factors, such as population growth, rising petrol prices, etc. Therefore, the elasticities estimated by models A and B are probably overestimates.

Models C and D circumvent this problem by subtracting patronage growth on a route representing a control (Sandringham). As expected, the elasticities estimated by models C and D are generally lower.

This control adjustment for models C and D seems to have worked quite well: in model C, the residual time trend (0.7%) is close to zero, which indicates that use of a control route has been effective in enabling us to distinguish between underlying growth and growth caused by service enhancements.

However, we note that the underlying growth rate or time trend cannot be estimated with much accuracy because we have only a month of data prior to the service change, and only a few months after the service change had fed through. Therefore, the models with the time trend omitted may produce relatively more accurate estimates. This led us to select model D (shaded) as our preferred model.

The models without constants – model B and model D - have higher ‘adjusted R^2’ but not too much weight should be given to this. The omission of a constant makes this measure less meaningful.

B4.2 Saturday services

For the Saturday data, the recommended models are model C and model D and both are shown shaded grey in table B.2. Both models make an adjustment to patronage growth using control growth.

Deciding between these models is difficult. On one hand, model C (which includes a time trend) is perhaps more accurate than model D because it controls for the underlying patronage growth rate. The underlying patronage growth rate can be estimated with moderate accuracy in this case because we have almost a year of data prior to the service change.

However, model C estimates the underlying growth rate to be 3% when we would expect it to be 0% if the time trend is working properly (although we note that the underlying growth rate is not statistically significantly different from 0%). This raises questions about the effectiveness of the time trend, suggesting that the model without the time trend may be more appropriate.

Again as expected, the elasticities are (much) lower once an adjustment is made to reflect growth in the control route (Sandringham).

Table B.2 Econometric analysis to estimate quarterly elasticities – Saturday

Model	Dependent variable	Headway before	Headway after	% increase in services	Time trend (ie constant)	Impact of service enhancement:		Adjusted R^2
						0–3 mths after	4–6 mths after	
A	Patronage	20 min	15 min	38%	2.6% (-3.4%, 8.6%)	0.67*** (0.35, 1.00)	0.78*** (0.45, 1.11)	0.30
B	Patronage	20 min	15 min	38%	n/a - omitted	0.74*** (0.46, 1.03)	0.85*** (0.57, 1.14)	0.46
C	Patronage growth minus control growth	20 min	15 min	38%	3.1% (-1.3%, 7.4%)	0.34** (0.10, 0.57)	0.46*** (0.22, 0.70)	0.20
D	Patronage growth minus control growth	20 min	15 min	38%	n/a - omitted	0.42*** (0.21, 0.63)	0.52*** (0.34, 0.75)	0.37

*** Statistically significant at 0.1%, ** Statistically significant at 1%, * Statistically significant at 5%

B5 Conclusions

Table B.3 summarises elasticity estimates and ranges, based on the preferred models, and notes the robustness of the findings in terms of confidence intervals.

Table B.3 Summary of service elasticity estimates

Item	Weekday interpeak	Weekend
Headway before (typical)[a]	12 min	20 min
Headway after (typical)[a]	9 min	15 min
% increase in services	57%	37%
Elasticity:		
0–3 months after	0.36	~0.40
4–6 months after	0.46	~0.50
7–9 months after	0.47	
10–12 months after	0.45	
95% confidence interval	±0.15	±0.20
Robustness of model	High	Med

[a] These are typical headways on the main sub-routes comprising the Mt Eden Road group of routes: the headways on the combined routes are considerably lower.

The weekday interpeak estimates appear to be the most robust, as the time trend, when fitted, is close to zero. This indicates that use of a control route has been effective in enabling us to distinguish between underlying growth and growth caused by service enhancements.

We have less confidence in the accuracy of the Saturday estimates because the time trend, when fitted, was above zero. Furthermore, the service elasticity range is wider for the Saturday estimates, representing the underlying 'noisiness' of the Saturday data.

However, we note that both the weekday interpeak and the Saturday data have produced very similar estimates and patterns. The average service elasticity was about 0.35 to 0.40 in the first quarter, rising to 0.45 to 0.50 in the second quarter. No significant increases were detected in subsequent (third and fourth) quarters for the interpeak analysis. Thus the evidence indicates that about 70%–80% of the effects of the service enhancement occurred in the first quarter, and the full effect on patronage fed through during the second quarter.

Table B.1 Econometric analysis to estimate quarterly elasticities – Monday to Friday

	Dependent variable	Headway before	Headway after	% increase in services	Time trend (ie constant)	Impact of service enhancement:				Adjusted R^2
						0–3 mths after	4–6 mths after	7–9 mths after	10–12 mths after	
Model A	Interpeak patronage growth	12 min	9 min	57%	6.5%	0.25 (-0.10, 0.60)	0.43* (0.08, 0.78)	0.58** (0.23, 0.93)	0.60*** (0.27, 0.94)	0.17
Model B	Interpeak patronage growth	12 min	9 min	57%	n/a - omitted	0.37** (0.11, 0.63)	0.55*** (0.28, 0.81)	0.70*** (0.43, 0.96)	0.72*** (0.46, 0.97)	0.53
Model C	Interpeak patronage growth minus control growth	12 min	9 min	57%	0.7% (-6.7%,8.1%)	0.35** (0.14, 0.55)	0.45*** (0.24, 0.65)	0.46*** (0.25, 0.66)	0.44*** (0.24, 0.64)	0.29
Model D	Interpeak patronage growth minus control growth	12 min	9 min	57%	n/a - omitted	0.36*** (0.21, 0.51)	0.46*** (0.31, 0.61)	0.47*** (0.32, 0.62)	0.45*** (0.30, 0.60)	0.64

*** Statistically significant at 0.1%, ** Statistically significant at 1%, * Statistically significant at 5%

Appendix C: Service elasticity assessments – Dunedin

C1 Introduction

This appendix focuses on the patronage growth observed after certain Sunday services were doubled on 1 July 2000 in Dunedin (New Zealand).

The Sunday (and public holiday) services on the following routes increased from two-hourly to hourly (ie doubled):

- The combined city routes:
  - Balaclava-Kenmure
  - Brockville-Halfway Bush
  - Corstorphine-Lookout Point
  - Pine Hill-Opoho
  - St Clair-Normanby
  - St Kilda-Waverley-Shiel Hill
  - Wakari-Roslyn
- St Clair-Normanby.

A number of other case studies for service additions in Dunedin during the period 1991–2009[58] were explored but were discarded as infeasible for a range of reasons:

- Some service additions were relatively inconsequential.
- Some service additions were 'tarnished' (previously poorly run services were rescheduled to make timetables more regular, to introduce clockface timetables, and to make services more reliable).
- (In one case) the service addition related to commercial services, for which the Otago Regional Council (ORC) does not hold the relevant patronage data.

C2 Data sources

C2.1 Service levels

The Sunday service levels on the routes covered increased by 100%, from two-hourly to hourly.

C2.2 Patronage

The ORC provided quarterly patronage data for the routes above from September 1991 to December 2007.

[58] The data was provided to us in two databases: quarterly patronage data from September 1991 to December 2007 and daily patronage data from 26 November 2007 to 31 August 2009.

The ORC suggested a number of control routes (Port Chalmers, Mosgiel, Green Island, Brighton and Pennisula) that had not experienced service changes over the relevant period, and had been largely unaffected by service changes on other routes. Unfortunately, there was no Sunday patronage data available for these control routes between July 1996 and October 2000.

Therefore, we decided to use Saturday patronage on the combined city routes (as listed above) as a control for Sunday patronage. There was no Saturday patronage data for the St Clair/Normanby route.

The Saturday and Sunday patronage data for the combined city routes was transformed by dividing, respectively, by the number of Saturdays and Sundays in each quarter.

C3 Analyses and findings

The combined city routes all experienced an increase in Sunday frequency from two-hourly to one-hourly from 1 July 2000.

C3.1 Analyses

Refer figures C.1 and C.2 and table C.1.

Figure C.1 shows that patronage appears to have increased following the introduction of the increased services (ie Q2000.3) and it appears to have continued to grow thereafter for some time.

The dotted line in figure C.2 shows there was a discernable 'jump' in the ratio of Sunday to Saturday patronage in the 2000.3 quarter and in the following quarters.

However, there is evidence in figure C.2 of the growing popularity of Sunday shopping around this time: Sunday patronage (as a ratio of Saturday patronage) was already growing prior to the service enhancement. The growing popularity of Sunday shopping makes discerning the impact of the service enhancement difficult, because we do not know how much of the post-July 2000 growth shown in figure C.2 would have occurred anyway, and how much was the result of the service change.

To address this uncertainty, we made two extreme assumptions about the amount of growth that would have occurred in Sunday patronage, using two alternative 'business-as-usual' (BAU) scenarios (ie in the absence of the service enhancement):

- The first scenario assumes that the ratio of Sunday to Saturday patronage would have continued to grow at the same rate as observed before the service change.
- The second scenario assumes that the ratio of Sunday to Saturday patronage would have stabilised at the level observed just prior to the service change.

These two extreme scenarios are illustrated in figure C.3. We expect that the reality would lie somewhere between these two scenarios.

Figure C.3 also shows that actual patronage increased sharply immediately following the service change, with most of the response shown in the 12 months after the service change. Beyond 12 months, one interpretation of the data is that growth stabilised (was saturated) after about a further 12 months (ie around period 2002.3); but another interpretation, reflected in the saturation curve shown, is that patronage still continued to grow although at a decreasing rate through the seven-year 'after' period plotted in figure C.3.

The difference between the observed growth and the BAU scenarios in figure C.3 was used as a basis for the estimation of elasticities shown in figure C.4.

Figure C.1 Combined city routes (and the St Clair/Normanby route) Sunday patronage since introduction

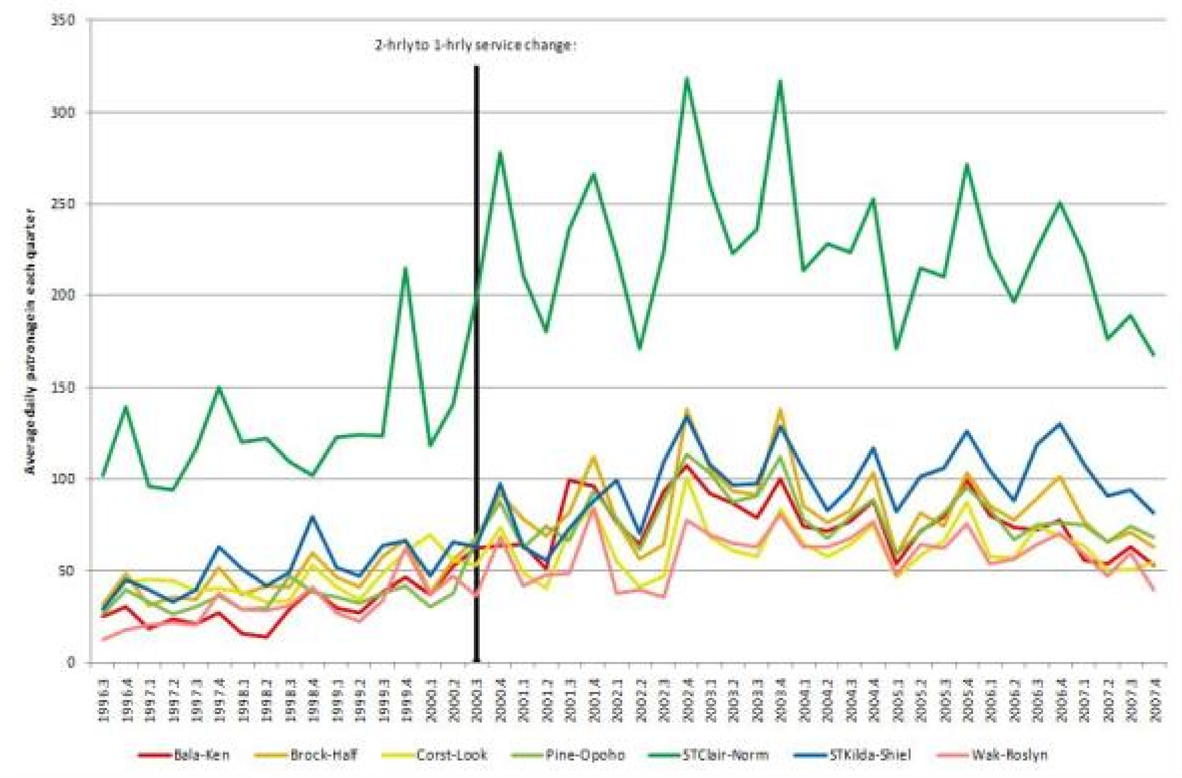


Figure C.2 Combined city routes Sunday patronage since introduction, as a ratio of the control (ie Saturday patronage)

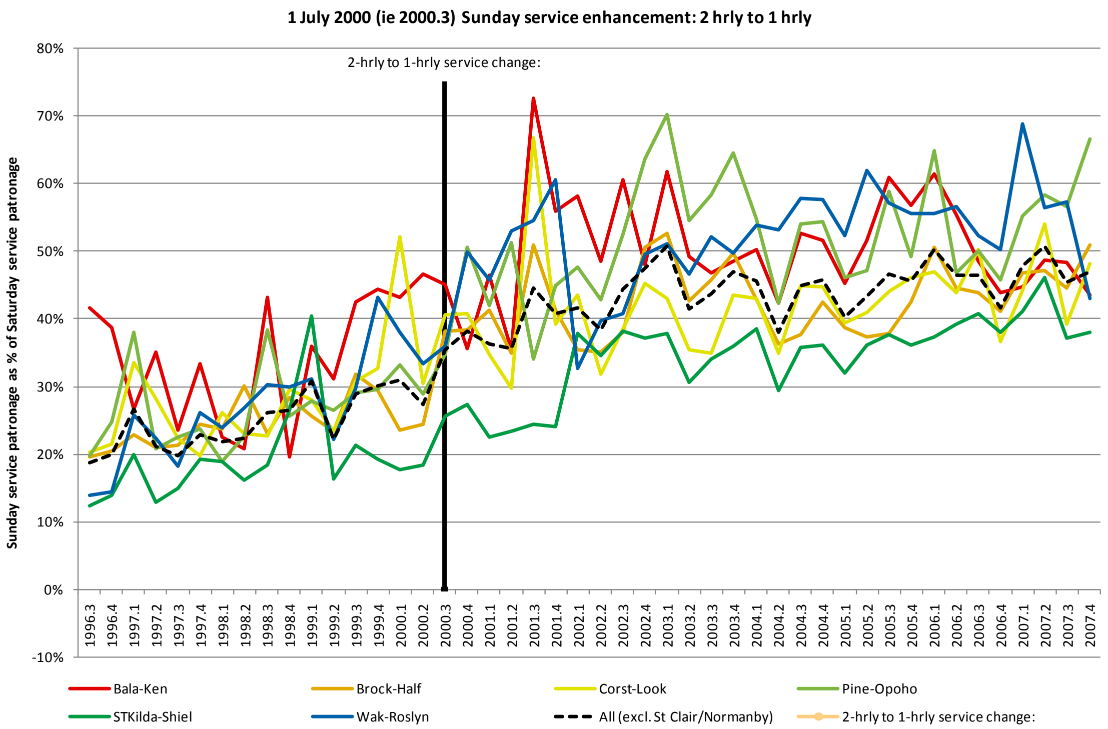


Figure C.3 Combined city routes Sunday patronage since introduction, as a ratio of the control (ie Saturday patronage) – with 'business-as-usual' scenarios

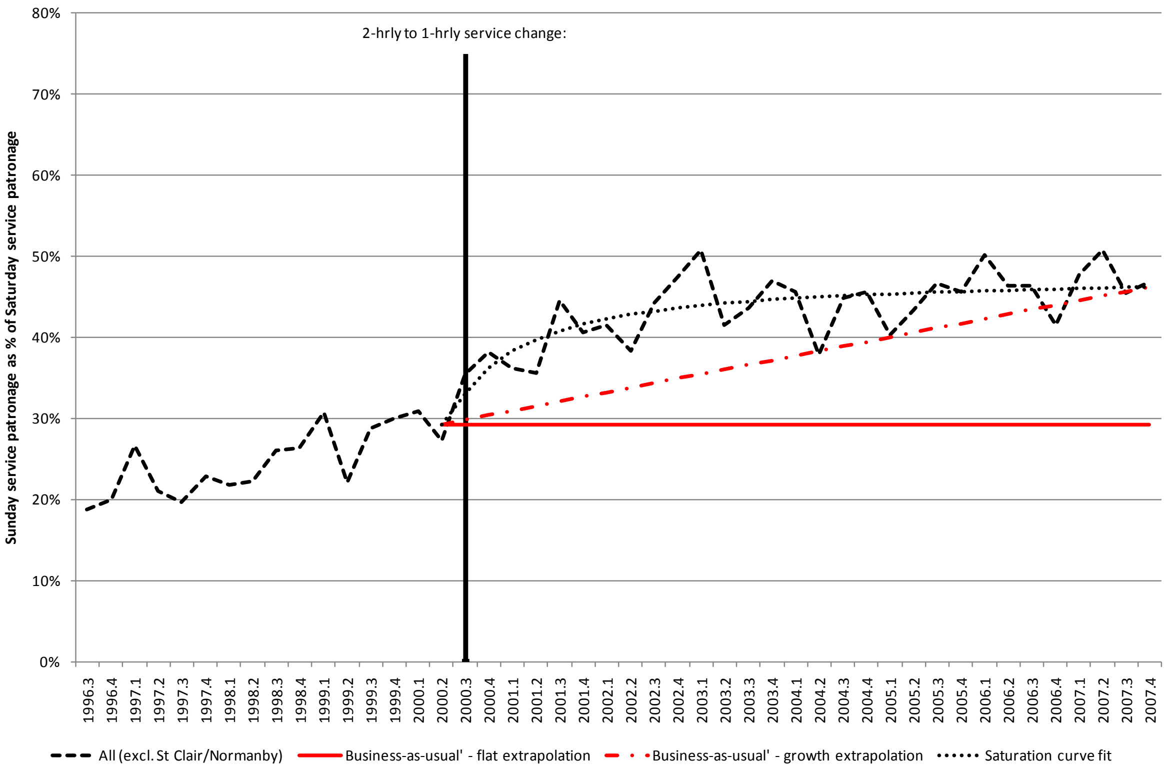
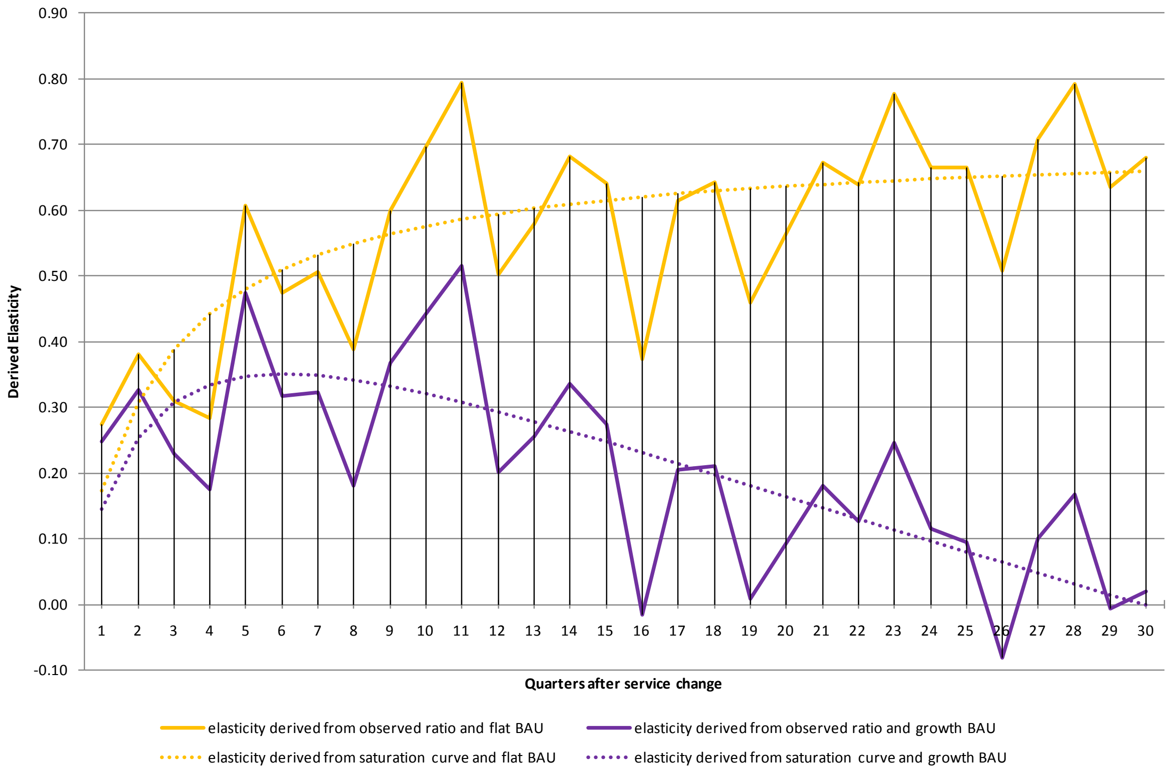


Figure C.4 Derived elasticities based on 'business-as-usual' assumptions.



The calculations behind the derived elasticities are shown in table C.1. The derived elasticity (col. 4 or col. 5) is the natural log of the observed ratio of Sunday to Saturday patronage (col. 3) divided by the ratio assumed under BAU conditions (col. 9 or col. 10). The derived elasticity can also be shown as a formula[59]:

$$\text{Derived Elasticity} = ln\left(\frac{\left(\frac{P_{Sun}}{P_{Sat}}\right)^{Case\ Study\ -Actual\ \ Growt\ h}}{\left(\frac{P_{Sun}}{P_{Sat}}\right)^{BAU}}\right)$$

Figure C.1 shows that the elasticities derived from observed ratios are quite volatile. Therefore, we also derived 'fitted' elasticities (col. 7 or col. 8) which were the natural log of the 'saturation curve fit' ratio (col. 6, also shown in figure C.3) divided by the ratio under BAU conditions (col. 9 or col. 10 again). Again, this can also be shown as a formula:

$$\text{Derived Elasticity} = ln\left(\frac{\left(\frac{P_{Sun}}{P_{Sat}}\right)^{Case\ Study\ -Saturation\ \ Curve\ Fit\ Growt\ h}}{\left(\frac{P_{Sun}}{P_{Sat}}\right)^{BAU}}\right)$$

Table C.2 shows the observed ratio of Sunday to Saturday patronage again, but in this table the observed ratio was 'factored up' so it equalled 100% in the 4th quarter. It shows that the observed ratio continued to grow even after four quarters had passed: it grew approximately 30% more over the next year or so, eventually settling at around 130%.

[59] The 'standard' elasticity formula is that *Elasticity = ln (% patronage change) – ln (% service change)*. In this case, the service change factor is 100% = 1, and ln(1) = 0. Hence the service change term can be eliminated from the equation.

Table C.1 Derivation of elasticities

		col 1	col 2	col 3	col 4	col 5	col 6	col 7	col 8	col 9	col 10
Number of quarters following introduction	Date at which quarter ends	Average patronage per day		**Observed ratio** of Sunday to Saturday patronage	Elasticity derived from **observed ratio** and BAU scenarios		**Saturation curve fit** to observed ratio of Sunday to Saturday patronage	Elasticity derived from **saturation curve fit** of observed ratio		Ratios assumed under BAU scenarios	
		Route	Control								
		Sun	Sat		Flat	Growth		Flat	Growth	Flat	Growth
.	Mar-99	231	751	31%	.	.	.	.	.	.	.
.	Jun-99	205	922	22%	.	.	.	.	.	.	.
.	Sep-99	279	969	29%	.	.	.	.	.	.	.
.	Dec-99	344	1,146	30%	.	.	.	.	.	.	.
.	Mar-00	259	835	31%	.	.	.	.	.	.	.
Zero	Jun-00	314	1,151	27%	.	.	29%	.	.	29%	29%
Q1*	Sep-00	350	987	35%	0.27	0.25	33%	0.17	0.15	29%	30%
Q2	Dec-00	483	1,267	38%	0.38	0.33	36%	0.31	0.25	29%	30%
Q3	Mar-01	358	987	36%	0.31	0.23	38%	0.39	0.31	29%	31%
Q4	Jun-01	338	948	36%	0.28	0.18	40%	0.44	0.33	29%	32%
Q5	Sep-01	439	985	45%	0.61	0.47	41%	0.48	0.35	29%	32%
Q6	Dec-01	558	1,371	41%	0.47	0.32	42%	0.51	0.35	29%	33%
Q7	Mar-02	422	1,015	42%	0.51	0.32	42%	0.53	0.35	29%	33%
Q8	Jun-02	333	869	38%	0.39	0.18	43%	0.55	0.34	29%	34%
Q9	Sep-02	439	990	44%	0.60	0.37	43%	0.56	0.33	29%	34%
Q10	Dec-02	671	1,415	47%	0.70	0.44	44%	0.58	0.32	29%	35%
Q11	Mar-03	547	1,078	51%	0.79	0.52	44%	0.59	0.31	29%	36%
Q12	Jun-03	490	1,183	41%	0.50	0.20	44%	0.59	0.29	29%	36%
Q13	Sep-03	479	1,095	44%	0.58	0.26	44%	0.60	0.28	29%	37%
Q14	Dec-03	643	1,369	47%	0.68	0.34	45%	0.61	0.26	29%	37%
Q15	Mar-04	471	1,031	46%	0.64	0.27	45%	0.61	0.25	29%	38%
Q16	Jun-04	419	1,104	38%	0.37	-0.02	45%	0.62	0.23	29%	38%
Q17	Sep-04	467	1,042	45%	0.61	0.20	45%	0.62	0.21	29%	39%
Q18	Dec-04	549	1,203	46%	0.64	0.21	45%	0.63	0.20	29%	39%
Q19	Mar-05	347	862	40%	0.46	0.01	45%	0.63	0.18	29%	40%
Q20	Jun-05	448	1,036	43%	0.56	0.09	45%	0.64	0.16	29%	41%
Q21	Sep-05	469	1,006	47%	0.67	0.18	46%	0.64	0.15	29%	41%
Q22	Dec-05	586	1,286	46%	0.64	0.13	46%	0.64	0.13	29%	42%
Q23	Mar-06	464	926	50%	0.78	0.25	46%	0.64	0.11	29%	42%
Q24	Jun-06	419	904	46%	0.66	0.11	46%	0.65	0.10	29%	43%
Q25	Sep-06	494	1,064	46%	0.66	0.09	46%	0.65	0.08	29%	43%
Q26	Dec-06	525	1,261	42%	0.51	-0.08	46%	0.65	0.06	29%	44%
Q27	Mar-07	439	918	48%	0.71	0.10	46%	0.65	0.05	29%	45%
Q28	Jun-07	372	734	51%	0.79	0.17	46%	0.66	0.03	29%	45%
Q29	Sep-07	413	908	45%	0.64	-0.01	46%	0.66	0.01	29%	46%
Q30	Dec-07	359	766	47%	0.68	0.02	46%	0.66	0.00	29%	46%

Table C.2 Combined city routes Sunday patronage since introduction, benchmarked against Saturday patronage

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Index of patronage (set=100% at 4 quarters after introduction: Jun-01)		Ratio of route index to control index (set =100% at 4 quarters after introduction:Jun-01)
		Route	Control			
		Sun	Sat	Route %	Control %	
Zero	Jun-00	314	1,151	93%	121%	77%
Q1*	Sep-00	350	987	104%	104%	99%
Q2	Dec-00	483	1,267	143%	134%	107%
Q3	Mar-01	358	987	106%	104%	102%
Q4	Jun-01	338	948	100%	100%	100%
Q5	Sep-01	439	985	130%	104%	125%
Q6	Dec-01	558	1,371	165%	145%	114%
Q7	Mar-02	422	1,015	125%	107%	117%
Q8	Jun-02	333	869	99%	92%	108%
Q9	Sep-02	439	990	130%	104%	124%
Q10	Dec-02	671	1,415	199%	149%	133%
Q11	Mar-03	547	1,078	162%	114%	143%
Q12	Jun-03	490	1,183	145%	125%	116%
Q13	Sep-03	479	1,095	142%	116%	123%
Q14	Dec-03	643	1,369	190%	144%	132%
Q15	Mar-04	471	1,031	139%	109%	128%
Q16	Jun-04	419	1,104	124%	116%	106%
Q17	Sep-04	467	1,042	138%	110%	126%
Q18	Dec-04	549	1,203	163%	127%	128%
Q19	Mar-05	347	862	103%	91%	113%
Q20	Jun-05	448	1,036	133%	109%	122%
Q21	Sep-05	469	1,006	139%	106%	131%
Q22	Dec-05	586	1,286	174%	136%	128%
Q23	Mar-06	464	926	138%	98%	141%
Q24	Jun-06	419	904	124%	95%	130%
Q25	Sep-06	494	1,064	146%	112%	130%
Q26	Dec-06	525	1,261	155%	133%	117%
Q27	Mar-07	439	918	130%	97%	134%
Q28	Jun-07	372	734	110%	77%	142%
Q29	Sep-07	413	908	122%	96%	128%
Q30	Dec-07	359	766	106%	81%	132%

C3.2 Summary findings – combined city routes Sunday service enhancements

We conclude from table C.1 and figure C.4 that the elasticity was about 0.15 in the first quarter and then grew to 0.30–0.45 after a year and 0.35–0.55 after two years:

- The ‘flat’ BAU produced estimates of 0.44 after one year and 0.55 after two years. But these are most likely overestimates because they assume that, in the absence of the service change, there would have been no further growth in Sunday patronage relative to Saturday patronage.
- The ‘growth’ BAU produced estimates of 0.33 after one year and 0.35 after six quarters. But these are most likely underestimates because they assume that the pre-service change growth in Sunday patronage would have continued indefinitely for the next two years, which seems unlikely.

We note that the elasticities estimated using the ‘growth’ BAU scenario start dropping from about the sixth quarter onwards, and eventually reach zero after about 30 quarters. This is because the BAU ‘growth’ patronage level becomes higher than the patronage level actually observed (figure C.3).

Our conclusion from this assessment is that, beyond the first one to two years after the service increase, the weight of evidence is much more consistent with the ‘flat’ BAU scenario than the ‘growth’ scenario, while recognising that the 'flat' BAU scenario is likely to represent an upper bound in terms of the elasticity values. We therefore conclude that the best estimate elasticity values in this case are:

- approx 0.15 after first quarter
- approx 0.40 by the fourth quarter
- approx 0.50 by the eighth quarter
- approx 0.60 after four to five years.

Appendix D: Service elasticity assessments – Hamilton

D1 Introduction

This appendix focuses on the patronage growth observed after the introduction of new bus services in Hamilton (New Zealand):

- the CBD shuttle, introduced in April 2006
- the Orbiter, introduced in July 2006
- Sunday services on a range of routes, introduced in September 2008.

D2 Data sources

Environment Waikato provided us with monthly patronage data for these routes and for various control routes. The monthly patronage data was spilt into peak weekday patronage, off-peak weekday patronage, Saturday patronage and (where available) Sunday patronage.

We transformed the weekday patronage data by dividing it by the number of weekday in each month. Similarly, Saturday and Sunday patronage data was transformed by dividing it, respectively, by the number of Saturdays and Sundays in each month.

The control routes for analysis of the CBD shuttle and the Orbiter were the following:

- no. 5 – Chartwell
- no. 10 – Hillcrest
- no. 14 – Claudelands
- no. 30 – Northerner.

These control routes were selected on the basis that they are typical Hamilton service routes which have not experienced service changes over the relevant period, and have been largely unaffected by service changes on other routes. They were added together to create patronage across combined control routes.

D3 CBD shuttle

The CBD shuttle was introduced in April 2006 and is a free shuttle which connects key points in the central city via a loop. In August 2008, it was extended to connect with the Orbiter in Bridge Street.

The CBD shuttle operates on a 10-minute frequency from 0700–1800 hours weekdays and 0900–1300 hours Saturdays.

D3.1 Analyses – peak periods

Refer to figures D.1 and D.2 and table D.1.

Figure D.1 Peak CBD shuttle patronage trends since introduction, compared with control routes

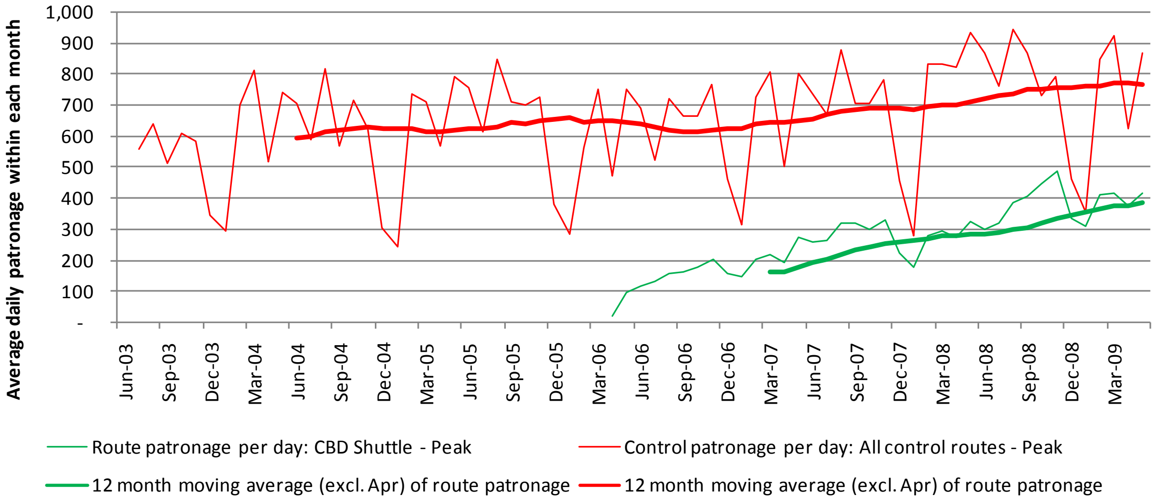
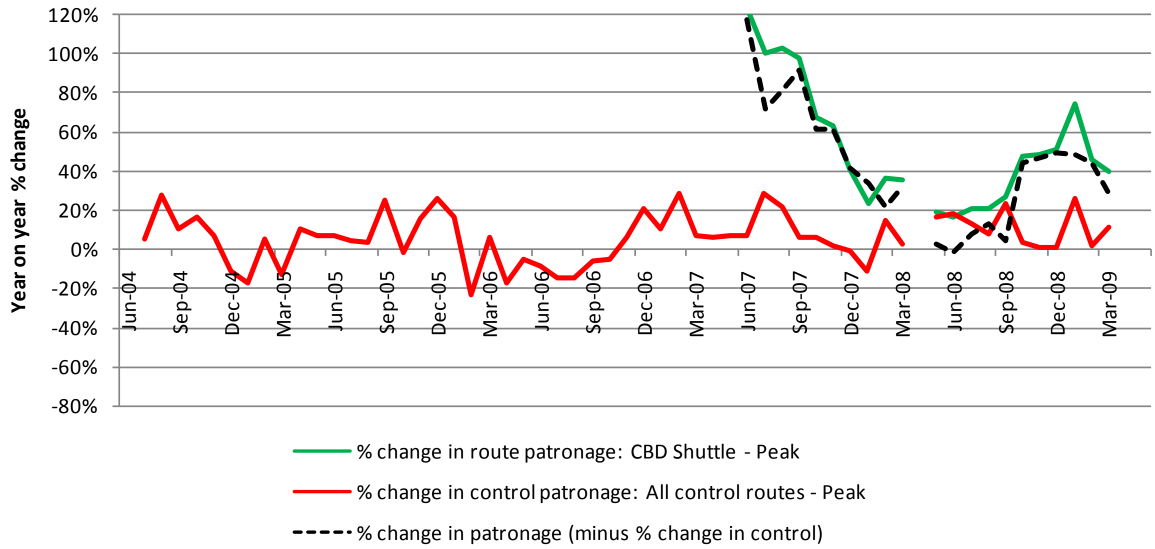


Figure D.2 Peak CBD shuttle patronage growth since introduction, compared with control routes



April 2008 and April 2009 data have been removed from figure D.1 to remove anomalistic growth patterns caused by the 2008 and 2009 V8 races in Hamilton. Free buses operated Thursday to Sunday in 2008 and Friday to Sunday in 2009 and this caused an unusual blip in patronage.

Table D.1 Peak CBD shuttle patronage since introduction, benchmarked against control routes

Number of quarters following introduction	Date at which quarter ends:	Average patronage per day		Index of patronage (set=100% at 4 quarters after introduction: Mar-07)		Ratio of route index to control index (set =100% at 4 quarters after introduction:Mar-07)
		Route	Control			
		CBD Shuttle - Peak	All control routes - Peak	Route %	Control %	
Zero	Mar-06	-	534	0%	87%	0%
Q1*	Jun-06	106	720	56%	117%	48%
Q2	Sep-06	150	636	79%	103%	77%
Q3	Dec-06	179	630	94%	103%	92%
Q4	Mar-07	190	615	100%	100%	100%
Q5	Jun-07	267	767	141%	125%	113%
Q6	Sep-07	301	749	159%	122%	130%
Q7	Dec-07	283	648	149%	105%	142%
Q8	Mar-08	252	646	133%	105%	126%
Q9	Jun-08	314	899	166%	146%	113%
Q10**	Sep-08	372	855	196%	139%	141%
Q11	Dec-08	421	661	222%	108%	206%
Q12	Mar-09	378	707	199%	115%	173%

* Note: service introduced in Apr-06

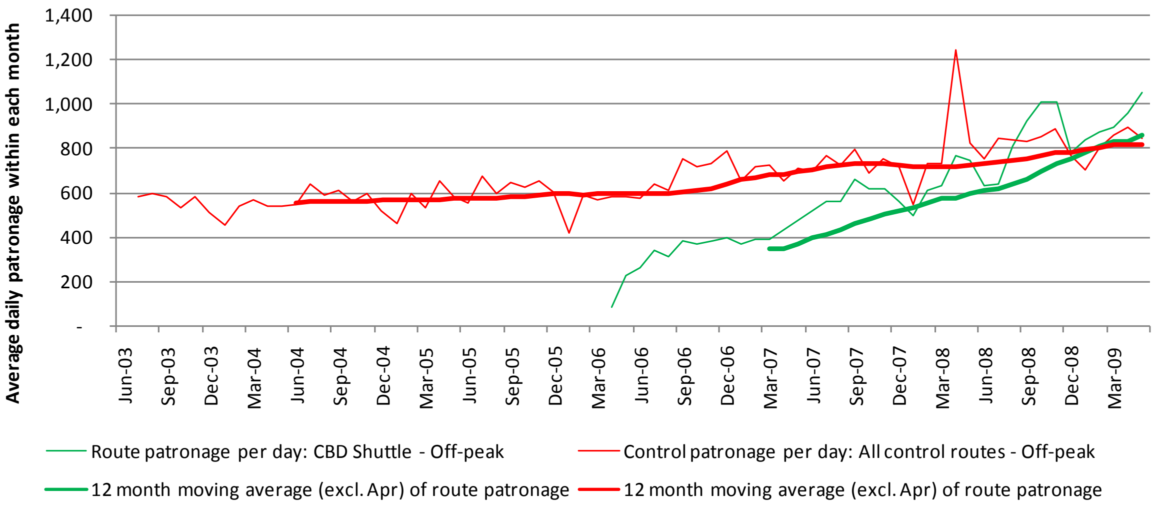
** CDB Shuttle connected with Orbiter in August 2008 (ie Q10)

Figure D.2 and table D.1 both show that patronage growth on the CBD shuttle appeared to 'saturate' around early 2008, which was about two years after introduction. However, the CBD shuttle connected with the Orbiter in August 2008 and this appears to have triggered another growth-spurt in patronage.

D3.2 Analyses – off-peak periods

Refer to figures D.3 and D.4 and table D.2.

Figure D.3 Off-peak CBD shuttle patronage trends since introduction, compared with control routes



A clear 'spike' can be seen in April 2008 on the control route, showing the impact of the 2008 V8 races. This anomaly was removed from the moving average and other analyses.

Figure D.4 Off-peak CBD shuttle patronage growth since introduction, compared with control route growth

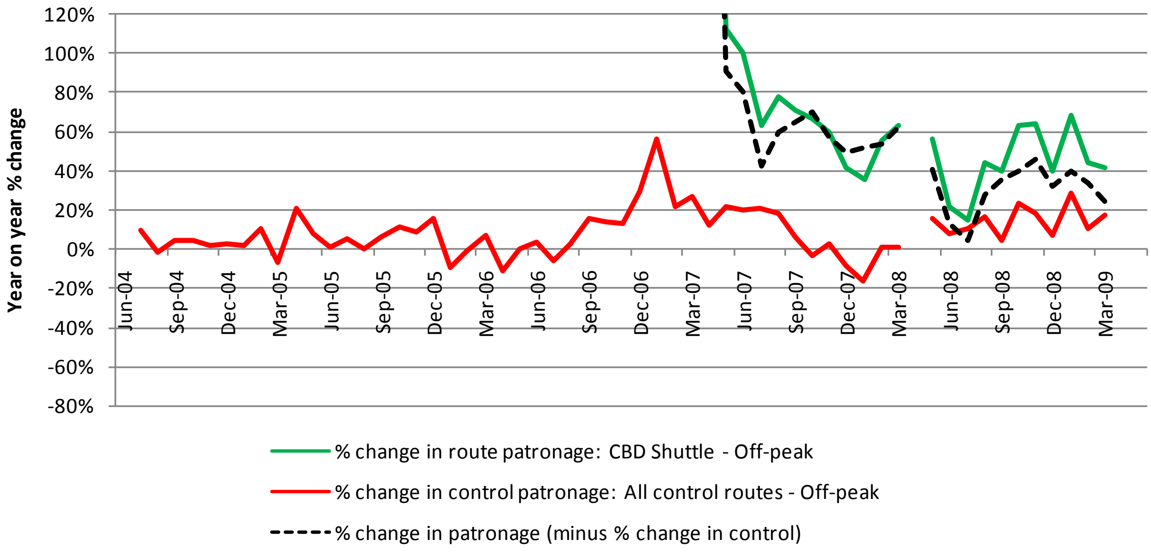


Table D.2 Off-peak CBD shuttle patronage since introduction, benchmarked against control routes

Number of quarters following introduction	Date at which quarter ends:	Average patronage per day: Route – CBD Shuttle - Off-peak	Average patronage per day: Control – All control routes - Off-peak	Index of patronage (set=100% at 4 quarters after introduction: Mar-07): Route %	Index of patronage (set=100% at 4 quarters after introduction: Mar-07): Control %	Ratio of route index to control index (set =100% at 4 quarters after introduction:Mar-07)
Zero	Mar-06	-	528	0%	75%	0%
Q1*	Jun-06	243	583	64%	83%	76%
Q2	Sep-06	349	668	91%	95%	96%
Q3	Dec-06	385	747	101%	107%	94%
Q4	Mar-07	382	701	100%	100%	100%
Q5	Jun-07	501	705	131%	101%	130%
Q6	Sep-07	595	764	156%	109%	143%
Q7	Dec-07	598	722	156%	103%	152%
Q8	Mar-08	581	672	152%	96%	159%
Q9	Jun-08	692	789	181%	113%	161%
Q10**	Sep-08	794	842	208%	120%	173%
Q11	Dec-08	934	838	244%	120%	204%
Q12	Mar-09	871	792	228%	113%	202%

* Note: service introduced in Apr-06
** CDB Shuttle connected with Orbiter in August 2008 (ie Q10)

Again, there is evidence from figure D.4 and table D.2 that patronage growth on the CBD shuttle appeared to saturate around the first half of 2008, which was about eight quarters after introduction. Again, there was another growth spurt following connection with the Orbiter in August 2008.

D3.3 Analyses – Saturdays

Refer to figures D.5 and D.6 and table D.3.

Figure D.5 Saturday CBD shuttle patronage trends since introduction, compared with control routes

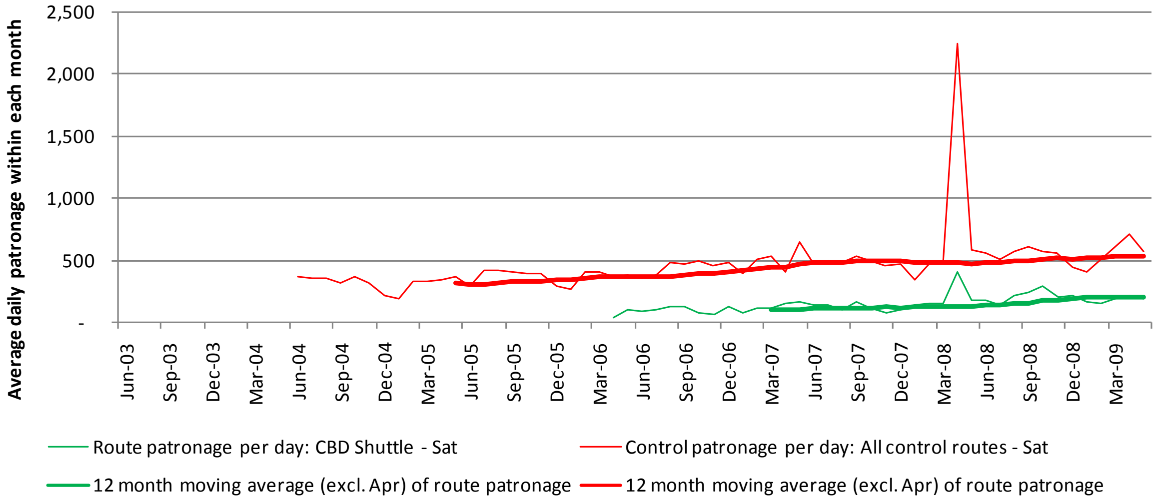


Figure D.5 illustrates the phenomenal rise in Saturday patronage on both the shuttle and the control routes during the month of the April 2008 V8 races in Hamilton.

Figure D.6 Saturday CBD shuttle patronage growth since introduction, compared with control routes growth

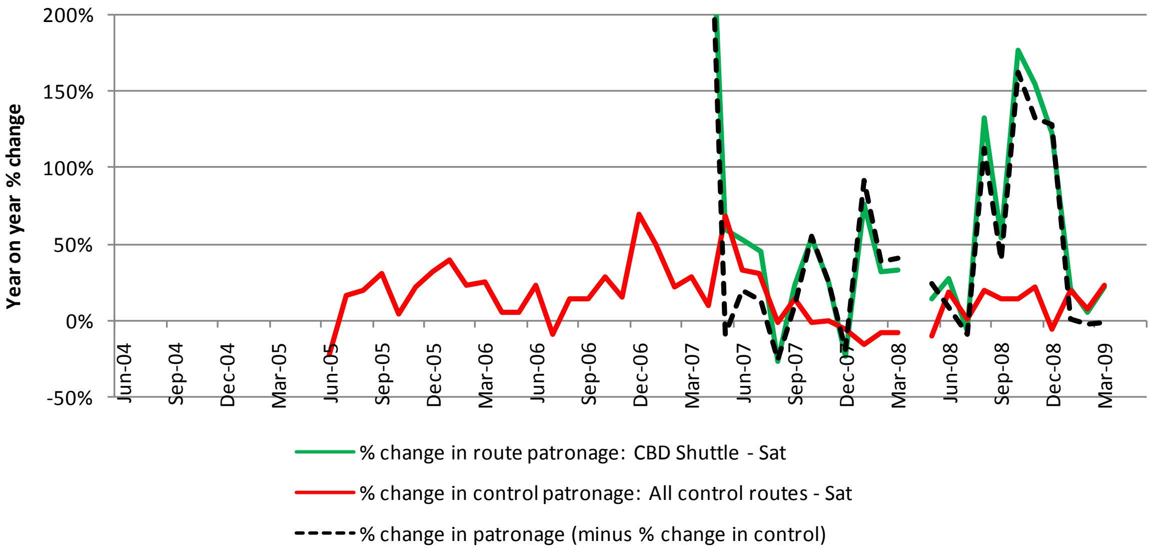


Figure D.6 and table D.3 suggest that the impact of the introduction of the CBD shuttle on Saturday patronage was characterised by rapid growth during the initial quarters and relatively immediate saturation (compared to peak and off-peak weekly patronage).

The connection with the Orbiter in August 2008 also triggered rapid growth followed by relatively immediate saturation.

Table D.3 Saturday CBD shuttle patronage since introduction, benchmarked against control routes

Number of quarters following introduction	Date at which quarter ends:	Average patronage per day		Index of patronage (set=100% at 4 quarters after introduction: Mar-07)		Ratio of route index to control index (set =100% at 4 quarters after introduction:Mar-07)
		Route	Control			
		CBD Shuttle - Sat	All control routes - Sat	Route %	Control %	
Zero	Mar-06	-	360	0%	76%	0%
Q1*	Jun-06	96	368	95%	78%	123%
Q2	Sep-06	118	440	118%	93%	127%
Q3	Dec-06	87	479	87%	101%	86%
Q4	Mar-07	100	474	100%	100%	100%
Q5	Jun-07	150	558	150%	118%	127%
Q6	Sep-07	132	501	132%	106%	125%
Q7	Dec-07	96	469	95%	99%	96%
Q8	Mar-08	144	430	144%	91%	159%
Q9	Jun-08	182	572	181%	121%	150%
Q10**	Sep-08	200	562	199%	118%	168%
Q11	Dec-08	242	521	241%	110%	219%
Q12	Mar-09	168	504	168%	106%	158%

* Note: service introduced in Apr-06
** CDB Shuttle connected with Orbiter in August 2008 (ie Q10)

D3.4 Summary findings – CBD shuttle

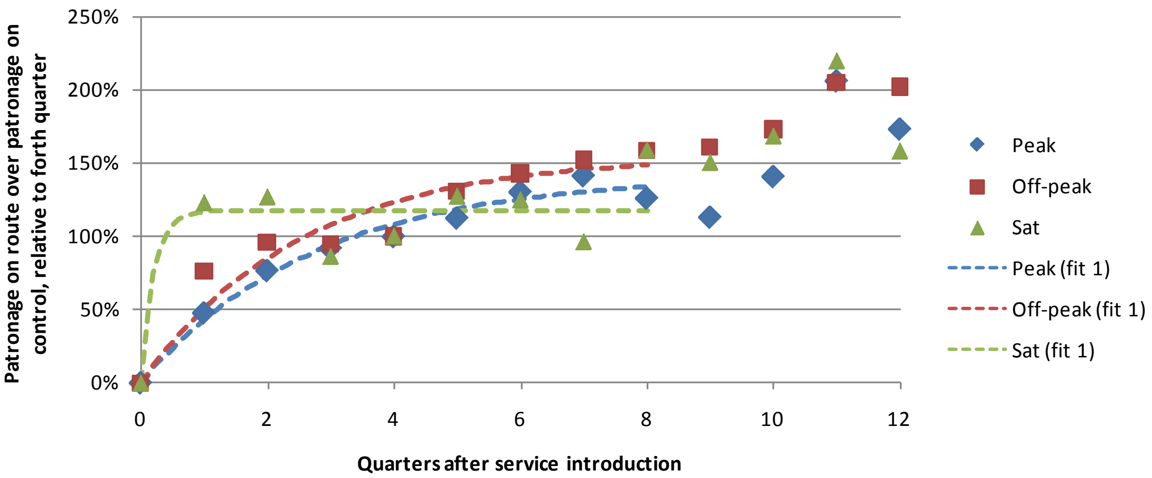
Figure D.1 shows that peak weekday patronage on the CBD shuttle reached about 400 customers a day by early 2009, compared with about 800 customers a day for the four control routes combined.

Figure D.3 shows that off-peak weekday patronage on the CBD shuttle exceeded 1000 customers a day in early 2009, which exceeded the 800 customers a day on the four control routes.

Figure D.5 shows that weekday patronage on the CBD shuttle was about 250 customers a day, compared with 500 customers a day for the four control routes.

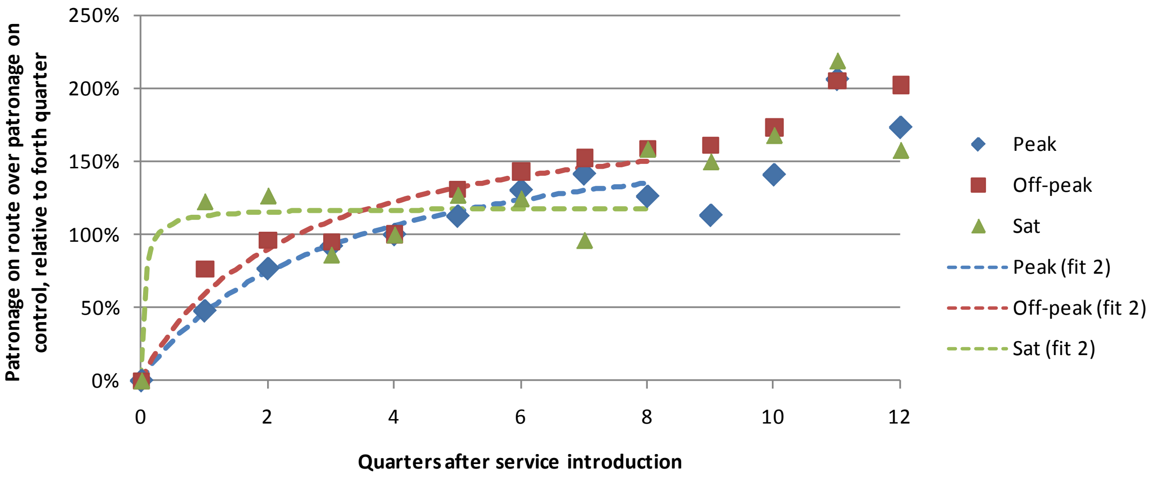
Figures D.7 and D.8 illustrate the level of patronage (peak, off-peak and Saturday) on the CBD shuttle, relative to the four control routes, for the nine quarters following introduction. There is a suggestion that 'saturation' is reached after about eight quarters or two years, although this is not conclusive (longer-term trends could not be established, given the extension of the service in the 10th quarter).

Figure D.7 Route patronage over control patronage



Fitted using 'two-parameter exponential': h=a(1-exp(-b*t))

Figure D.8 Route patronage over control patronage



Fitted using 'two-parameter saturation growth': h=a*t/(b+t)

There is little to choose between the alternative growth curves ('exponential' and 'saturation') in figures D.7 and D.8 in terms of their fit to the observed data.

Patronage on the CBD shuttle grew rapidly for the first year after introduction, exceeding growth on the control routes. However, growth on the CBD shuttle continued to exceed growth on the control routes for another year, suggesting that it takes at least two years for an introduced route to reach 'saturation'.

There was a further growth spurt following the connection of the CBD shuttle with the Orbiter in August 2008.

Interestingly, Saturday patronage seemed to exhibit a relatively more rapid response to both introduction and connection with the Orbiter.

D4 The Orbiter

The Orbiter was introduced in July 2006 and 'orbits' around Hamilton, linking together shopping centres, tertiary campuses and the hospital.

The Orbiter runs in both directions on weekdays every 15 minutes from 0615–1800 hours and every 35 minutes from 1800–2200 hours. Services run every 35 minutes from 06.15–2000 hours Saturdays, Sundays and public holidays.

D4.1 Analyses – peak periods

Refer to figures D.9 and D.10 and table D.4.

Figure D.9 Peak Orbiter patronage trends since introduction, compared with control routes

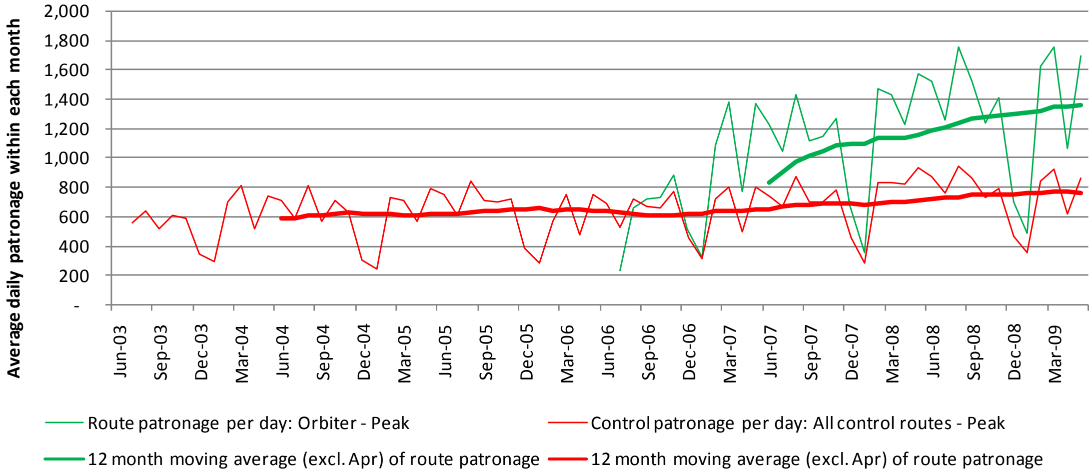


Figure D.10 Peak Orbiter patronage growth since introduction, compared with control routes

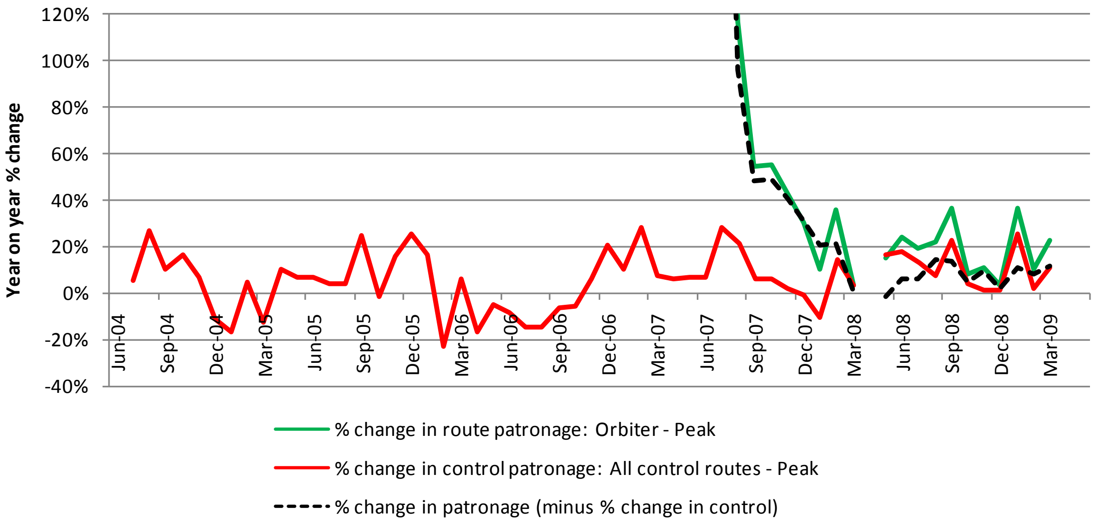


Table D.4 Peak Orbiter patronage since introduction, benchmarked against control routes

Number of quarters following introduction	Date at which quarter ends:	Average patronage per day		Index of patronage (set=100% at 4 quarters after introduction: Jun-07)		Ratio of route index to control index (set =100% at 4 quarters after introduction:Jun-07)
		Route	Control			
		Orbiter - Peak	All control routes - Peak	Route %	Control %	
Zero	Jun-06	-	720	0%	94%	0%
Q1*	Sep-06	539	636	42%	83%	50%
Q2	Dec-06	714	630	55%	82%	67%
Q3	Mar-07	929	615	72%	80%	89%
Q4	Jun-07	1,298	767	100%	100%	100%
Q5	Sep-07	1,199	749	92%	98%	95%
Q6	Dec-07	1,029	648	79%	84%	94%
Q7	Mar-08	1,086	646	84%	84%	99%
Q8	Jun-08	1,550	899	119%	117%	102%
Q9**	Sep-08	1,509	855	116%	111%	104%
Q10	Dec-08	1,117	661	86%	86%	100%
Q11	Mar-09	1,288	707	99%	92%	108%
Q12	May-09	1,723	893	133%	116%	114%

* Note: service introduced in Jul-06
** CDB Shuttle connected with Orbiter in August 2008 (ie Q9)
Orbiter started travelling through the Hospital Campus September 2008 (ie Q9)

D4.2 Analyses – off-peak periods

Refer to figures D.11 and D.12 and table D.5.

Figure D.11 Off-peak Orbiter patronage trends since introduction, compared with control routes

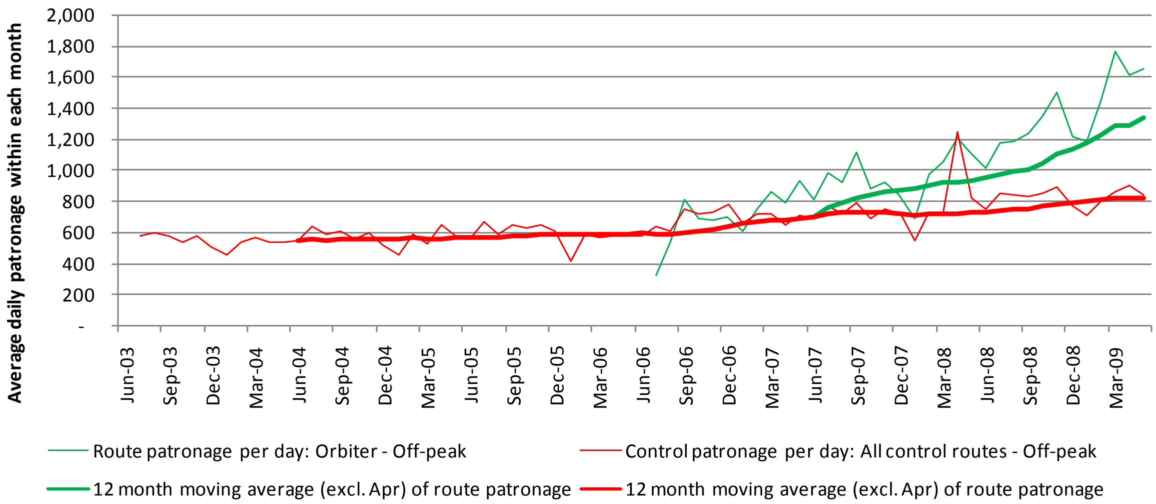


Figure D.12 Off-peak Orbiter patronage growth since introduction, compared with control routes

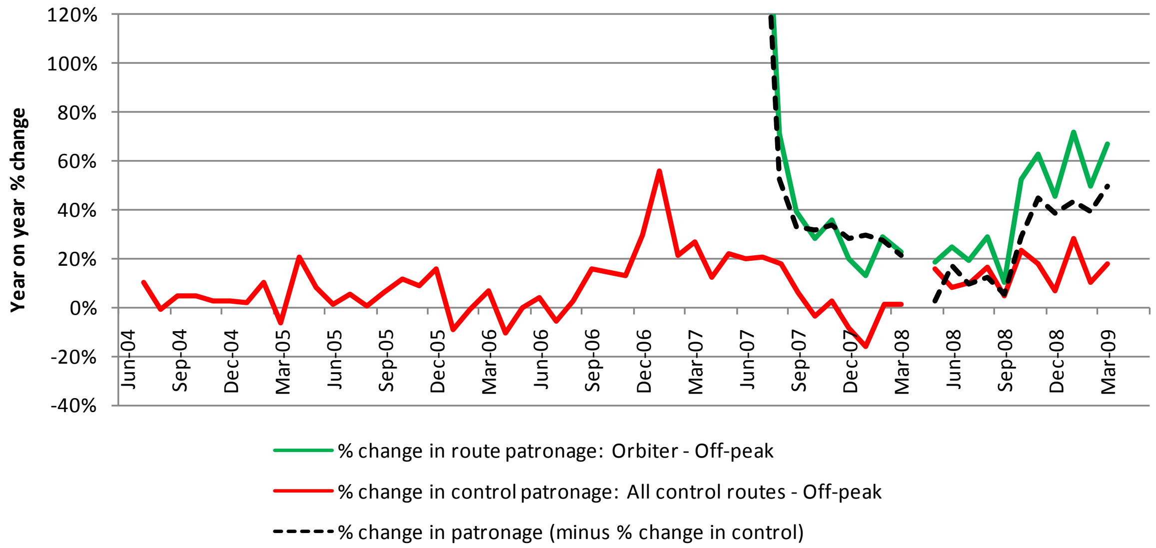


Table D.5 Off-peak Orbiter patronage since introduction, benchmarked against control routes

Number of quarters following introduction	Date at which quarter ends:	Average patronage per day		Index of patronage (set=100% at 4 quarters after introduction: Jun-07)		Ratio of route index to control index (set =100% at 4 quarters after introduction:Jun-07)
		Route	Control			
		Orbiter - Peak	All control routes - Peak	Route %	Control %	
Zero	Jun-06	-	720	0%	94%	0%
Q1*	Sep-06	539	636	42%	83%	50%
Q2	Dec-06	714	630	55%	82%	67%
Q3	Mar-07	929	615	72%	80%	89%
Q4	Jun-07	1,298	767	100%	100%	100%
Q5	Sep-07	1,199	749	92%	98%	95%
Q6	Dec-07	1,029	648	79%	84%	94%
Q7	Mar-08	1,086	646	84%	84%	99%
Q8	Jun-08	1,550	899	119%	117%	102%
Q9**	Sep-08	1,509	855	116%	111%	104%
Q10	Dec-08	1,117	661	86%	86%	100%
Q11	Mar-09	1,288	707	99%	92%	108%
Q12	May-09	1,723	893	133%	116%	114%

* Note: service introduced in Jul-06
** CDB Shuttle connected with Orbiter in August 2008 (ie Q9)
Orbiter started travelling through the Hospital Campus September 2008 (ie Q9)

D4.3 Analyses – Saturdays

Refer to figures D.13 and D.14 and table D.6.

Figure D.13 Saturday Orbiter patronage trends since introduction, compared with control routes

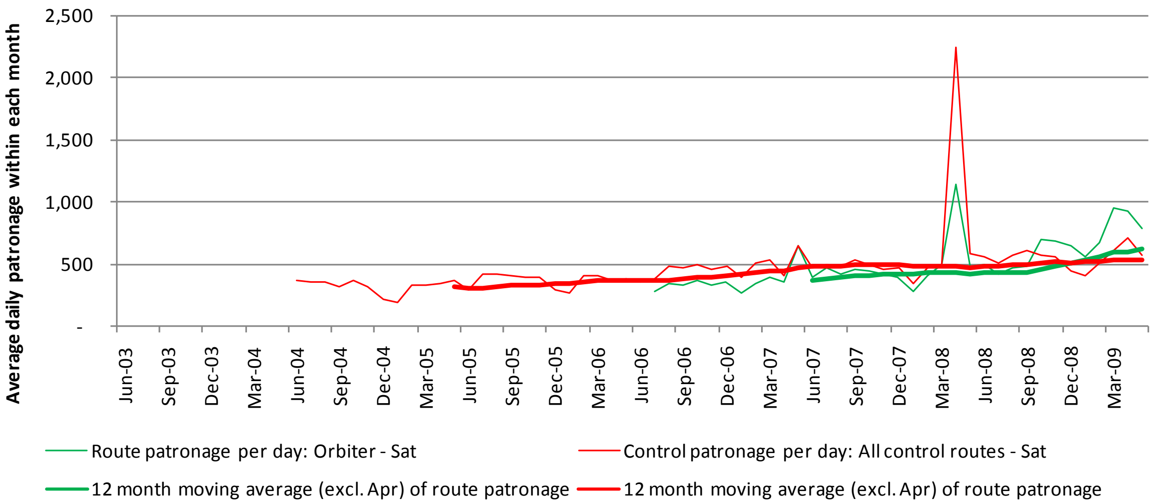


Figure D.14 Saturday Orbiter patronage growth since introduction, compared with control routes

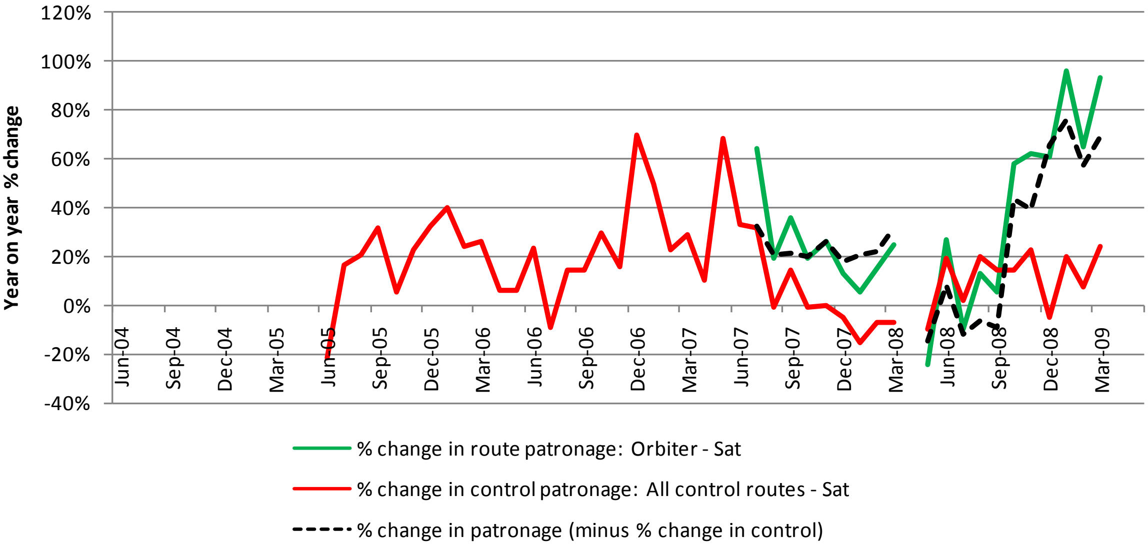


Table D.6 Saturday Orbiter patronage since introduction, benchmarked against control routes

Number of quarters following introduction	Date at which quarter ends:	Average patronage per day		Index of patronage (set=100% at 4 quarters after introduction: Jun-07)		Ratio of route index to control index (set =100% at 4 quarters after introduction:Jun-07)
		Route	Control			
		Orbiter - Sat	All control routes - Sat	Route %	Control %	
Zero	Jun-06	-	368	0%	66%	0%
Q1*	Sep-06	323	440	63%	79%	79%
Q2	Dec-06	353	479	68%	86%	80%
Q3	Mar-07	338	474	65%	85%	77%
Q4	Jun-07	517	558	100%	100%	100%
Q5	Sep-07	448	501	87%	90%	97%
Q6	Dec-07	422	469	82%	84%	97%
Q7	Mar-08	394	430	76%	77%	99%
Q8	Jun-08	494	572	96%	102%	93%
Q9**	Sep-08	461	562	89%	101%	89%
Q10	Dec-08	678	521	131%	93%	140%
Q11	Mar-09	728	504	141%	90%	156%
Q12	May-09	871	588	169%	105%	160%

* Note: service introduced in Jul-06

** CDB Shuttle connected with Orbiter in August 2008 (ie Q9)
Orbiter started travelling through the Hospital Campus September 2008 (ie Q9)

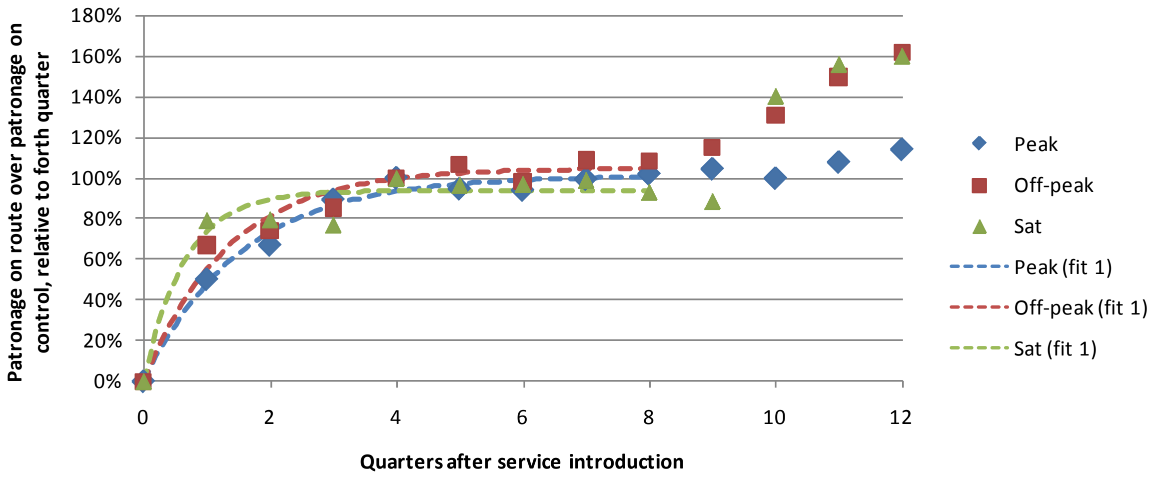
D4.4 Summary findings – Orbiter

Figure D.10 shows that weekday peak patronage on the Orbiter reached 1400 customers a day in early 2009, which exceeds the four control routes which carried together 800 customers a day. Weekday off-peak patronage on the Orbiter, shown in figure D.12, was roughly the same: 1400 customers a day for the Orbiter and 800 customers a day for the control routes.

Figure D.13 shows that the Saturday Orbiter carried 500 customers a day in early 2009, while the four control routes carried about the same number of customers.

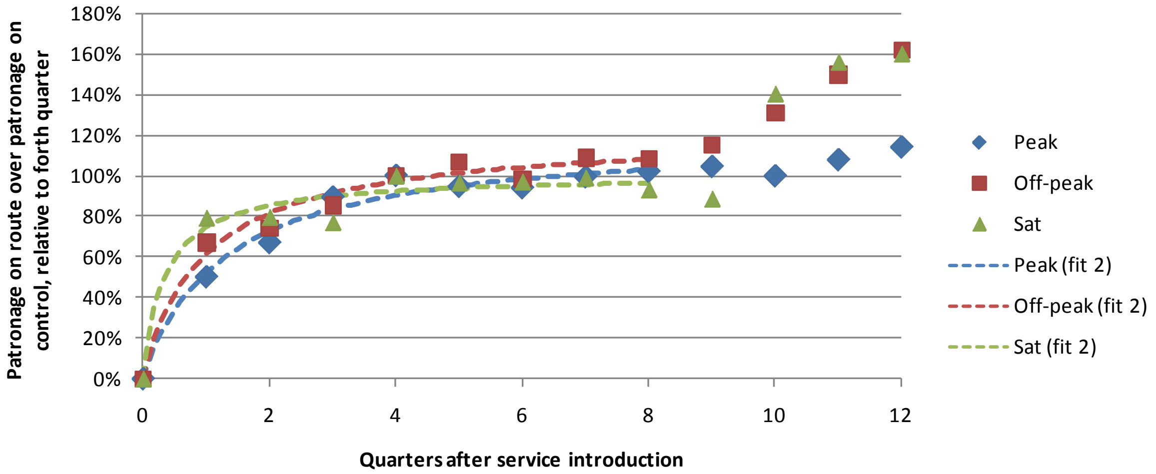
Figures D.15 and D.16 illustrate the level of patronage (peak, off-peak and Saturday) on the Orbiter, relative to the four control routes, for the eight quarters following introduction.

Figure D.15 Route patronage over control patronage



Fitted using 'two-parameter exponential': h=a(1-exp(-b*t))

Figure D.16 Route patronage over control patronage



Fitted using 'two-parameter saturation growth': h=a*t/(b+t)

There is little to choose between the alternative growth curves ('exponential' and 'saturation') in figures D.15 and D.16 in terms of their fit to the observed data, although the 'saturation' curve gives a slightly better fit. (The 'exponential' curve assumes that saturation has occurred after eight quarters, whereas the 'saturation' curve indicates continuing slow growth.)

The Orbiter data indicates that growth is close to saturation after four quarters, although there is evidence of some continuing slow growth in the second year. We note that this is a quicker saturation than was observed for the CBD shuttle patronage, which continued to exhibit faster growth than the control patronage for about eight quarters.

The relative rapidity of response to the introduction of the Orbiter service follows a similar pattern to the CBD shuttle, in the sense that Saturday patronage responds very rapidly, followed by off-peak patronage, while the response of peak patronage to a service introduction appears to be more drawn out.

D5 Sunday services

D5.1 Analyses

Sunday services were introduced in September 2008, on a selection of routes.

Refer to figure D.17 and table D.7.

Figure D.17 Sunday service patronage trends since introduction, compared with Saturday patronage

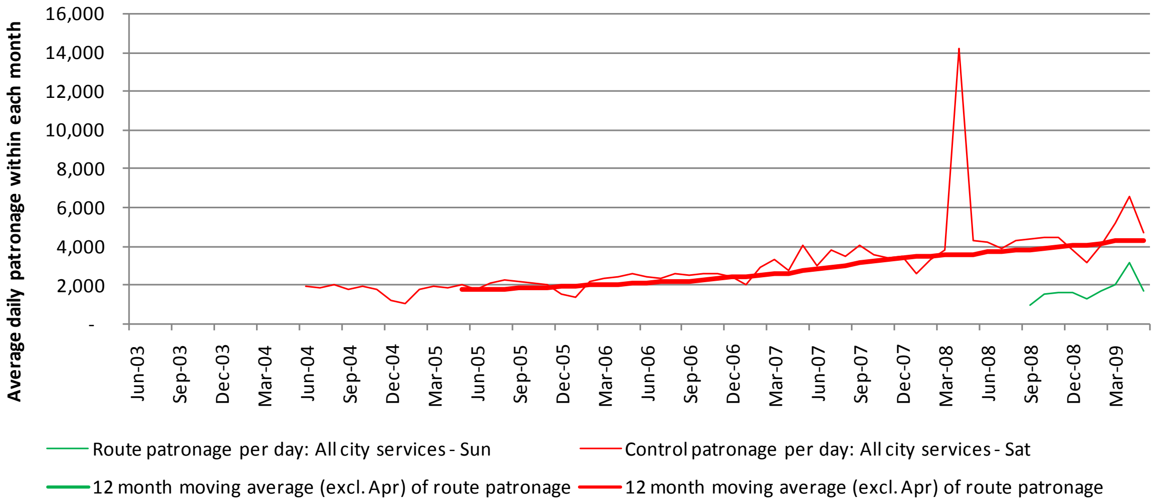


Table D.7 Sunday service patronage since introduction, benchmarked against Saturday patronage

Number of quarters following introduction	Date at which quarter ends:	Average patronage per day		Index of patronage (set=100% at 3 quarters after introduction: May-09)		Ratio of route index to control index (set =100% at 3 quarters after introduction:May-09)
		Route	Control			
		All city services - Sun	All city services - Sat	Route %	Control %	
Zero	Aug-08	-	4,187	0%	84%	0%
Q1*	Nov-08	1,413	4,477	75%	90%	83%
Q2	Feb-09	1,553	3,714	82%	75%	110%
Q3	May-09	1,886	4,971	100%	100%	100%

* Note: service introduced in Sep-08

D5.2 Summary findings – Sunday services

Since introduction, it has taken approximately three quarters for patronage on the Sunday services to reach about 2000 customers per day, which is roughly half of the 4000 customers per day carried on all Saturday services. However, it should be noted that of the 27 routes operating on Saturdays, only 12 of these operate on Sundays.

On the 12 Sunday routes, services operate on weekdays, Saturdays, Sundays and public holidays. Furthermore, the timetables for Saturdays are identical to the timetables for Sundays; therefore, any differences between Saturday and Sunday patronage cannot be attributed to lower frequency.

A comparison of patronage on Sunday and Saturday routes is shown in tables D.8 to D.10. We see that Sunday patronage on these routes is typically 65% to 70% of Saturday patronage. We also see that the Sunday : Saturday patronage ratio appears to have stabilised after the initial four quarters of growth.

Table D.8 Sunday service patronage (since introduction) as a ratio of Saturday patronage

Month	Months since introduction of Sunday services:	Ratio of Sunday patronage to Saturday patronage on "Key Routes": Orbiter	1. Pukete	2. Silverdale	3. Dinsdale	4. Flagstaff	7. Glenview	9.Nawton	11. Fairfield	13. University	16. Rototuna	17. Hamilton East Uni	18. Te Rapa	All "Key Routes"
Aug-08	Zero	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sep-08	Month 1	70%	19%	37%	33%	35%	62%	19%	55%	17%	37%	28%	22%	39%
Oct-08	Month 2	60%	40%	51%	54%	65%	122%	65%	69%	42%	56%	58%	44%	58%
Nov-08	Month 3	61%	45%	60%	53%	60%	112%	61%	63%	63%	51%	60%	42%	59%
Dec-08	Month 4	66%	51%	61%	72%	78%	156%	75%	64%	85%	61%	65%	58%	69%
Jan-09	Month 5	62%	49%	59%	72%	76%	104%	70%	61%	74%	55%	66%	58%	65%
Feb-09	Month 6	66%	49%	74%	59%	78%	103%	68%	75%	63%	63%	58%	53%	66%
Mar-09	Month 7	58%	50%	66%	62%	48%	104%	62%	64%	56%	57%	58%	55%	60%
Apr-09	Month 8	58%	66%	76%	72%	38%	120%	73%	69%	76%	64%	72%	82%	70%
May-09	Month 9	57%	53%	63%	66%	67%	116%	57%	55%	56%	61%	56%	41%	59%

* "Key Routes" are services (with relatively high passenger numbers) that operate on weekdays, Saturdays, Sundays and public holidays

Table D.9 Average passengers per trip on Sunday services, since introduction of Sunday services

Month	Months since introduction of Sunday services:	Average passengers per trip (on Sundays) on "Key Routes" since the introduction of Sunday services: Orbiter	1. Pukete	2. Silverdale	3. Dinsdale	4. Flagstaff	7. Glenview	9.Nawton	11. Fairfield	13. University	16. Rototuna	17. Hamilton East Uni	18. Te Rapa	All "Key Routes"
Aug-08	Zero	0	0	0	0	0	0	0	0	0	0	0	0	0
Sep-08	Month 1	14	3	6	6	5	6	3	8	3	9	5	4	7
Oct-08	Month 2	18	5	11	9	7	10	9	9	7	14	10	7	10
Nov-08	Month 3	17	6	13	10	8	11	8	9	8	14	10	7	11
Dec-08	Month 4	18	6	10	11	8	12	9	10	8	15	8	8	11
Jan-09	Month 5	14	4	9	9	7	7	6	6	7	10	8	6	8
Feb-09	Month 6	18	5	13	11	10	9	9	9	9	15	11	8	11
Mar-09	Month 7	23	7	13	14	7	12	10	9	10	18	15	9	13
Apr-09	Month 8	23	13	24	22	9	22	18	19	18	32	22	20	20
May-09	Month 9	19	6	11	13	7	10	9	8	10	17	13	8	11

* "Key Routes" are services (with relatively high passenger numbers) that operate on weekdays, Saturdays, Sundays and public holidays

Table D.10 Average passengers per trip on Saturday services, since introduction of Sunday services

Month	Months since introduction of Sunday services:	Average passengers per trip (on Saturdays) on "Key Routes" since the introduction of Sunday services: Orbiter	1. Pukete	2. Silverdale	3. Dinsdale	4. Flagstaff	7. Glenview	9.Nawton	11. Fairfield	13. University	16. Rototuna	17. Hamilton East Uni	18. Te Rapa	All "Key Routes"
Aug-08	Zero	20	13	20	17	14	10	13	15	14	24	18	19	17
Sep-08	Month 1	20	14	17	19	13	10	14	15	16	25	17	16	17
Oct-08	Month 2	29	13	23	17	11	8	14	13	17	26	18	15	18
Nov-08	Month 3	29	14	21	19	13	10	14	14	13	26	17	18	18
Dec-08	Month 4	27	11	17	15	10	7	12	15	9	25	13	15	15
Jan-09	Month 5	23	9	16	13	9	7	9	10	10	19	12	11	13
Feb-09	Month 6	28	10	17	18	12	9	14	12	15	24	19	15	17
Mar-09	Month 7	40	13	20	22	15	11	17	15	18	31	25	17	22
Apr-09	Month 8	39	20	31	31	25	19	25	28	24	50	30	24	29
May-09	Month 9	33	11	18	19	11	8	15	15	18	27	22	19	19

* "Key Routes" are services (with relatively high passenger numbers) that operate on weekdays, Saturdays, Sundays and public holidays

Appendix E: Service elasticity assessments – Perth

E1 Introduction

This appendix focuses on the patronage impacts of evening service frequency improvements to feeder buses to Perth's Northern Suburbs rail line.

Discussions were held with the Western Australia Public Transport Authority (PTA) to identify bus service frequency changes in Perth since 2001 (the start of PTA's available detailed patronage data series) that would be suitable for the derivation of service frequency elasticities. There were few appropriate cases warranting consideration for project purposes. PTA identified several cases of bus service enhancements for services linked to the railway system: three of these cases involved combined rail and bus service changes relating to the introduction of the Mandurah rail line, and were not therefore suitable for project purposes.

The other cases suitable for project purposes involved weekday PM/evening frequency improvements to the feeder bus services to the Northern Suburbs rail line, on 24 August 2008 and 24 October 2008. Feeder services to/from 5 stations were involved: Whitfords, Warwick, Stirling, Joondalup and Clarkson.

Frequency improvements were made on these services in the weekday 1500–1800 period and the weekday 1800–2100 period. The frequency changes for the earlier period were relatively small (eg 10%–15% increases in frequency) which made deriving statistically significant results difficult. Therefore, our analyses below focused on the 1800–2100 period, which experienced more dramatic service enhancements (ie 30%–80% increases in frequency).

Further details on the nature of the service changes are shown in tables E.1a and E.1b:

Table 1b shows that the most significant changes in service levels were in the 1900–2000 period, particularly for outbound services. However, 'shoulder' services between 1800 and 1900 hours and 2000 and 2100 hours were captured in the analysis as we judged that they would be affected by the more frequent services between 1900 and 2000 hours.

E2 Data sources

PTA provided patronage data by hour by route for each week in the period July 2007 to April 2009. They also provided details of the number of bus trips operated within each hourly period.

As noted above, our analyses focused on the service and patronage changes in the weekday 1800–2100 period.

As 'control' routes, we used the patronage on the same route over the weekday 0900–1500 period: these services were not changed over the analysis period concerned.

E3 Graphical analyses

The graphs (at the end of this appendix) show the trends in patronage and service levels on each of the five routes (1800–2100) and the corresponding control routes:

- Whitfords figures E.1a/E.1b
- Warwick figures E.2a/e.2b

- Stirling figures E.3a/E.3b
- Joondalup figures E.4a/E.4b
- Clarkson figures E.5a/E.5b

Table E.1a Summary of service changes to feeder buses to the Northern Suburbs line (weekdays 1800–2100)

Locality	To locality		From locality		Both directions		% change in no. of services
	Initial headway	Final headway	Initial headway	Final headway	Initial headway	Final headway	
Whitfords	51 min	29 min	55 min	45 min	53 min	33 min	58%
Warwick	64 min	32 min	77 min	60 min	68 min	38 min	78%
Stirling	51 min	30 min	60 min	47 min	54 min	35 min	56%
Joondalup	64 min	37 min	60 min	60 min	62 min	43 min	44%
Clarkson	38 min	26 min	51 min	51 min	42 min	32 min	30%

Table E.1b – Detail on service changes to feeder buses to the Northern Suburbs line

Locality	Hour	To locality		From locality		Dates of service changes
		Initial headway	Final headway	Initial headway	Final headway	
Whitfords	6pm to 7pm	32 min	19 min	48 min	34 min	24 August 2008 12 October 2008
	7pm to 8pm	120 min	46 min	60 min	48 min	
	8pm to 9pm	60 min	60 min	60 min	60 min	
Warwick	6pm to 7pm	40 min	21 min	100 min	60 min	24 August 2008 12 October 2008
	7pm to 8pm	210 min	60 min	60 min	60 min	
	8pm to 9pm	60 min	60 min	60 min	60 min	
Stirling	6pm to 7pm	43 min	23 min	50 min	38 min	12 October 2008
	7pm to 8pm	80 min	40 min	120 min	60 min	
	8pm to 9pm	60 min	60 min	60 min	60 min	
Joondalup	6pm to 7pm	47 min	26 min	60 min	60 min	12 October 2008
	7pm to 8pm	105 min	53 min	60 min	60 min	
	8pm to 9pm	60 min	60 min	60 min	60 min	
Clarkson	6pm to 7pm	22 min	20 min	40 min	40 min	12 October 2008
	7pm to 8pm	80 min	27 min	60 min	60 min	
	8pm to 9pm	60 min	60 min	60 min	60 min	

Each set of graphs shows, on a weekly basis:

- Average weekly numbers of bus trips and patronage for the services in question (1800–2100), and 52 week moving averages.
- Year-on-year changes in weekly numbers of bus trips and in patronage for the services in question (1800–2100) and the control (0900–1500).

The graphs show the (generally) clear relationships between the changes in service levels and in patronage, after adjustment for the control patronage changes (especially on the (b) graphs).

E4 Econometric analyses

Table E.2 (following) shows the results of econometric analyses of the patronage data. These econometric analyses estimated the impact of the service enhancements on patronage levels.

Most of the elasticity estimates obtained are significant (different from zero) at the 1% significance level at least. The best estimates in these cases all lie in the range 0.26 to 0.87, and mostly in the range 0.3 to 0.7. This is very consistent with most other evidence on short-run bus service elasticities.

The initial models are labelled model A and model B in table E.2. These models attribute most patronage growth to service enhancements. However, this assumption is most likely inaccurate because other explanatory variables are likely to contribute to patronage growth such as population growth and petrol prices. Therefore, the estimates produced by model A and model be are relatively less accurate and will generally be overestimates.

Model C and model D were introduced to address the problems described above. These models took 1800–2100 patronage growth rates and subtracted interpeak growth rates (0900–1500) on the same services, for the same week, to create a new dependent variable. The idea is that factors such as population growth and petrol price changes will have a similar impact on the inter-peak so this transformation will remove the effect of these variables from the new dependent variable.

The results of this method are as anticipated: the elasticities are much lower for model C and model D but generally still statistically significant. In the case of Clarkson there was no evidence that the service enhancements had any significant impact on patronage.

However, the elasticities shown for model C and model D in table E.2 still need to be interpreted with some caution, because the underlying assumption is that patronage growth on the services in question (early evening) would have been the same as the patronage growth trends on the control (inter-peak) services, in the absence of service enhancements.

Choosing between model C and model D is difficult. However, we have doubts about model C which led us to adopt model D as the preferred model. Model C employs a time trend for underlying growth of the dependent variable (patronage growth minus control growth) but we have reservations as to whether this underlying growth can be calculated accurately given the period of data available (between 6 and 12 weeks).

We note that the use of the inter-peak as a control does appear to have worked more effectively for certain routes: ie Whitfords, Stirling and Clarkson. For these, routes, the dependent variable had a growth rate close to zero prior to service changes, which suggests that the control removed the influence of any explanatory variables other than service changes. Furthermore, these routes produced similar estimates regardless of whether model C or model D was used.

We have less confidence in the remaining routes: ie Warwick and Joondalup. For these routes, the dependent variable exhibited strongly negative growth prior to the service change, models C and D produced quite different results, and the time trends (when fitted for model C) seemed implausible. We think that the control has not worked in these situations and there are other variables affecting patronage on these routes which our analysis has not been able to account for.

Table E.2 Econometric analyses

Model type	Route	Dependent variable	Head-way before	Head-way after	% increase in services	Time trend (ie constant)	Impact of service enhancement: 1-3 mths after	Impact of service enhancement: 4-6 mths after	Impact of service enhancement: 7-9 mths after	Adjusted R^2	Pre-service change growth in dependent variable
Model A	Whitfords	Patronage growth	58 min	33 min	58%	5.1% (-4.3%, 14.5%)	0.39*** (0.23, 0.56)	0.47*** (0.27, 0.67)	0.45*** (0.23, 0.67)	0.38	9.4%
Model B	Whitfords	Patronage growth	58 min	33 min	58%	n/a – omitted	0.47*** (0.38, 0.56)	0.56*** (0.44, 0.68)	0.55*** (0.43, 0.67)	0.85	9.4%
Model C	Whitfords	Patronage growth minus control growth	58 min	33 min	58%	-1.3% (-9.0%, 6.4%)	0.35*** (0.22, 0.49)	0.43*** (0.26, 0.60)	0.38*** (0.20, 0.56)	0.43	2.0%
Model D	Whitfords	Patronage growth minus control growth	58 min	33 min	58%	n/a – omitted	0.33*** (0.26, 0.41)	0.41*** (0.31, 0.50)	0.36*** (0.26, 0.45)	0.82	2.0%
Model A	Warwick	Patronage growth	58 min	38 min	78%	-10.4%' (-21.3%, 0.6%)	0.51*** (0.28, 0.73)	0.61*** (0.40, 0.81)	0.54*** (0.36, 0.73)	0.54	-14.8%
Model B	Warwick	Patronage growth	58 min	38 min	78%	n/a – omitted	0.35*** (0.19, 0.51)	0.48*** (0.32, 0.63)	0.44*** (0.28, 0.59)	0.66	-14.8%
Model C	Warwick	Patronage growth minus control growth	58 min	38 min	78%	-17.3%*** (-26.3%, -8.3%)	0.52*** (0.33, 0.70)	0.64*** (0.47, 0.81)	0.53*** (0.37, 0.68)	0.65	-21.3%
Model D	Warwick	Patronage growth minus control growth	58 min	38 min	78%	n/a – omitted	0.26** (0.10, 0.41)	0.42*** (0.27, 0.56)	0.34*** (0.20, 0.49)	0.60	-21.3%
Model A	Stirling	Patronage growth	56 min	35 min	56%	4.1% (-3.1%, 11.2%)	0.54*** (0.31, 0.78)	0.69*** (0.50, 0.88)	0.79*** (0.59, 0.99)	0.66	6.2%
Model B	Stirling	Patronage growth	56 min	35 min	56%	n/a – omitted	0.62*** (0.43, 0.81)	0.76*** (0.61, 0.91)	0.87*** (0.72, 1.01)	0.85	6.2%

Model type	Route	Dependent variable	Head-way before	Head-way after	% increase in services	Time trend (ie constant)	Impact of service enhancement:			Adjusted R^2	Pre-service change growth in dependent variable
							1-3 mths after	4-6 mths after	7-9 mths after		
Model C	Stirling	Patronage growth minus control growth	56 min	35 min	56%	-2.4% (-10.0%, 5.2%)	0.56*** (0.32, 0.81)	0.49*** (0.28, 0.69)	0.78*** (0.57, 0.99)	0.60	-0.2%
Model D	Stirling	Patronage growth minus control growth	56 min	35 min	56%	n/a – omitted	0.52*** (0.32, 0.71)	0.45*** (0.29, 0.60)	0.74*** (0.58, 0.89)	0.77	-0.2%
Model A	Joondalup	Patronage growth	62 min	43 min	44%	22.2%*** (15.2%, 29.3%)	-0.02 (-0.25, 0.21)	0.16 (-0.08, 0.40)	n/a – no data	0.01	22.2%
Model B	Joondalup	Patronage growth	62 min	43 min	44%	n/a – omitted	0.49*** (0.25, 0.72)	0.66*** (0.41, 0.92)	n/a – no data	0.50	22.2%
Model C	Joondalup	Patronage growth minus control growth	62 min	43 min	44%	-9.2%* (-16.4%, -2.1%)	0.34** (0.10, 0.57)	0.61*** (0.37, 0.85)	n/a – no data	0.38	-9.2%
Model D	Joondalup	Patronage growth minus control growth	62 min	43 min	44%	n/a - omitted	0.13 (-0.05, 0.31)	0.40*** (0.21, 0.59)	n/a – no data	0.29	- 9.2%
Model A	Clarkson	Patronage growth	42 min	32 min	30%	14.3%*** (8.2%, 20.5%)	0.26’ (-0.03, 0.55)	0.21 (-0.09, 0.51)	n/a – no data	0.04	14.3%
Model B	Clarkson	Patronage growth	42 min	32 min	30%	n/a – omitted	0.73*** (0.47, 0.99)	0.68*** (0.40, 0.96)	n/a – no data	0.56	14.3%
Model C	Clarkson	Patronage growth minus control growth	42 min	32 min	30%	2.2% (-4.4%, 8.7%)	-0.01 (-0.32, 0.29)	-0.18 (-0.51, 0.14)	n/a – no data	-0.01	2.2%
Model D	Clarkson	Patronage growth minus control growth	58 min	33 min	30%	n/a – omitted	0.06 (-0.16, 0.28)	-0.11 (-0.35, 0.13)	n/a – no data	-0.02	2.2%

*** Statistically significant at 0.1%, ** Statistically significant at 1%, * Statistically significant at 5%, ‘Statistically significant at 10%

Table E.3 Summary of service elasticity best estimates

	Whitfords	Warwick	Stirling	Joondalup	Clarkson
Headway before	53 min	68 min	54 min	62 min	38 min
Headway after	33 min	38 min	35 min	43 min	26 min
% increase in services	58%	78%	56%	44%	30%
Elasticity:					
0–3 months after	0.33	0.26	0.52	0.13	0.06
4–6 months after	0.41	0.42	0.45	0.40	-0.11
7–9 months after	0.36	0.34	0.74	n/a	n/a
95% confidence interval	±0.20	±0.30	±0.20	±0.20	±0.25
Robustness of model	Med	Low	High	Low	Med

E5 Conclusions

Table E.3 draws from table E.2 to summarise our best estimate elasticity estimates and ranges, based on the preferred models. Our main finding is that the Clarkson elasticity estimates are not significant. This may reflect that the service increase was the smallest of all five routes, and/or may indicate that the additional services did not affect patronage levels for whatever reasons.

- All the other elasticity estimates are highly significant (mostly at the 0.1% level), except for the Joondalup 0-3 months figure.
- Of the nine elasticity estimates that are significant at the 0.1% level, in 8 cases the best estimates lie between 0.33 and 0.52. This is a reasonably narrow range for such analyses and is consistent with most other evidence on short-run bus service elasticities.
- Apart from Clarkson, there is no clear difference in elasticity values between the other four routes.
- There is no clear pattern of increase in elasticities over time from the introduction of the service increases – although some weak evidence that the elasticity values beyond the first three months are rather higher than in the initial period.

Figure E.1a – Whitfords 1800–2100 hrs – trend in patronage and service levels (ie trip counts)

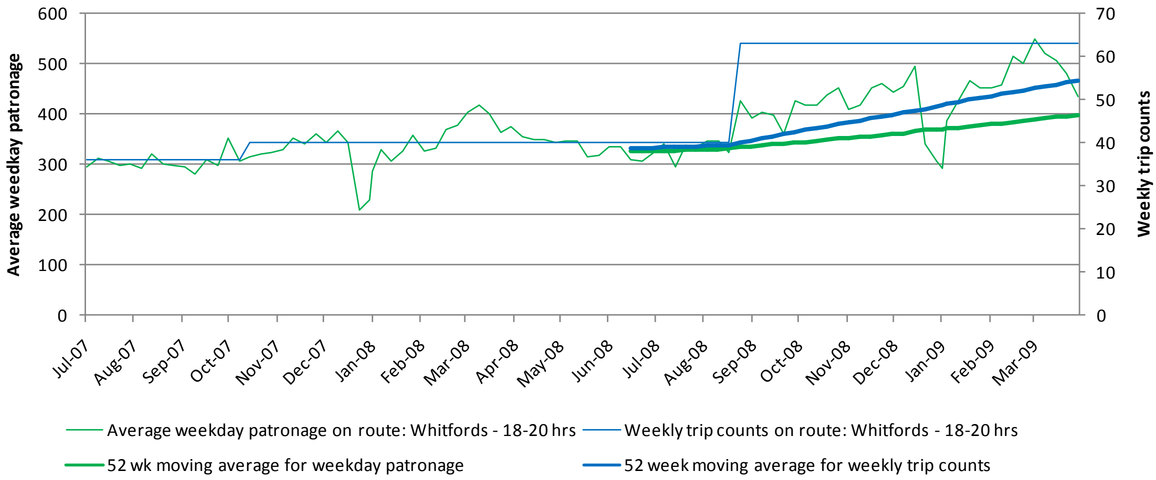


Figure E.1b Whitfords 1800–2100 hrs – patronage growth before and after control adjustment (year-on-year changes)

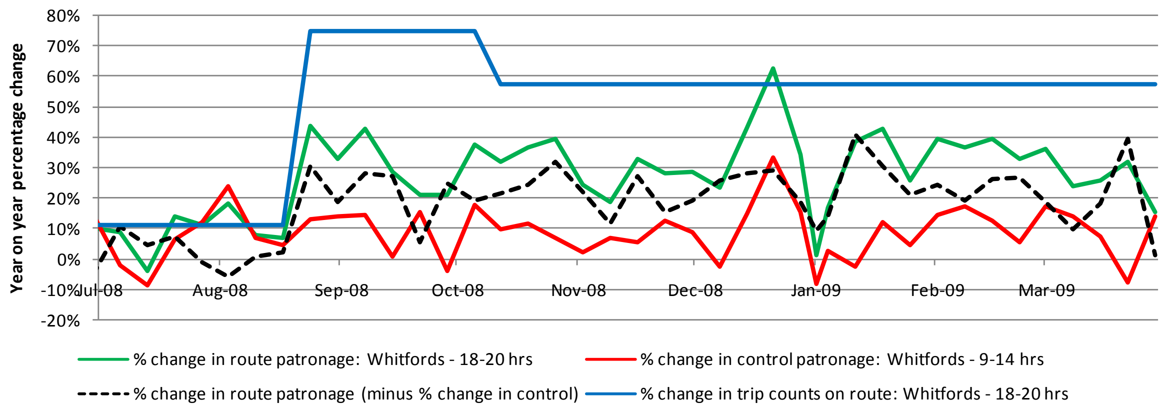


Figure E.2a Warwick 1800–2100 hrs – trend in patronage and service levels (ie trip counts)

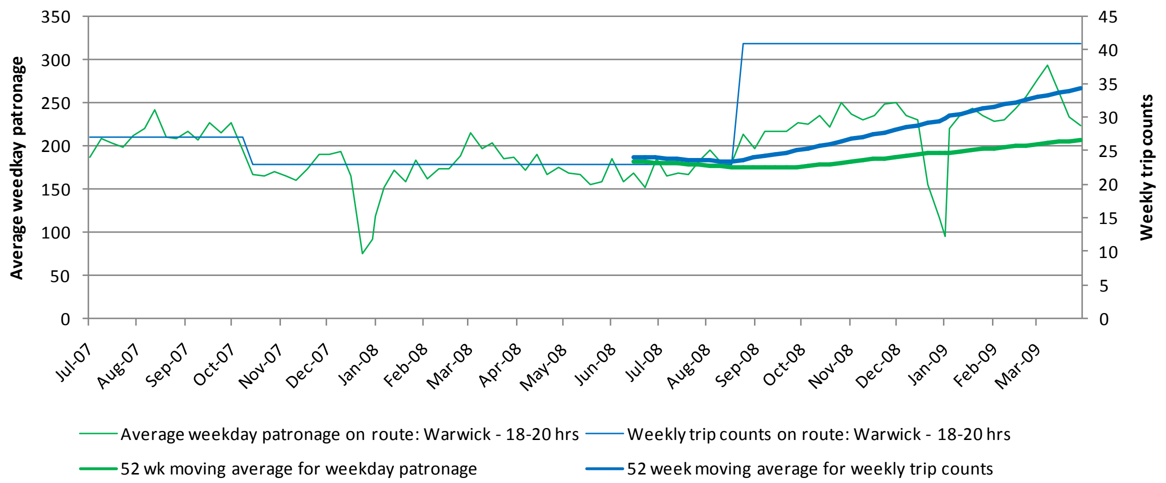


Figure E.2b Warwick 1800–2100 hrs – patronage growth before and after control adjustment (year on year changes)

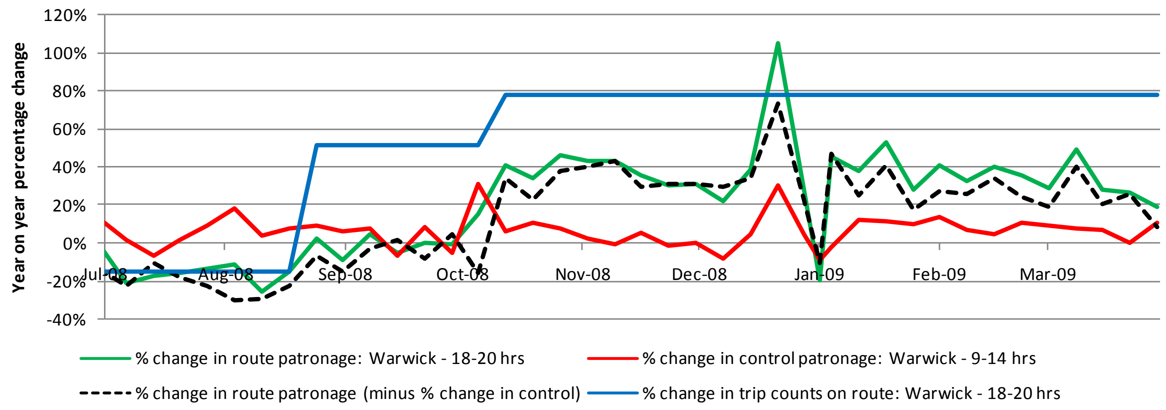


Figure E.3a Stirling 1800–2100 hrs – trend in patronage and service levels (ie trip counts)

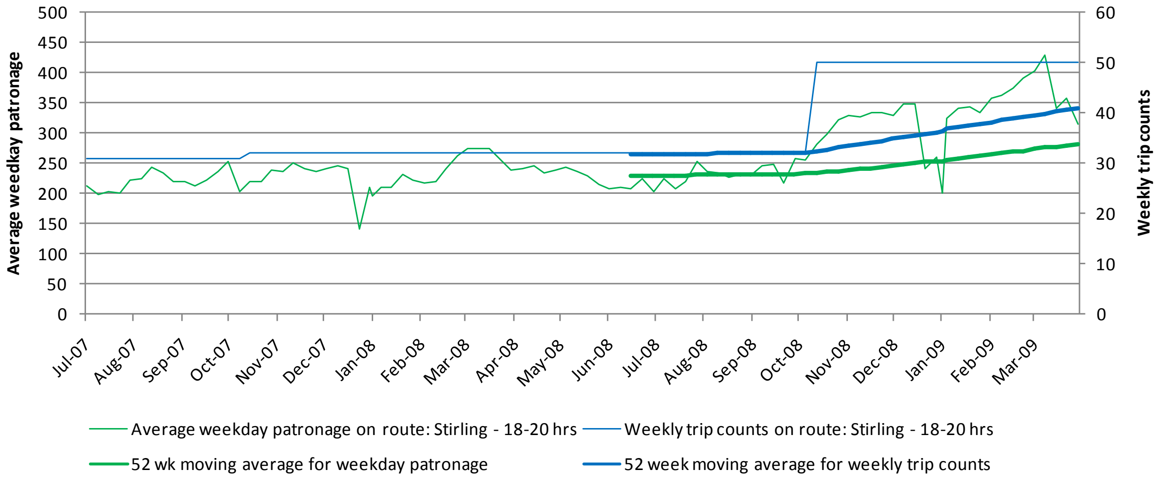


Figure E.3b Stirling 1800–2100 hrs – patronage growth before and after control adjustment (year on year changes)

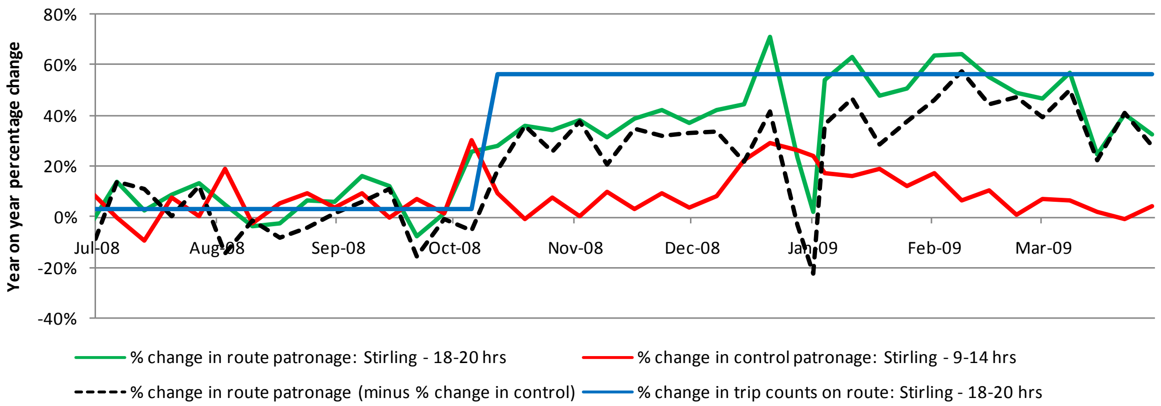


Figure E.4a Joondalup 1800–2100 hrs – trend in patronage and service levels (ie trip counts)

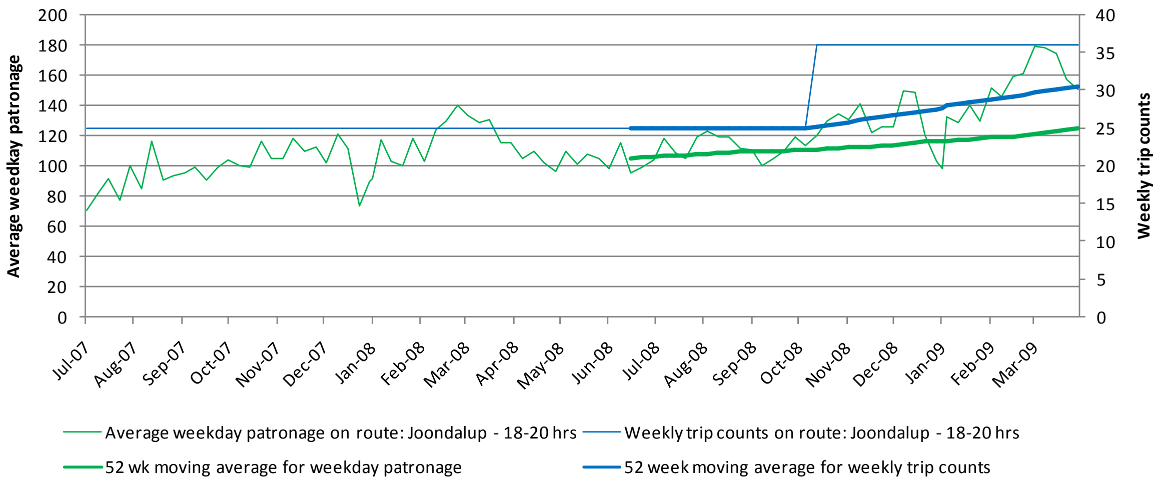


Figure E.4b Joondalup 1800–2100 hrs – patronage growth before and after control adjustment (year on year changes)

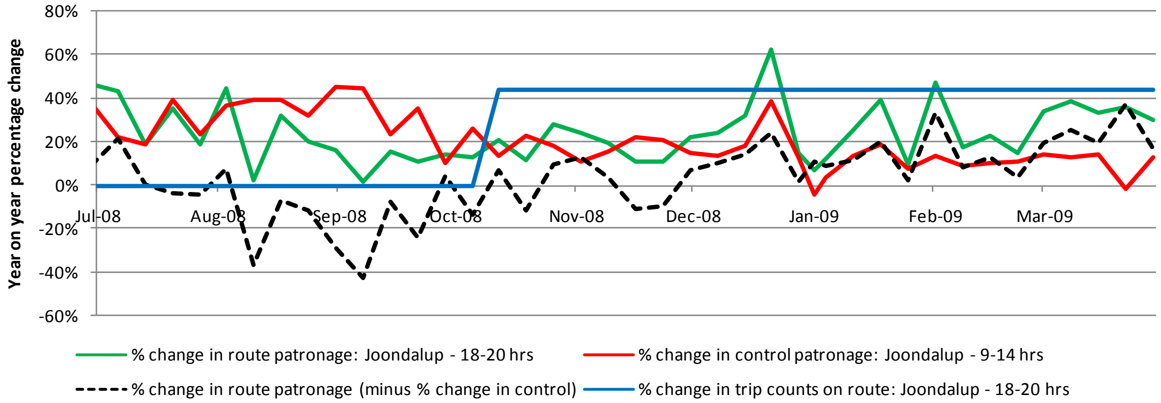


Figure E.5a Clarkson 1800–2100 hrs – trend in patronage and service levels (ie trip counts)

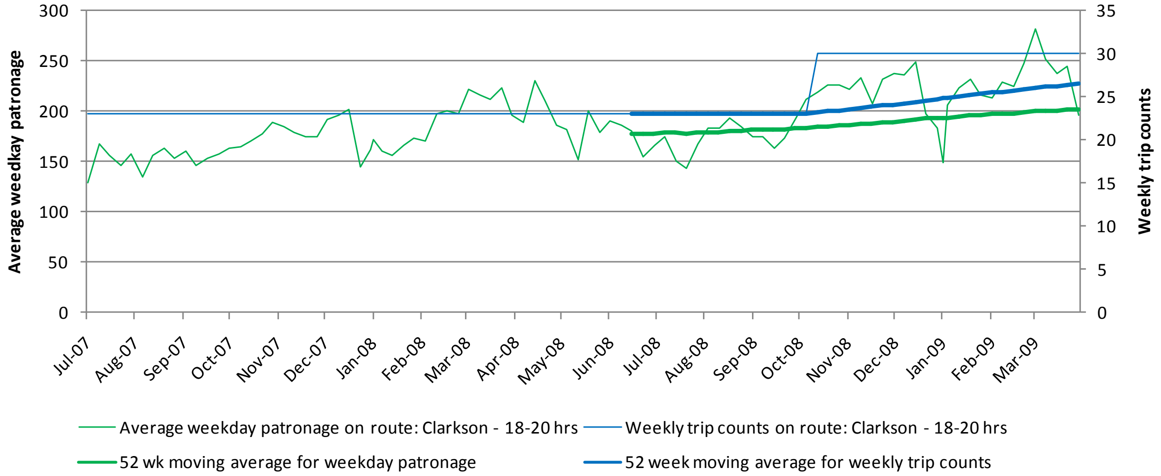
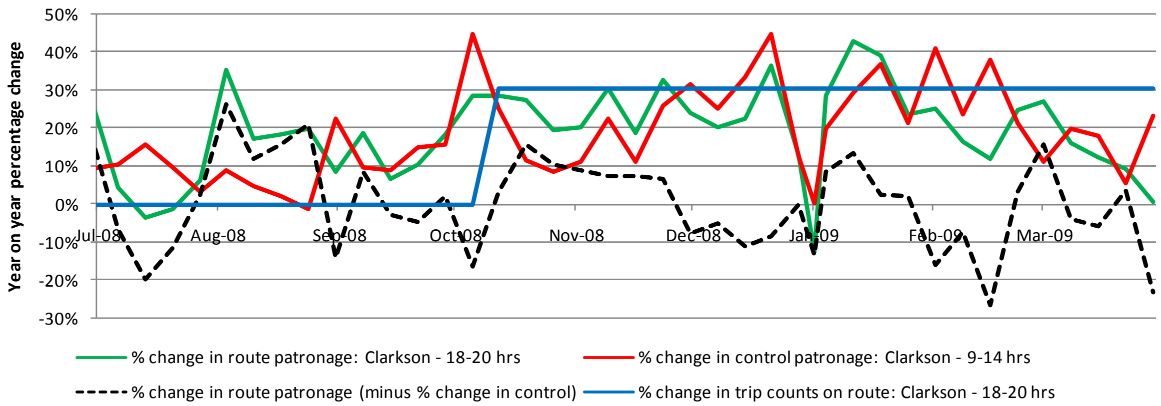


Figure E.5b Clarkson 1800–2100 hrs – patronage growth before and after control adjustment (year on year changes)



Appendix F: Service elasticity assessments – Brisbane

F1 Introduction

This appendix covers the project analyses of Brisbane's experience since 2004 with increases in bus service levels, principally in off-peak periods. It provides full details of the various analyses undertaken, the results of which have then been summarised in the main report (section 4.6).

The analyses covered service frequency increases on five routes, all operated by Brisbane Transport, initiated over the period November 2004 – February 2009. They were undertaken separately for three time periods – weekday evenings, Saturdays and Sundays. In most cases, the increases in the number of services operated were very substantial, in the range of 50% to 300%.

The focus of the work was on estimating service frequency elasticities for the day types/time periods in which the services were improved. In particular, the analyses examined how these elasticity values varied by day/time period and over time following the service improvements.

F1.1 Acknowledgements

We would like to express our great thanks to Brian Bothwell (Brisbane Transport) for his invaluable support for this work, in terms of data provision, advice and review of draft findings. This support has made a major contribution to the quality of the research and its findings.

F2 Methodology and data

F2.1 Service changes analysed

The focus of the project was to analyse the effects of changes in bus service frequencies on patronage at off-peak periods, and in particular to estimate demand elasticities with respect to service frequencies.

Services in three time periods were nominated for examination of off-peak frequency effects:

- weekday evening – timetabled trips starting 1900–2259 hours
- Saturday daytime – timetabled trips starting 1000–1759 hours
- Sunday daytime – timetabled trips starting 1000–1759 hours.

Based on discussions with Brisbane Transport (BT), service changes on the following routes were identified as appropriate candidates for analysis:

- 140 (February 2009)
- 150 (November 2004)
- 190 (February 2006 and November 2008, Saturday only)
- 200 (April 2008)
- 345 (February 2006).

Table F.1 provides further details on each of the service changes assessed, including information on initial service frequencies and the proportionate frequency change. In all these cases, except where noted, frequency increases for all three time periods of interest were introduced at the same time.

F2.2 Patronage data

The basic unit of patronage used in our analyses was passenger boardings per day (both directions combined) on the route of interest (or control route) in the nominated time periods (weekday evening, Saturday daytime, Sunday daytime). BT provided us with data on this basis.

For each route of interest (and the corresponding control route), we requested patronage data starting 24 months prior to the service change and continuing as far as possible (usually December 2009 in practice), except in cases where other events some time after the service change meant that the analysis of data after these events would not be useful. For each route, the data obtained covered part or all of the period October 2002 to December 2009: table F.1 provides the details for each route.

A number of data deficiencies and issues were examined, principally as follows:

- In the period September 2007 to February 2008, BT had major problems with its new ticketing equipment, resulting in under-recording of passenger boardings on all services; the extent of this under-recording varied over the period, and may not have been equal on all routes. Hence, wherever possible, the data provided for this period was not used, either for estimating before/after patronage changes or for extrapolating route patronage.
- For routes 190 (before) and 199 (after), there was a three-month gap in the 'after' data immediately following the February 2006 service change. This affected the 190/199 analyses for all three time periods, preventing any elasticity estimates for the first quarter after the service change and the corresponding quarter in the following years.

Several other data problems were identified affecting individual routes, and have been noted in the relevant text. Generally, these meant that the elasticities for the affected quarterly period either could not be estimated, or could be estimated only with reduced levels of confidence because of incomplete data.

As a general comment, we went to considerable efforts to 'clean up' the data set provided prior to undertaking the elasticity analyses.

F2.3 'Control' routes

For all analyses undertaken, we applied 'control' routes, as noted above. The intention was that the 'control' route would allow for any factors, other than the service change under examination, which might have affected patronage on the route in question over the analysis period.

Two approaches were taken to 'control route' selection:

1 **Control route.** Use of another BT route (or group of routes), which was judged to be reasonably similar in characteristics to the route in question, but not affected by any service changes or other local factors affecting patronage within the period of interest. Appropriate routes were selected in discussion with BT. However, it was found that, in a number of cases, several of the selected control routes exhibited quite substantial increases or decreases in patronage over the analysis period, differing from the 'before' trends for the route in question. Given this, a second approach to defining control routes was taken, as follows.

Table F.1 BNE off-peak service improvements – service changes and patronage data summary

Route No	Service Change Date	Control Routes	Period of Pax Data		Weekday Evening (1900-2300)			Saturday (1000-1800)			Sunday (1000-1800)		
			Start Period	End Period	Initial Freq (1-way trips/ hr)	Initial Headway (mins)	Frequency Increase (%)	Initial Freq (1-way trips/ hr)	Initial Headway (mins)	Frequency Increase (%)	Initial Freq (1-way trips/ hr)	Initial Headway (mins)	Frequency Increase (%)
140	Feb-09	120+170+180	Jan-06	Dec-09	1.125	53.3	256%	2.0	30	100%	1.44	42	178%
130+140 (1)	Feb-09	120+170+180	Jan-06	Dec-09	5.75	10.4	50%	6.0	10	33%	5.44	11	47%
150	Nov-04	140	Oct-02	Jun-08	1.125	53.3	278%	2.0	30	100%	1.44	41.7	178%
190/199	Feb-06	375	Feb-04	Dec-09	1.0	60	300%	2.0	30	100%	2.0	30	100%
190+191/ 196+199 (1)	Feb-06	375	Feb-04	Dec-09	2.0	30	194%	4.0	15	50%	4.0	15	50%
199	Nov-08	375	Nov-07	Dec-09				4.0	15	50%			
196+199 (1)	Nov-08	375	Nov-07	Dec-09				6.0	10	33%			
200	Apr-05	210+212	Mar-03	Dec-09	1.25	48	220%	2.0	30	100%	1.5	40	167%
345	Feb-06	330	Jan-04	May-08	1.0	60	313%	2.0	30	100%	2.0	30	100%

Notes: (1) These wider analyses (including additional routes) were undertaken to test the effects of any passenger abstraction from competing routes.

2 **Route extrapolation.** This alternative method involved extrapolation of the 'before' patronage trends calculated for the route in question for the two years prior to the service change. These trends were assumed to continue to apply (in %pa terms) to the period after the service change, thus providing an alternative 'control route'[60].

In all cases, elasticities were calculated by applying each of the above methods. These results were then reviewed, and a judgement made as to which of these methods (or what weighted average of the results for both methods) gave the most plausible elasticity trends in each case.

F2.4 Scope of analyses

In general, the analyses for each route/time period compared the change in patronage on that route/period following the service frequency increase and the extent of the service increase. This enabled derivation of a route/time period service elasticity.

However, potentially, a change in service on a single route/time period may have wider impacts on patronage, ie:

A on other (competing or complementary) routes at the same time period

B on the same routes at other time periods

C on other (competing or complementary) routes at other time periods.

These 'secondary' impacts are often ignored in studies that derive route-based elasticity estimates, but they may be very significant. Ignoring them may underestimate or overestimate the true market response to service changes.

In regard to these three potential responses, we proceeded as follows:

A **Effects on other routes.** For two of the routes we assessed (140, 190/199), it became readily evident that increasing the services on these routes led to significant switching ('abstraction') of some passengers from closely competing routes. In the case of route 140, the main route affected was the 130; in the case of route 190/199, it was 191/196. Therefore, in addition to assessing the patronage impacts on route 140 alone, we also assessed the impacts on routes 130 and 140 together. The elasticity estimate for route 140 alone would be 'abnormally' high, because it included the 'abstraction' component; whereas the elasticity for 140 + 130 together should be 'normal', representing the net effect on corridor patronage. Similar comment applies to the 190/199 + 191/196 assessment.

B **Effects in other time periods.** Prima facie, if a service is improved in one time period (eg weekday evenings), the improvement would also be expected to influence patronage in other time periods in which people are travelling on the same round trip or trip chain (eg weekday interpeak or PM peak). In the case of weekend travel, it would be expected that the majority of people (but not all) would complete their round trip between 1000 and 1800 hours, so that service changes in this period would have very limited effects outside these hours.The project has not, at this stage, investigated effects in other time periods in any detail. However, we have identified evidence that suggests these might be quite substantial:

- In relation to weekday evening travel, it would be expected that a substantial proportion of travellers would have made their outward trip earlier in the day, so that significant effects on interpeak and PM

[60] Where data was available we took a weighted average of growth for the 52 weeks in the year prior to the service change (75% weight) and the 52-week period between one and two years prior to the service change (25% weight). In most cases, however, there was insufficient data to do this, so we used data only for the 52 weeks in the year prior to the service change.

peak travel might be expected. Hence our weekday evening elasticity estimates might very significantly underestimate the full market response[61].

– In relation to weekend travel, our analysis of Sunday patronage on one route indicated that it increased significantly when Saturday services were increased on the same route.

Thus the limited evidence assembled to date indicates that patronage effects in other time periods may be quite substantial (the shorter the time period for analysis, the larger the effects in other periods are likely to be). To the extent these effects are ignored, elasticity values will be understated. This appears to be a priority aspect for further attention.

C **Effects on other routes at other time periods**. Given the above discussion, this effect might be expected to be somewhat secondary to effects A and B, but could still be of significance. In practical terms, we suggest that if the extent of effects A and B can be identified in any specific case, then it should be possible to make a good estimate of the likely extent of effect C without having to undertake wider data analyses. If further work is to be undertaken on effect B, we suggest the effect C impacts also be investigated along with this.

F2.5 Elasticity formulation

We adopted a commonly used elasticity formulation as the basis for our estimation of service frequency elasticities. This was:

$$\text{Elasticity} = \frac{\ln(\text{patronage increase factor})}{\ln(\text{service increase factor})}$$

This (natural) logarithmic function has a number of advantages over alternative elasticity functions in terms of the project requirements, including that it provides consistent elasticity results in cases where:

- Two sets of service changes are made on a route: the total patronage effects calculated for the two separate changes will be the same as if the patronage effect was calculated for both changes together.
- A service increase is followed by a service decrease (or vice versa), resulting in no net service change: this method will calculate no net patronage change, while other methods generally do not.

In our estimation of elasticities using the above function:

- We compared patronage in each 'after' period with that for the corresponding period in the 52 weeks immediately before the service change (thus overcoming any seasonality effects).
- We compared these patronage changes on the route under examination with patronage changes on a specified 'control' (unaffected) route, and calculated elasticities on the net change (thus allowing for any other 'external' factors that might have affected patronage over the relevant period).

On this basis, the above elasticity function was expressed as follows:

$$\text{Estimated elasticity } E_e = \frac{\ln[(P_R^{Ta}/P_R^{Tb})/(P_C^{Ta}/P_C^{Tb})]}{\ln(S_R^{Ta}/S_R^{Tb})}$$

where: E_e = service frequency elasticity estimate (for time period T_a)

P = patronage in specified period

[61] The project finding that its weekday evening elasticity estimates are significantly lower than its weekend estimates is supporting evidence for this conclusion.

S = number of service trips over time period (four or eight hours)

R = route experiencing service change

C = control route

Ta = time period (day, week, month, etc) after the service change

Tb = corresponding time period in the year immediately before the service change (the 'before' period is the day/week in the 52 weeks before the service change selected to be exactly 364 days or a multiple thereof, before the 'after' period).

F2.6 Estimation of elasticity values

Patronage data were provided by BT on a daily basis for each of the day types/time periods of interest, for both the routes of interest and the control route.

We used this data to calculate, on a daily basis:

- for the route of interest: ratio of daily 'after' patronage to patronage on the 'equivalent' day in the 52 weeks before the service change[62]
- For the 'control' route: similar ratio of daily 'after' patronage to 'before' patronage
- the ratio A/B.

The formulation above was then used to derive estimated elasticity values on a daily basis.

Similarly, averaged elasticities were calculated for longer periods, using average patronage data over these periods. In particular, we calculated average elasticities over four week and 13 week (quarterly) periods.

For most of the project work in assessing patterns of elasticity results, we focused on average values for each 13-week (quarterly) period after the service change. The result was elasticity estimates for Q1, Q2, Q3, Q4 etc following the service change. In practice, the continuing rate of growth in market response (and hence elasticity estimates) is much reduced beyond the first 12 months, and hence we derived annual average elasticities beyond the first year. This resulted in a set of elasticity estimates for the following periods: Q1, Q2, Q3, Q4, Y2, Y3, Y4 etc.

We chose the Q4 elasticity estimate (ie relating to the period 40–52 weeks after the service change) as our single primary indicator of market response: one reason for this choice is that it is largely consistent with the definition of short-run elasticities generally found in the literature. When examining elasticity trends over time we have then related these back to the Q4 elasticity value as the base.

F2.7 Saturation curve assessment

As noted above, we estimated elasticity values initially on a daily basis; and then derived from these weekly, four-weekly and 13-weekly average values. The graphical results presented in this appendix include daily average values, 13-week moving average values and average values for each 13-week period. As expected, the daily values showed wide variations from day to day; while the 13-week period averages showed a reasonably smooth curve, increasing over time since the service change but at a decreasing rate.

In order to be able to generalise from the various results, it is useful to fit a smooth curve to the results, indicating the 'underlying' trends over time. In this case, a 'saturation'-type curve was most appropriate,

[62] This 'equivalent' day was selected as the day 364 days before, or (beyond the first year after the service change) the appropriate multiple of 364 days before, the day in question.

reflecting an expectation that in the long run the elasticity would be expected to approach a fixed value (rather than continue to increase indefinitely).

In developing our saturation curves we adopted a popular equation for curve fitting – the 'two-parameter saturation growth' function:

$$E_s = A.T/(B+T)$$

where T is time (following the introduction of the service change), and A and B are two parameters.

An alternative popular equation used for curve fitting is the 'two parameter exponential' function:

$$Y = A\ (1\text{-}exp(\text{-}B*T))$$

where T is time, and A and B are two parameters (Kirk 2005).

Both of these equations were initially tested and compared (in our analysis of the Hamilton data – appendix D). We found that both equations provided a similar fit to the set of elasticity estimates. However, the 'two-parameter saturation growth' method generally provided a better fit for off-peak data. Therefore, that method was employed for analysis of the remaining centres (including Brisbane).

Hence the saturation curve formula adopted was:

Curve fitted elasticity $E_s = \quad A.T_a/(B + T_a)$

where: A is a parameter representing the long-run elasticity

B is a parameter representing the speed of convergence to the long- run elasticity

T_a is time since introduction of service change.

Analysis of the dataset of actual elasticity estimates enables A and B to be estimated so as to minimise the following:

Sum of squared error: $\sum_{t=0}^{t=n}$ (derived elasticity–curve-fitted elasticity)^2

$$= \sum_{Ta=0}^{Ta=n} [\mathrm{E_e} - \mathrm{A}.T_\mathrm{a}/(\mathrm{B} + T_\mathrm{a})]^2$$

In much of the work in the project to examine the patterns of elasticity results (eg in examining elasticity changes over time), the saturation curve estimates were used in place of (or in addition to) the actual results so as to minimise the effects of random fluctuations in the data.

F3 Weekday evening analyses

F3.1 Route 140 analysis

F3.1.1 Service change

The service change occurred on 23 February 2009, with services increasing from about one to four services per hour (each direction).

Table F.2 Details of service change for 140

Date of service change for route/s 140:	Monday, 23 February 2009
Trips before	9
Trips afterwards	32
Ratio	3.56
Control route/s:	120+170+180

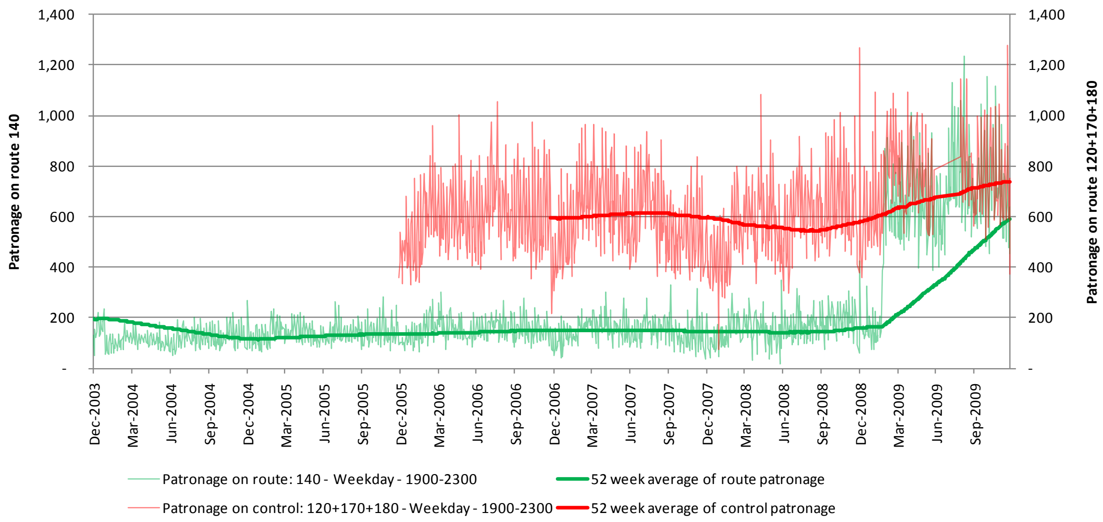
F3.1.2 Data availability and quantity

Given the timing, there were only about three quarters of data following the service change.

Note that there was a 'gash' in the data from Mon 24 September 2007 to Fri 29 February 2008 (see figure F.2) but, as the next section notes, this has not been a significant problem from the perspective of elasticity estimation.

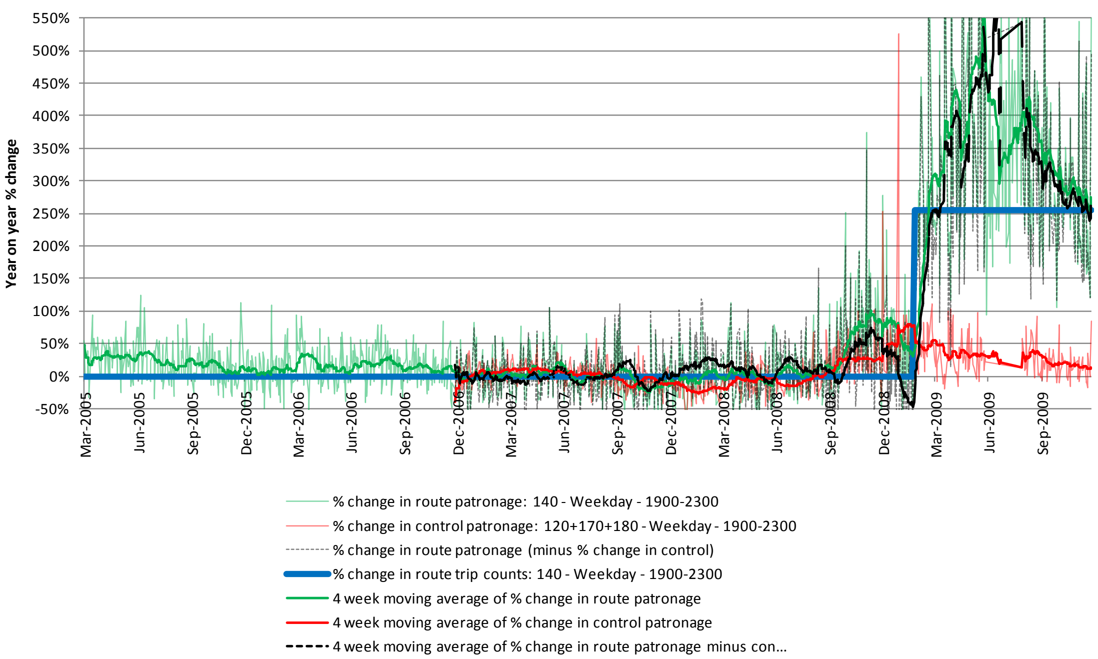
A more serious problem is the lack of control data between Mon 29 June 2009 and Wed 26 August 2009. This can be seen in figure F.1 as a gap in the September 2009 quarter.

Figure F.1 Patronage on route 140 and control routes



Another problem is that patronage growth on the control route increased significantly around the time of the fare change. This can be seen in figure F.1 and also in figure F.2. This could have distorted our estimates.

Figure F.2 Patronage growth rates on route 140 and control routes



F3.1.3 Elasticity estimation – control route method

Figure F.3 shows daily estimates of service elasticities, derived by comparing patronage growth on the route of interest with patronage growth on a control route.

These daily service elasticities were smoothed using a four-week moving average (see solid black line). In addition, a saturation curve was estimated, providing the 'best fit' to the observed daily elasticities (see dotted black line).

Figure F.3 Elasticity estimation for route 140 using control route method

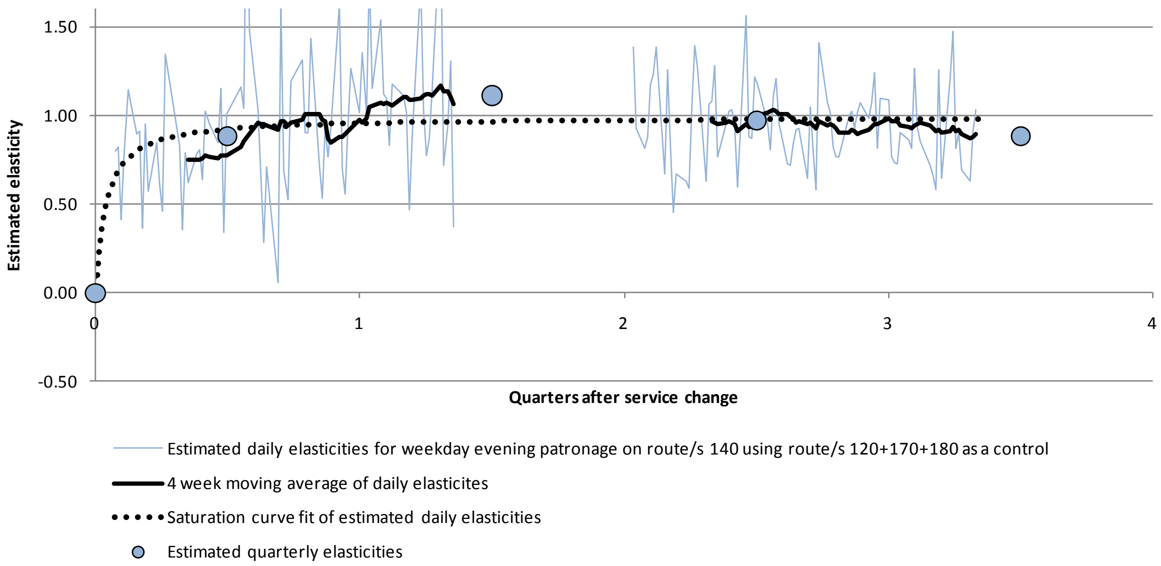


Table F.3 Elasticity estimation for route 140 using control route method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-09					0.00	0.00
Q1	May-09	648	792	4.53	1.39	0.88	0.87
Q2	Aug-09	620	722	6.19	1.31	1.11	0.97
Q3	Nov-09	718	779	4.28	1.23	0.97	0.98
Q4	#N/A	668	724	3.67	1.15	0.88	0.98
Long run							0.99

Note: The ratio of route trips after the service change compared to prior to the service change was 3.56

Note that the 'gash' in the data from Mon 24 September 2007 to Fri 29 February 2008 (see figure F.1) has had minimal impact on figure F.3. All it means is that about eight days of estimated elasticities were lost at the start of figure F.1.

However, the missing control data between Mon 29 June 2009 and Wed 26 August 2009 has a bigger impact on figure F.3 – it means that we cannot estimate elasticities for most of Q2.

We note that Q4 only includes about one month of data. Hence the estimated elasticity of 0.88 for that quarter should not be given as much weight as the other quarters.

We note that the elasticities shown in figure F.3 and table F.1 converge on about 1.00, which is an 'abnormally' high value. This most likely occurred because the service change on the 140 abstracted patronage from the 130. In the next section we combine the two routes together to obtain a more useful estimate of the net effect on patronage.

F3.1.4 Elasticity estimation – route extrapolation method

An alternative set of elasticity estimates was made, based on a 'control' created using an extrapolated growth rate of 3.64% per annum. This was derived based on a weighted average of the growth rate in the 52-week period prior to the service change (weight=75%) and the average growth rate in the 52-week period ending a year before the service change (weight=25%) but excluding the 'gash' from 24 September 2007 to 29 February 2008. The resulting estimates and corresponding saturation curve are shown in figure F.4, and the derivation of quarterly elasticity estimates is given in table F.3.

We note that Q4 only includes about one month of data. Hence the estimated elasticity of 0.95 for that quarter should not be given as much weight as the other quarters.

Figure F.4 Elasticity estimation using extrapolation method

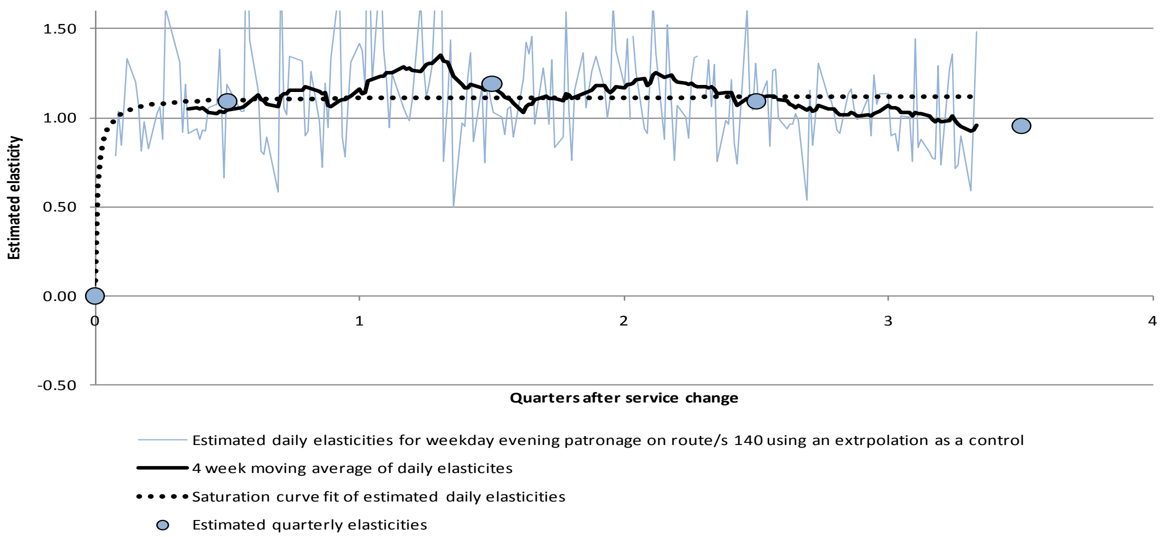


Table F.4 Elasticity estimation using extrapolation method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of extrapolated patronage this quarter to observed patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-09					0.00	0.00
Q1	May-09	648	168	4.53	1.04	1.09	1.07
Q2	Aug-09	655	155	5.15	1.04	1.19	1.11
Q3	Nov-09	718	182	4.30	1.04	1.09	1.12
Q4	#N/A	668	206	3.67	1.04	0.95	1.12
Long run							1.12

Note: The ratio of route trips after the service change compared to prior to the service change was 3.56

F3.1.5 Review and comments

The abnormally high elasticity estimates most likely reflect that the service improvement on 140 abstracted a significant proportion of the additional passengers from 130. Hence it is desirable to consider the two routes together (as below).

There appears to be strong growth in the control route patronage in the period following the service change (which is beyond the influence of the data 'gash' in the period September 2007 to February 2008). This may well result in the 'control' elasticity estimates all being underestimated.

The 'extrapolation' elasticity estimates have used an extrapolated growth rate in the route patronage of 3.6%pa. Based on this rate, the elasticity values appear to decline from Q2 onwards, suggesting that this growth rate may be too high and the Q3, Q4 extrapolation elasticity estimates too low.

F3.1.6 Conclusions

We consider that useful conclusions on elasticity values cannot be drawn for route 140 above, because of the likely abstraction of passengers from route 130. Both routes are best considered together (as below).

However, this analysis (combined with that below) does illustrate the dangers of overestimating corridor patronage responses if effects on patronage on competing routes are ignored.

F3.2 Route 130+140 analysis

F3.2.1 Service change

This section is designed to examine the impacts of the increase in service on routes 140 and 130 together, and thus the extent of abstraction of patronage from the 130. Therefore, the date of the service change remains Mon 23 February 2009. Taking the two routes together, the effective service frequency increase was 50%.

Table F.5 Details of service change

Date of service change for route/s 130+140:	Monday, 23 February 2009
Trips before	46
Trips afterwards	69
Ratio	1.50
Control route/s:	120+170+180

F3.2.2 Data availability and quantity

The data issues are the same as with the 130 analysis on its own. There is a 'gash' in the data from Mon 24 September 2007 to Fri 29 February 2008. And there is missing control data during the June–August 2009 period. These data issues show up in figures F.5 and F.6.

Figure F.5 Patronage on service route and control routes

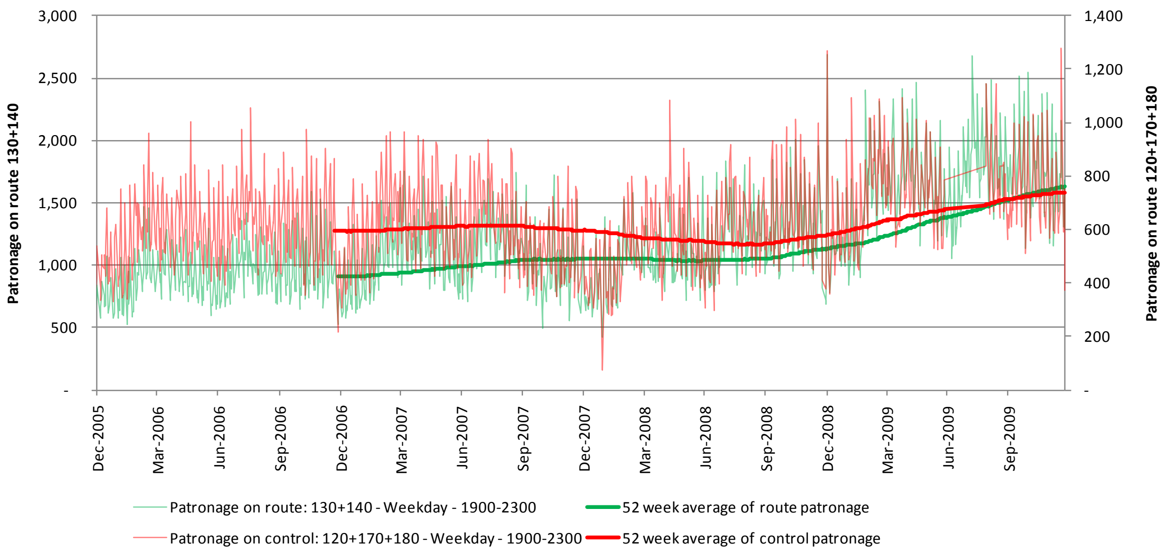
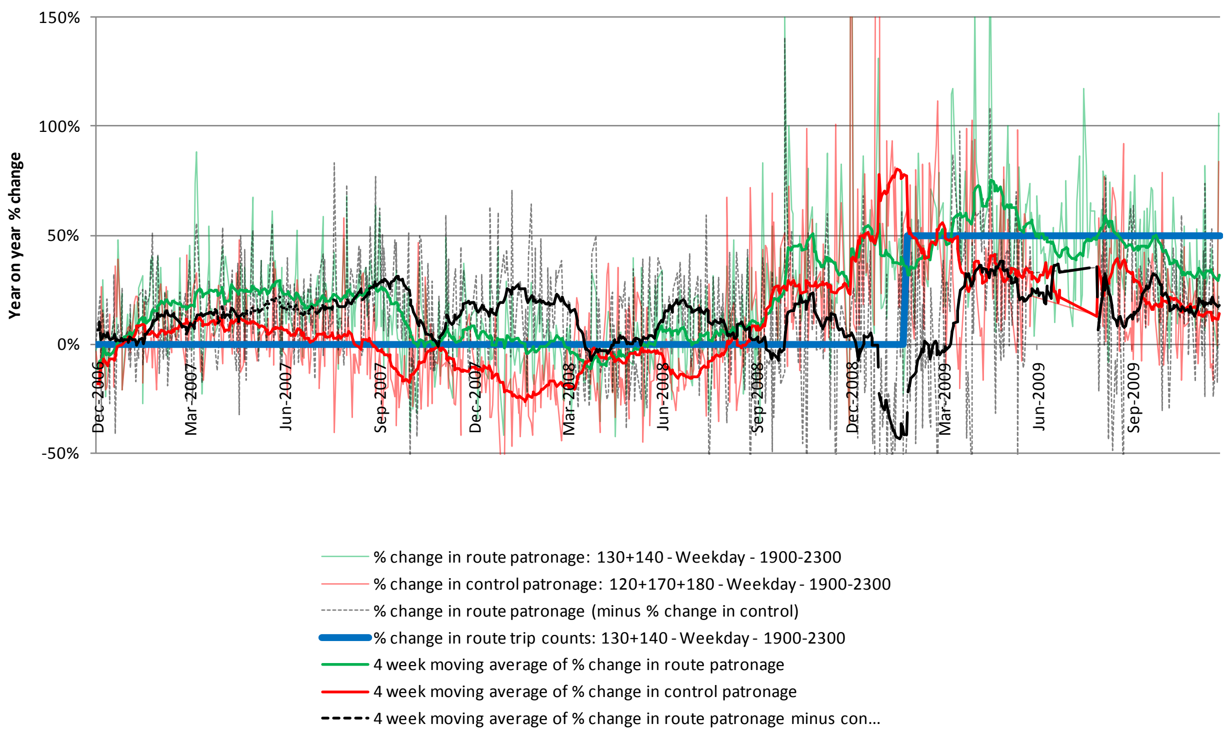


Figure F.6 Patronage growth rates on service route and control routes



Again figures F.5 and F.6 show a rapid increase in patronage growth on the control routes around the time of the service change. This could have distorted the elasticity estimates.

F3.2.3 Elasticity estimation – control route method

The elasticity estimates are shown in figure F.7 and table F.6 below. We encounter the same 'gaps' in the graph as with the analysis of the 130 on its own: about eight days of elasticities are missing at the beginning of figure F.5, due to the 'gash' in the data; and there are missing elasticities around the end of the second quarter, due to missing control data during the June–August 2009 period, as was shown in figure F.5.

In addition, figure F.7 shows unusually low estimates during the first month. It is not due to the December 2007–February 2008 'gash' because this has been removed. It appears to be due to the fact that the control patronage growth was unusually high for a period prior to and after the service change, as is seen in figure F.6.

We note that Q4 only includes about one month of data. Hence the estimated of elasticity of 0.33 for that quarter should not be given as much weight as the other quarters.

We note that the elasticity estimates in table F.6 for routes 130+140 are around 0.3–0.45. This range is much lower than the range of elasticity estimates in table F.3 for route 130 alone, which was 0.9–1.0. We consider that this difference relates to the 'abstraction' of patronage from the 140 route due to improved services on the 130.

Figure F.7 Elasticity estimation using control route method

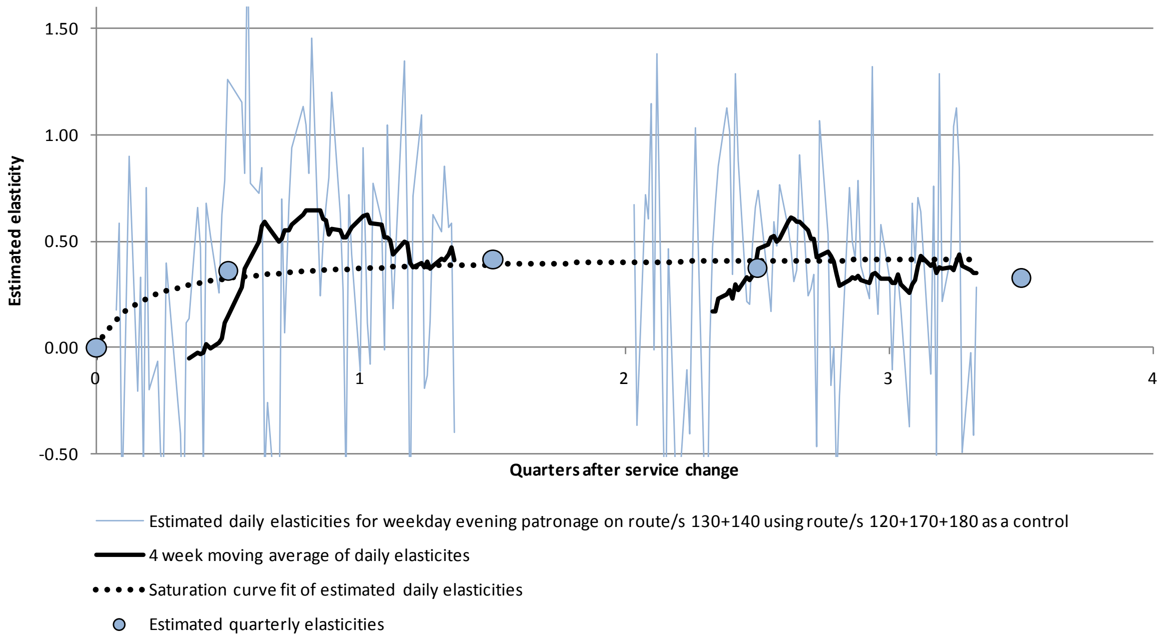


Table F.6 Elasticity estimation using control route method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-09					0.00	0.00
Q1	May-09	1,700	792	1.59	1.39	0.36	0.29
Q2	Aug-09	1,618	722	1.53	1.31	0.41	0.39
Q3	Nov-09	1,804	779	1.42	1.23	0.37	0.41
Q4	#N/A	1,662	724	1.32	1.15	0.33	0.41
Long run							0.44

Note: The ratio of route trips after the service change compared to prior to the service change was 1.50

F3.2.4 Elasticity estimation – route extrapolation method

An alternative set of elasticity estimates was made (figure F.8) based on a 'control' created using an extrapolation growth rate of 6.37% per annum; this was derived as a weighted average of the average growth rate in the 52-week period prior to the service (weight=75%) and the average growth rate in the 52-week period ending a year before the service change (weight=25%) but excluding the 'gash' from 24 September 2007 to 29 February 2008.

We note that Q4 only includes about one month of data. Hence the estimated of elasticity of 0.49 for that quarter should not be given as much weight as the other quarters.

We note that the saturation curve does not fit the data very well in figure F.8 because the estimated elasticities exhibit a downward trend – this is inconsistent with the general formulation of a saturation curve, indicating issues with the extrapolation rates used.

Figure F.8 Elasticity estimation using extrapolation method

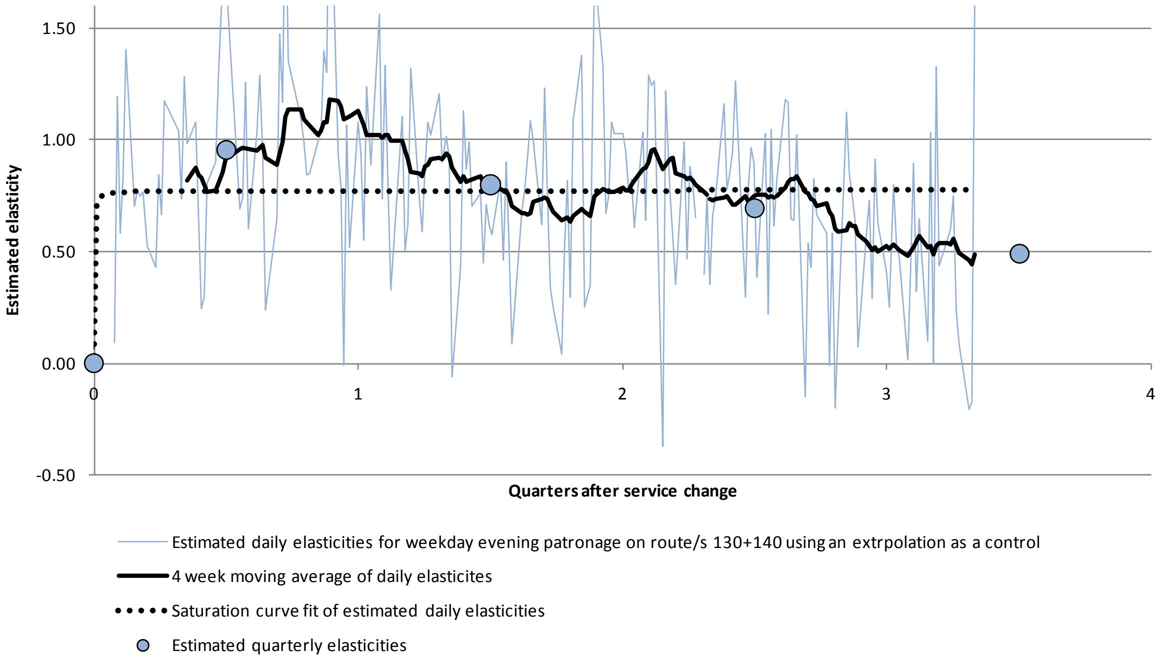


Table F.7 Elasticity estimation using extrapolation method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of extrapolated patronage this quarter to observed patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-09					0.00	0.00
Q1	May-09	1,700	1,154	1.59	1.06	0.95	0.77
Q2	Aug-09	1,657	1,209	1.49	1.06	0.80	0.77
Q3	Nov-09	1,807	1,370	1.42	1.06	0.69	0.77
Q4	#N/A	1,662	1,373	1.32	1.06	0.49	0.77
Long run							0.77

Note: The ratio of route trips after the service change compared to prior to the service change was 1.50

F3.2.5 Review and comments

As for route 140 alone (above), there appears to be strong growth in the control route patronage in the period following the service change (beyond the influence of the data 'gash'). This may well result in the 'control' elasticity estimates all being underestimated.

If we take the mean of the 'control' elasticity estimates and estimates assuming no change in control patronage, we get the following estimates for the first 4 quarters: 0.75, 0.73, 0.62, 0.51. It is unclear why these values decline over time.

The 'extrapolation' elasticity estimates have used an extrapolated growth rate in the 130/140 route patronage of 6.4% pa. Based on this rate, the elasticity values appear to decline after Q1, suggesting that this growth rate may be too high and the Q2/Q3/Q4 extrapolation elasticity estimates too low.

If we take the mean of the 'extrapolation' elasticity estimates and estimate assuming zero extrapolation, we get the following estimates for the first four quarters: 1.05, 0.83, 0.78, 0.59. Again, it is unclear why these values decline over time.

F3.2.6 Conclusions

For reasons that are unclear, the elasticity estimates generally appear to peak in Q1, then gradually decline through to Q4.

The 'control' elasticities are relatively low, most likely reflecting the substantial growth in control route patronage over the period in question. The 'extrapolation' elasticities are very much higher (but still reflecting an extrapolation growth rate of 6.4% pa).

Taking the average of the two sets of estimates noted above gives the following estimates for the first four quarters: 0.90, 0.70, 0.70, 0.55.

The corresponding averages of the two saturation curve estimates are 0.53, 0.58, 0.59, 0.59.

F3.3 Route 150 analysis

F3.3.1 Service change

The service change occurred on Monday 8 November 2004, with services increasing from about one to over four per hour (each direction).

Table F.8 Details of service change

Date of service change for route/s 150:	Monday, 8 November 2004
Trips before	9
Trips afterwards	34
Ratio	3.78
Control route/s:	140

F3.3.2 Data availability and quantity

Patronage data is available until June 2008: therefore, we have almost four years of data (15 quarters).

Both the route of interest and the control route are affected by the September 2007–February 2008 'gash', although this only has a minimal impact on the elasticities estimated.

There was a problem with the control route prior to late January 2004. Control route patronage apparently drops suddenly from this date onwards, as shown in figures F.9 and F.10. The reason for this remains unclear.

Figure F.9 Patronage on service route and control routes

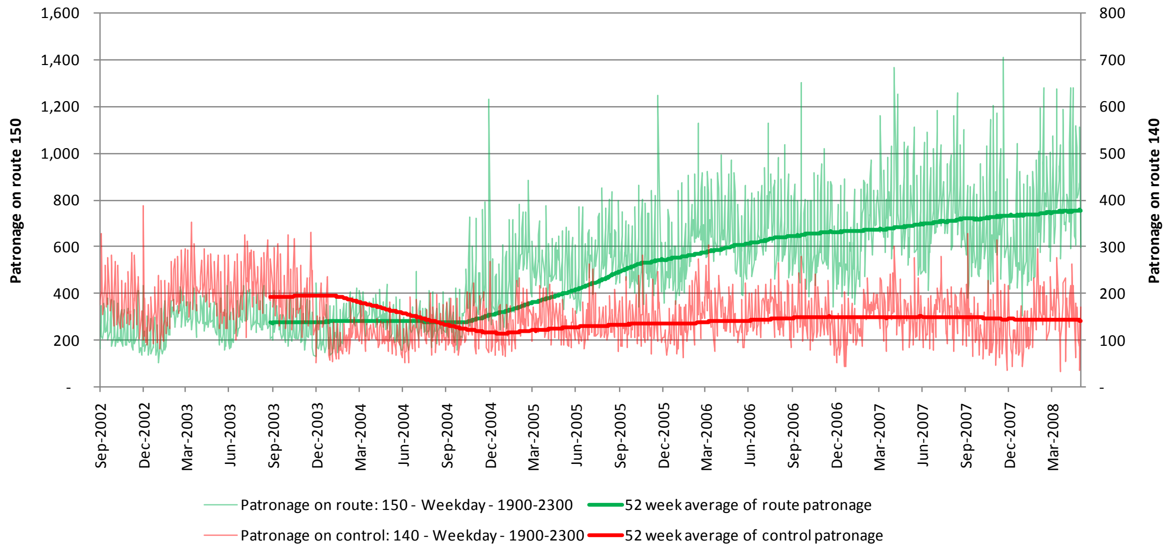
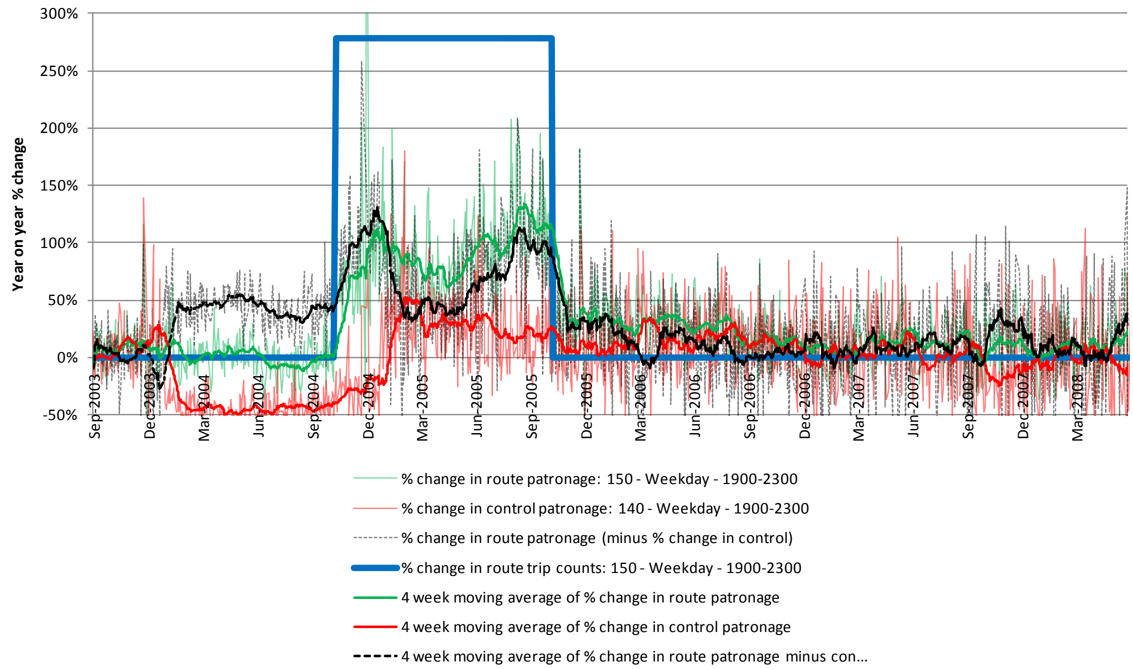


Figure F.10 Patronage growth rates on service route and control routes



F3.3.3 Elasticity estimation – control route method

Figure F.11 Elasticity estimation using control route method

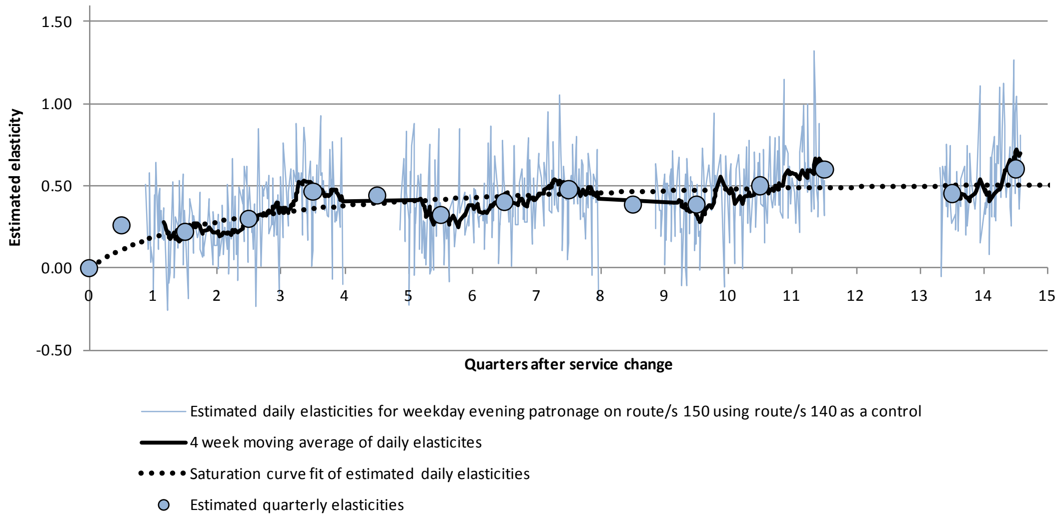


Table F.9 Elasticity estimation using control route method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Nov-04					0.00	0.00
Q1	Feb-05	405	114	1.79	1.28	0.26	0.10
Q2	May-05	547	145	1.80	1.37	0.22	0.24
Q3	Aug-05	520	133	1.89	1.29	0.30	0.31
Q4	Nov-05	593	138	2.18	1.19	0.46	0.36
Q5	Feb-06	514	120	2.45	1.41	0.44	0.39
Q6	May-06	697	162	2.28	1.53	0.32	0.42
Q7	Aug-06	659	147	2.39	1.44	0.40	0.44
Q8	Nov-06	695	158	2.53	1.37	0.48	0.45
Q9	Feb-07	577	122	2.71	1.62	0.38	0.46
Q10	May-07	746	157	2.42	1.49	0.39	0.47
Q11	Aug-07	761	148	2.73	1.44	0.50	0.48
Q12	Nov-07	823	164	2.98	1.39	0.60	0.49
Q13	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.50
Q14	May-08	885	170	2.69	1.51	0.45	0.50
Q15	Aug-08	874	146	3.06	1.44	0.60	0.51
Long run							0.58

Note: The ratio of route trips after the service change compared to prior to the service change was 3.78

Due to the fall in the control route on 27 January 2004, we cannot accurately measure the impact on patronage between the date of the service change (8 November 2004) and the point one year after the fall in the control route patronage (27 January 2005). This means that most of the first quarter of data is missing from figure F.11, along with the first quarters of subsequent years. Some estimates are produced for these quarters (ie Q1, Q5, Q9) but they are not very accurate because they are based on only a few observations.

We note that the September 2007–February 2008 'gash' causes a gap in figure F.11 that starts halfway through Q12 and ends at the beginning of Q14.

F3.3.4 Elasticity estimation –route extrapolation method

An alternative set of elasticity estimates was made based on a 'control' created using an extrapolation growth rate of 1.73% per annum. This was the average growth rate of route 150 for the 52-week period preceding the service change. These estimates are shown in figure F.12 and table F.10.

Figure F.12 Elasticity estimation using extrapolation method

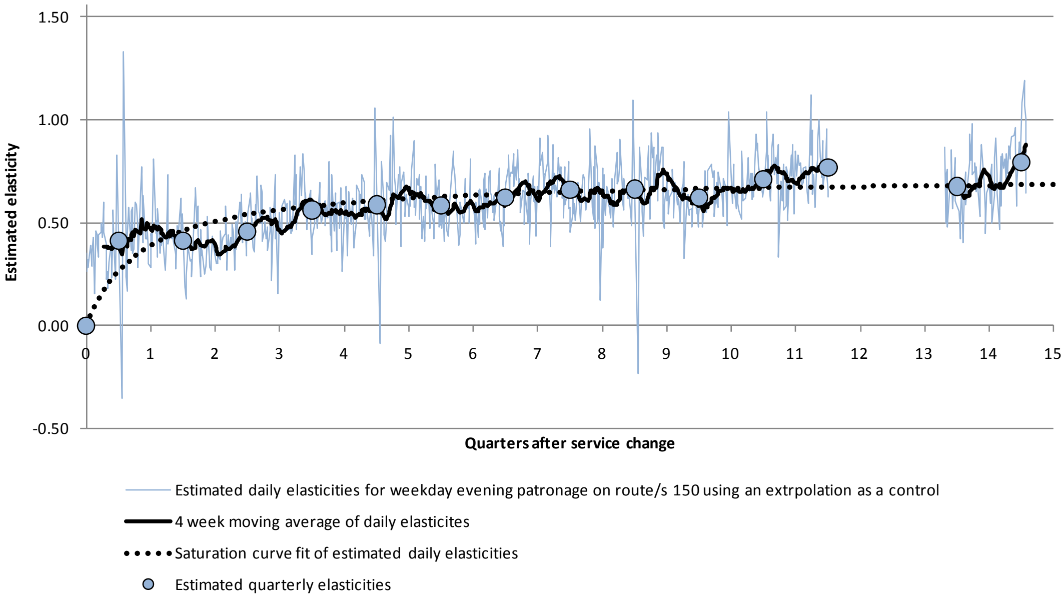


Table F.10 Elasticity estimation using extrapolation method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of extrapolated patronage this quarter to observed patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Nov-04					0.00	0.00
Q1	Feb-05	444	255	1.84	1.02	0.41	0.24
Q2	May-05	541	311	1.79	1.02	0.41	0.46
Q3	Aug-05	519	285	1.89	1.02	0.46	0.54
Q4	Nov-05	594	283	2.17	1.02	0.56	0.58
Q5	Feb-06	560	259	2.32	1.03	0.59	0.61
Q6	May-06	690	318	2.28	1.03	0.58	0.63
Q7	Aug-06	656	290	2.39	1.03	0.62	0.64
Q8	Nov-06	697	288	2.53	1.04	0.66	0.65
Q9	Feb-07	625	261	2.61	1.05	0.66	0.66
Q10	May-07	746	324	2.44	1.05	0.62	0.66
Q11	Aug-07	760	295	2.75	1.05	0.71	0.67
Q12	Nov-07	828	300	2.96	1.05	0.77	0.67
Q13	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.68
Q14	May-08	868	349	2.68	1.07	0.68	0.68
Q15	Aug-08	875	306	3.14	1.07	0.79	0.68
Long run							0.72

Note: The ratio of route trips after the service change compared to prior to the service change was 3.78

F3.3.5 Review and comments

The 'control' elasticity results appear to be reasonably well behaved, despite some data problems with the control route. Compared with the prior period, the control route shows patronage growth from the prior period of around 25%–30% in the first year, and 40%–50% in the second and third years. This suggests that the 'control' elasticity estimates may be on the low side.

The 'extrapolation' elasticity estimates are based on an extrapolation growth rate of 1.7%pa, and hence show higher elasticities with greater increases over time.

F3.3.6 Conclusions

A reasonable 'best estimate' assumption would be to take the mean of the 'control' and 'extrapolation' estimates. This would give the following results:

Q1 0.34, Q2 0.32, Q3 0.38, Q4 0.51

Y2 0.51, Y3 0.58, Y4 0.67.

The corresponding means for the two saturation curves would be:

Q1 0.17, Q2 0.35, Q3 0.43, Q4 0.47

Y2 0.53, Y3 0.57, Y4 0.59.

F3.4 Route 190/199 analysis

F3.4.1 Service change

The service change in February 2006 resulted in service increases from one to four trips per hour (each direction).

Table F.11 Details of service change

Date of service change for route/s 190+199:	Monday, 20 February 2006
Trips before	8
Trips afterwards	32
Ratio	4.00
Control route/s:	375

F3.4.2 Data availability and quantity

There were data problems around the time of the service change. Data for the old route (190) ended on 17 February 2006 and clean data on the new route (199) did not start until 22 May 2006. This was recognised by BT.

As with other routes, the 'gash' causes patronage to dip somewhat around September 2007 to February 2008.

Figure F.13 Patronage on service route and control routes

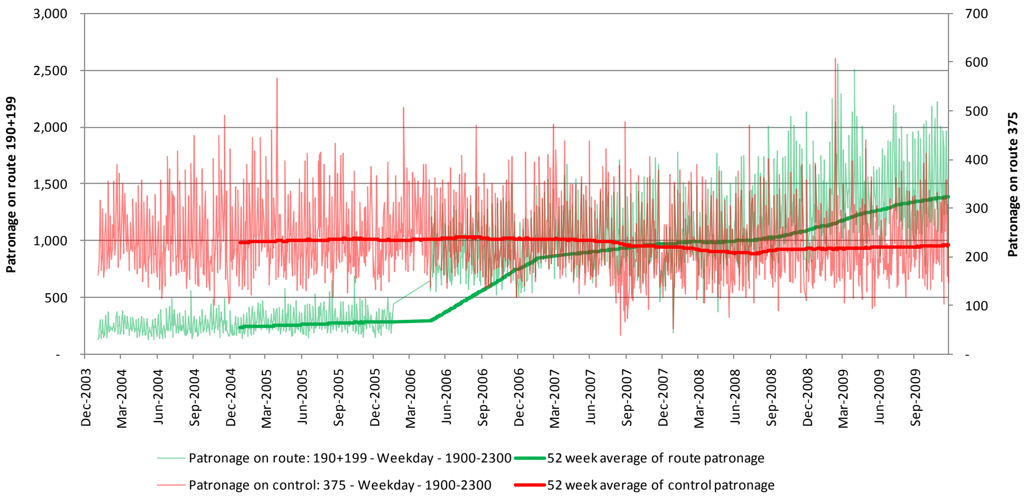
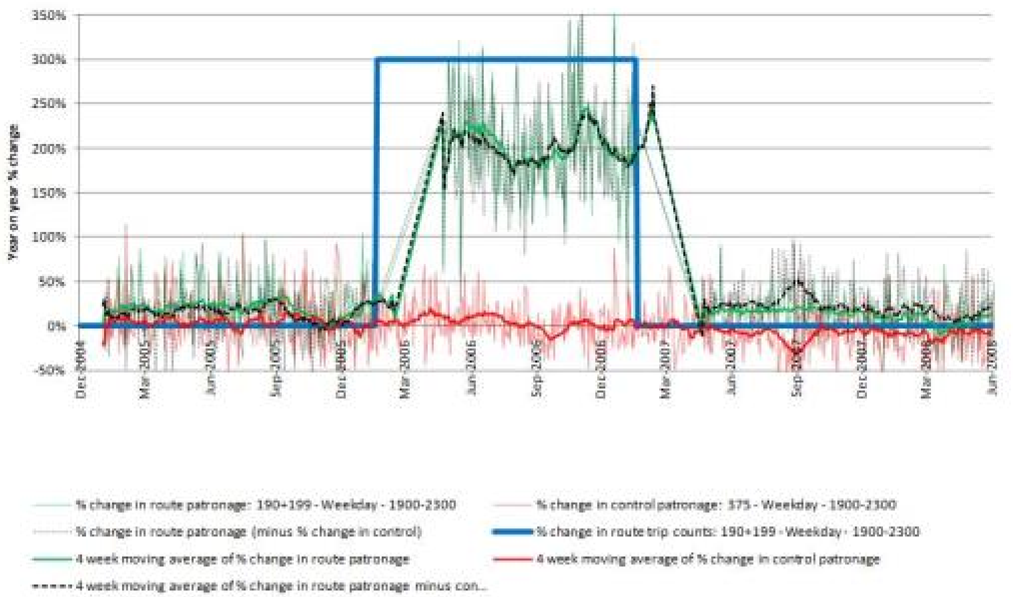


Figure F.14 Patronage growth rates on service route and control routes



F3.4.3 Elasticity estimation – control route method

Figure F.15 Elasticity estimation using control route method

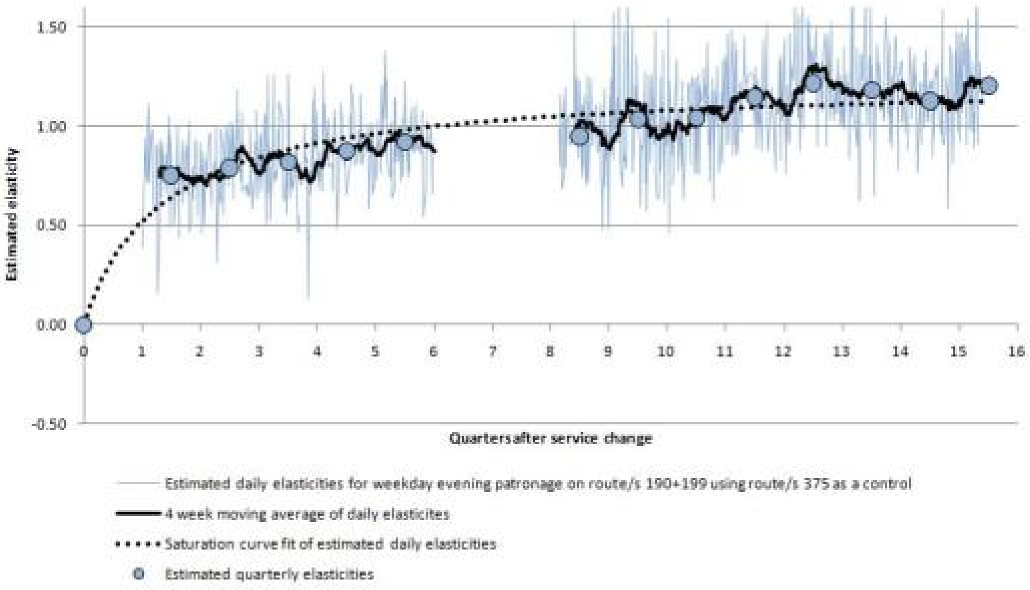


Table F.12 Elasticity estimation using control route method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-06					0.00	0.00
Q1	May-06	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.31
Q2	Aug-06	836	246	3.10	1.09	0.75	0.64
Q3	Nov-06	845	222	2.91	0.98	0.79	0.79
Q4	Feb-07	857	223	3.10	1.01	0.82	0.88
Q5	May-07	1,007	252	3.54	1.06	0.88	0.94
Q6	Aug-07	977	230	3.59	1.01	0.92	0.98
Q7	Nov-07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	1.01
Q8	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	1.04
Q9	May-08	1,003	222	3.50	0.94	0.95	1.06
Q10	Aug-08	1,053	215	3.93	0.96	1.04	1.07
Q11	Nov-08	1,186	221	4.15	0.99	1.04	1.09
Q12	Feb-09	1,286	216	4.67	0.96	1.15	1.10
Q13	May-09	1,436	222	5.04	0.94	1.22	1.11
Q14	Aug-09	1,363	226	5.09	1.01	1.18	1.11
Q15	Nov-09	1,390	232	4.86	1.03	1.13	1.12
Long run							1.23

Note: The ratio of route trips after the service change compared to prior to the service change was 4.00

Figure F.15 shows a gap for the first quarter after the service change; this is due to the fact that clean usable data was not available for route 199 until 22 May 2006, which was about three months after the service change.

Figure F.15 also shows a gap from the start of Q7 to the end of Q8 – the portion of this gap from halfway through quarter 7 to the end of quarter 8 corresponds to the September 2007–February 2008 'gash' which has been deleted hence meaning no elasticities could be estimated during this period. However, there was also an unusual fall in control route (375) patronage at the start of quarter 7, prior to the 'gash'. It is possible that the 'gash' for route 375 started earlier, from around 3 September 2007 (rather than 24 September 2007 as with all the other routes); regardless of the reason, this data has been deleted from figure F.15 and table F.12.

F3.4.4 Elasticity estimation – route extrapolation method

An alternative set of elasticity estimates was made based on a 'control' created using an extrapolation growth rate of 20.87% per annum: this was the average growth rate of route 190 for the 52-week period preceding the service change. The results are given in table F.13 and figure F.16.

The estimates provided in figure F.16 and table F.13 assume that patronage would have continued to grow at 20.87% per annum in the absence of a service improvement.

This appears to be a very high 'business as usual' patronage growth rate. Therefore, we think that the estimates in the last column of table F.13 (approaching 0.7) probably underestimate the true impact of the service enhancements. We give more weight to the table F.12 results which are higher (approaching 1.2).

However, both the table F.12 and table F.13 results are possibly distorted by 'abstraction' of patronage off routes 191 (before) and 196 (after). Section F3.5 following addresses this issue by including routes 191 and 196 in the elasticity estimation.

Figure F.16 Elasticity estimation using extrapolation method

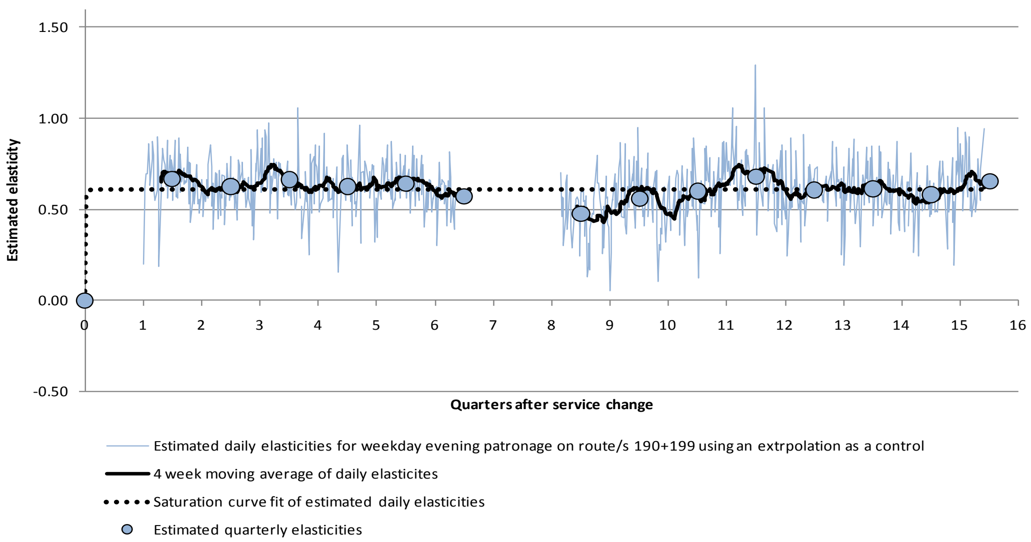


Table F.13 Elasticity estimation using extrapolation method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of extrapolated patronage this quarter to observed patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-06					0.00	0.00
Q1	May-06	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.61
Q2	Aug-06	836	340	3.10	1.21	0.67	0.61
Q3	Nov-06	845	361	2.91	1.21	0.63	0.61
Q4	Feb-07	857	344	3.10	1.21	0.66	0.61
Q5	May-07	1,007	429	3.54	1.46	0.62	0.61
Q6	Aug-07	977	411	3.59	1.46	0.64	0.61
Q7	Nov-07	1,007	463	3.28	1.46	0.57	0.61
Q8	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.61
Q9	May-08	1,003	516	3.50	1.77	0.48	0.61
Q10	Aug-08	1,053	497	3.93	1.77	0.56	0.61
Q11	Nov-08	1,186	527	4.15	1.77	0.60	0.61
Q12	Feb-09	1,286	510	4.67	1.77	0.68	0.61
Q13	May-09	1,436	624	5.04	2.13	0.61	0.61
Q14	Aug-09	1,363	600	5.09	2.13	0.61	0.61
Q15	Nov-09	1,390	637	4.86	2.13	0.58	0.61
Long run							0.61

Note: The ratio of route trips after the service change compared to prior to the service change was 4.00

F3.4.5 Review and comments

The 'control' elasticity estimates appear to be reasonably well behaved (noting data problems in Q1 and Q7/8). The control route patronage trends are also well behaved, with very small changes (always within ±10% of the prior quarter figures), particularly relative to the large change in the 190/199 route patronage.

The 'extrapolation' elasticity estimates are based on an extrapolation rate of 20.9% pa. This would appear to be on the high side, in terms of a continuing rate over the four-year period after the service change. We would therefore give greater weight to the 'control' elasticity estimates.

F3.4.6 Conclusions

For routes 190/199 above, we adopt the 'control' elasticity estimates as the best estimates available.

These estimates are relatively high, suggesting that a significant proportion of the patronage increase might be abstracted from other routes. This is tested through examining the wider group of routes (190/191 Before, 196/199 After) in the next section.

F3.5 Route 190+191/196+199 analysis

This analysis covers the same service change as the previous analysis (section F3.4), but also incorporates patronage changes on routes 191 (before) and 196 (after), in order to allow for any 'abstraction' effects.

F3.5.1 Service change

As with the 190/199, the service change was on Mon 20 February 2006. For the 190 + 191 routes (before) and the 196 + 199 routes (after), the effective service frequency increase was nearly 200%, from two trips per hour to nearly six trips per hour (each direction).

Table F.14 Details of service change

Date of service change for route/s 190+191+196+199:	Monday, 20 February 2006
Trips before	16
Trips afterwards	47
Ratio	2.94
Control route/s:	375

F3.5.2 Data availability and quantity

As with previous routes, there was a 'gash' in the data from Mon 24 September 2007 to Fri 29 February 2008.

Figure F.17 Patronage on service route and control routes

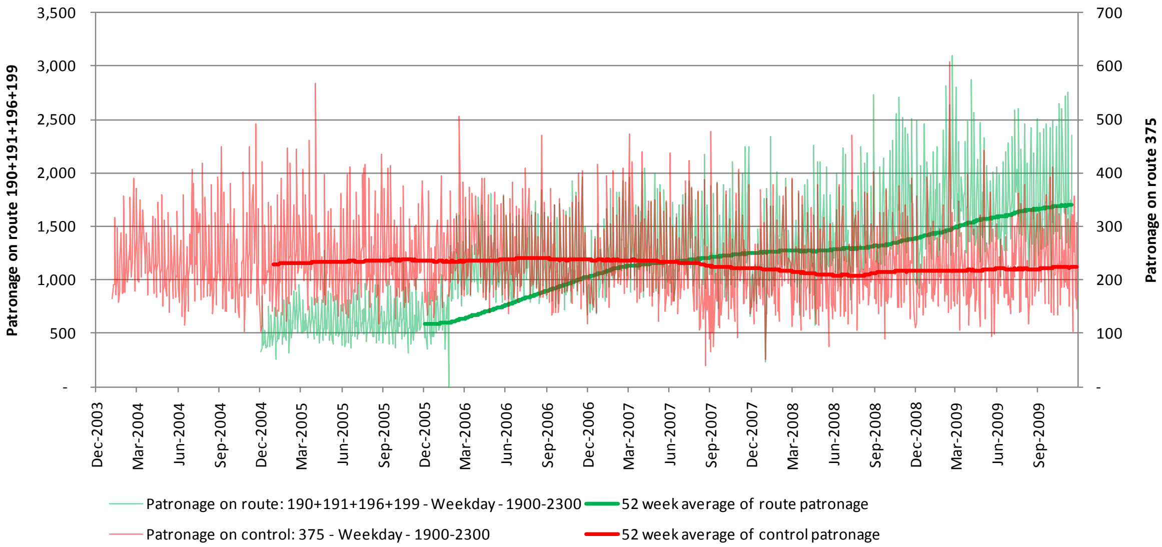
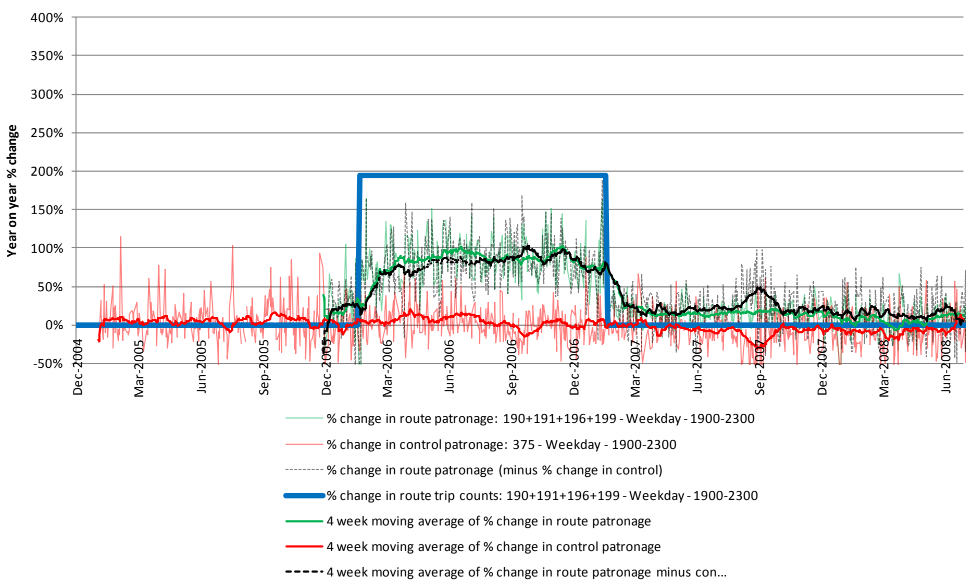


Figure F.18 Patronage growth rates on service route and control routes



F3.5.3 Elasticity estimation – control route method

Figure F.19a and table F.15a show the elasticity estimates using the control route method. As previously (refer section 3.4.3) elasticities for quarters 7 and 8 could not be estimated due to the September 2007–February 2008 'gash' in the data.

It is notable that the route patronage appeared to continue to increase strongly for at least three years after the service change (refer figure F.19a). This pattern of response is unusual and may well be the result of factors other than the service change. We have therefore made an alternative assessment of the saturation curve, based on data up to/including Q6 only – this is shown in figure F.19b and table F.15b: it results in a more typical shape for the saturation curve.

Figure F.19a Elasticity estimation using control route method – all data

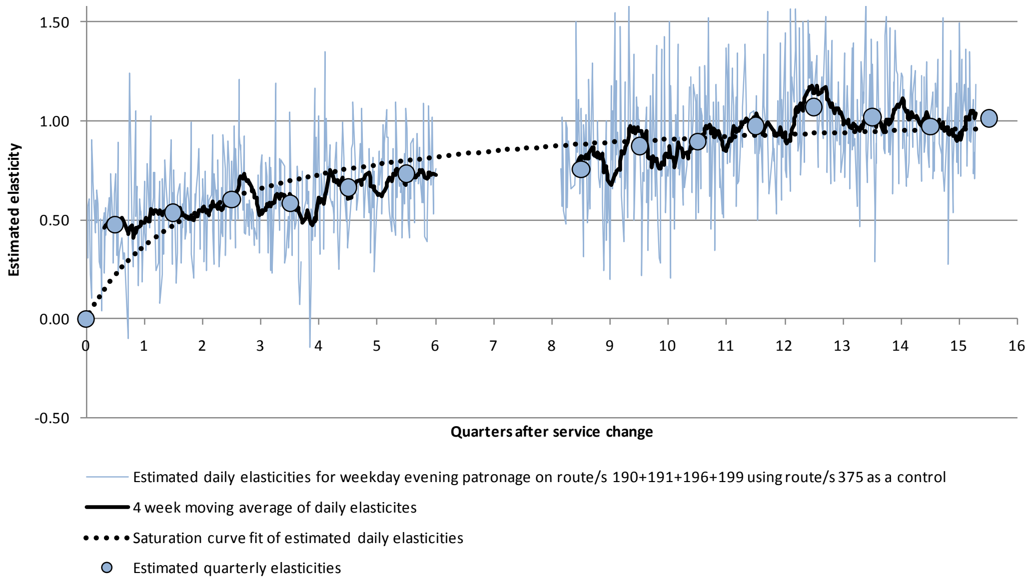


Figure F.19b Elasticity estimation using control route method – up to Q6 only

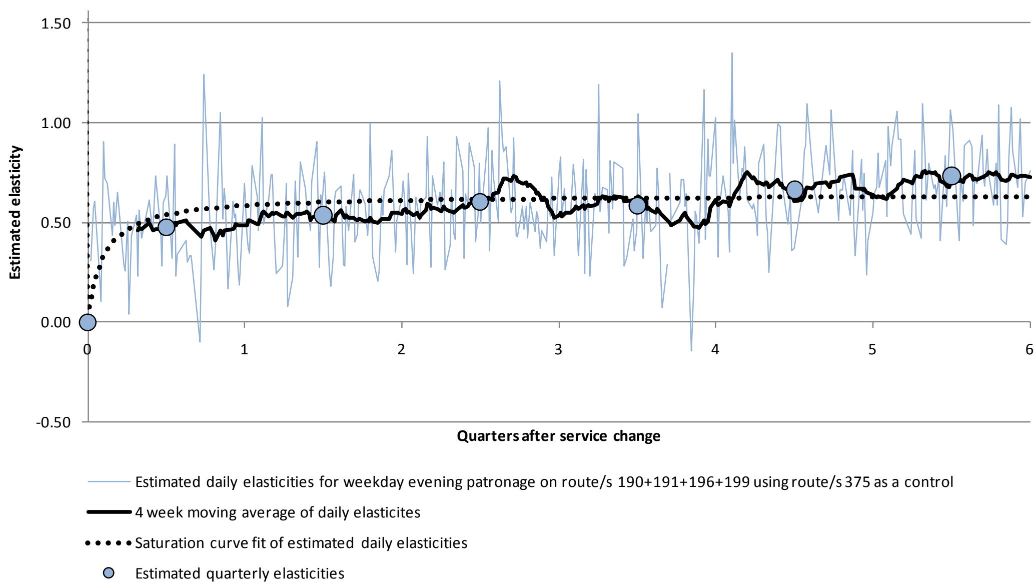


Table F.15a Elasticity estimation using control route method – all data

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-06					0.00	0.00
Q1	May-06	1,085	257	1.79	1.08	0.48	0.21
Q2	Aug-06	1,100	246	1.93	1.09	0.54	0.47
Q3	Nov-06	1,104	222	1.86	0.98	0.60	0.61
Q4	Feb-07	1,115	223	1.86	1.01	0.58	0.70
Q5	May-07	1,295	252	2.15	1.06	0.66	0.76
Q6	Aug-07	1,256	230	2.19	1.01	0.73	0.80
Q7	Nov-07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.83
Q8	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.86
Q9	May-08	1,292	222	2.10	0.94	0.76	0.88
Q10	Aug-08	1,345	215	2.37	0.96	0.87	0.90
Q11	Nov-08	1,501	221	2.56	0.99	0.90	0.91
Q12	Feb-09	1,627	216	2.72	0.96	0.98	0.93
Q13	May-09	1,779	222	2.95	0.94	1.07	0.94
Q14	Aug-09	1,665	226	2.94	1.01	1.02	0.95
Q15	Nov-09	1,701	232	2.88	1.03	0.97	0.96
Q16	#N/A	1,818	237	3.00	1.02	1.01	0.96
Long run							1.08

Note: The ratio of route trips after the service change compared to prior to the service change was 2.94

Table F.15b Elasticity estimation using control route method – up to Q6 only

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-06					0.00	0.00
Q1	May-06	1,085	257	1.79	1.08	0.48	0.49
Q2	Aug-06	1,100	246	1.93	1.09	0.54	0.60
Q3	Nov-06	1,104	222	1.86	0.98	0.60	0.62
Q4	Feb-07	1,115	223	1.86	1.01	0.58	0.62
Q5	May-07	1,295	252	2.15	1.06	0.66	0.63
Q6	Aug-07	1,256	230	2.19	1.01	0.73	0.63
Long run							0.64

Note: The ratio of route trips after the service change compared to prior to the service change was 2.94

F3.5.4 Elasticity estimation – route extrapolation method

Note that a figure and table could not be created for routes 190 + 191/196+199 because there was not a year's worth of route patronage data prior to the service change; therefore we could not establish annual growth rates to use as a basis for extrapolation.

F3.5.5 Review and comments

Given the balance of evidence, we adopted the results of the control route analyses up to period six only as giving the best saturation curve estimates. We ignored the elasticity estimates after this period as being unreliable (likely to be affected by other factors).

F3.5.6 Conclusions

This gives the following results based on the actual quarterly estimates:

Q1 0.48, Q2 0.54, Q3 0.60, Q4 0.58

Y2 0.70

The corresponding mean saturation estimates are:

Q1 0.49, Q2 0.60, Q3 0.62, Q4 0.62

Y2 0.63, Y3 0.63, Y4 0.64.

F3.6 Route 200 analysis

F3.6.1 Service change

The service change occurred on 18 April 2005, with services increasing by some 220%, from 1.25 trips per hour to 4.0 trips per hour (average each direction).

Table F.16 Details of service change

Date of service change for route/s 200:	Monday, 18 April 2005
Trips before	10
Trips afterwards	32
Ratio	3.20
Control route/s:	210+212

F3.6.2 Data availability and quantity

As with previous routes, there was a 'gash' in the data from Mon 24 September 2007 to Fri 29 February 2008.

Figure F.20 Patronage on service route and control routes

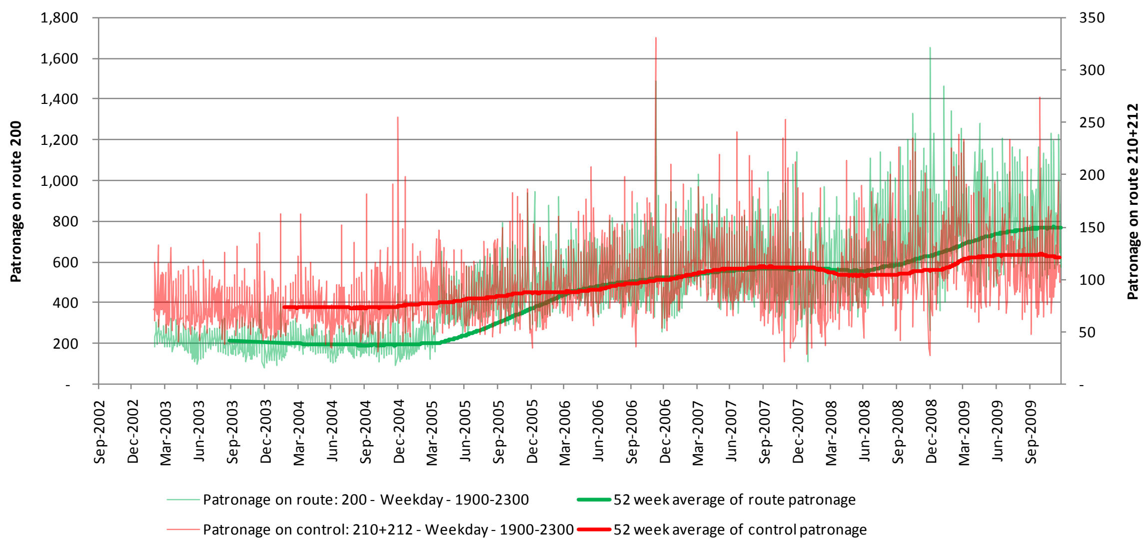
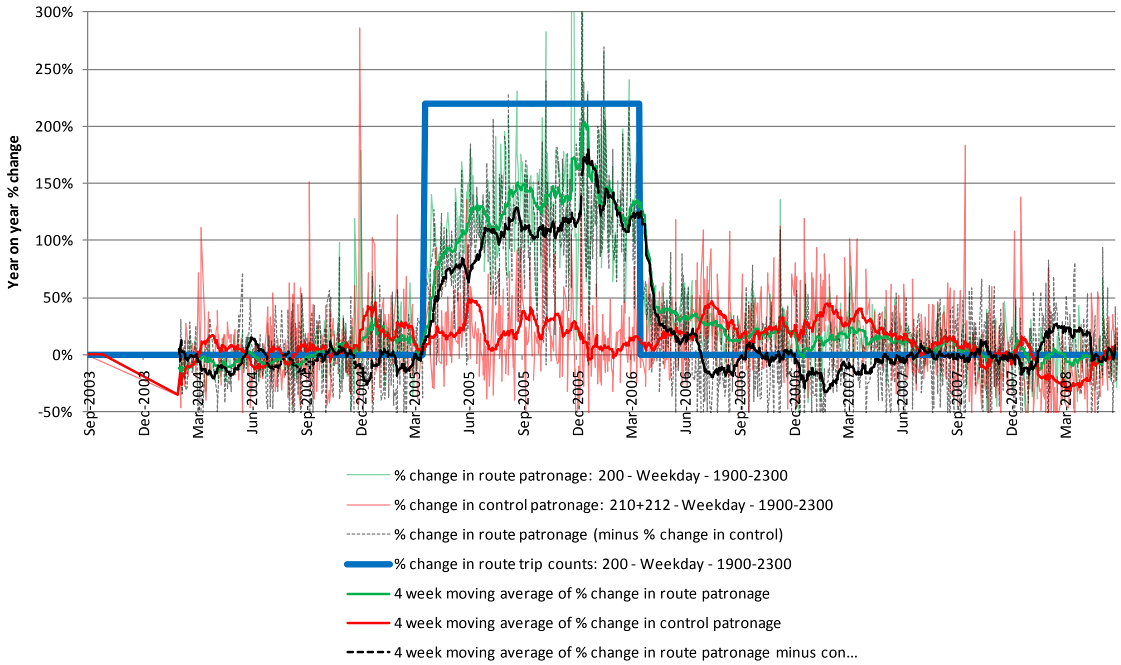


Figure F.21 Patronage growth rates on service route and control routes



F3.6.3 Elasticity estimation – the control route method

Figure F.22 Elasticity estimation using control route method

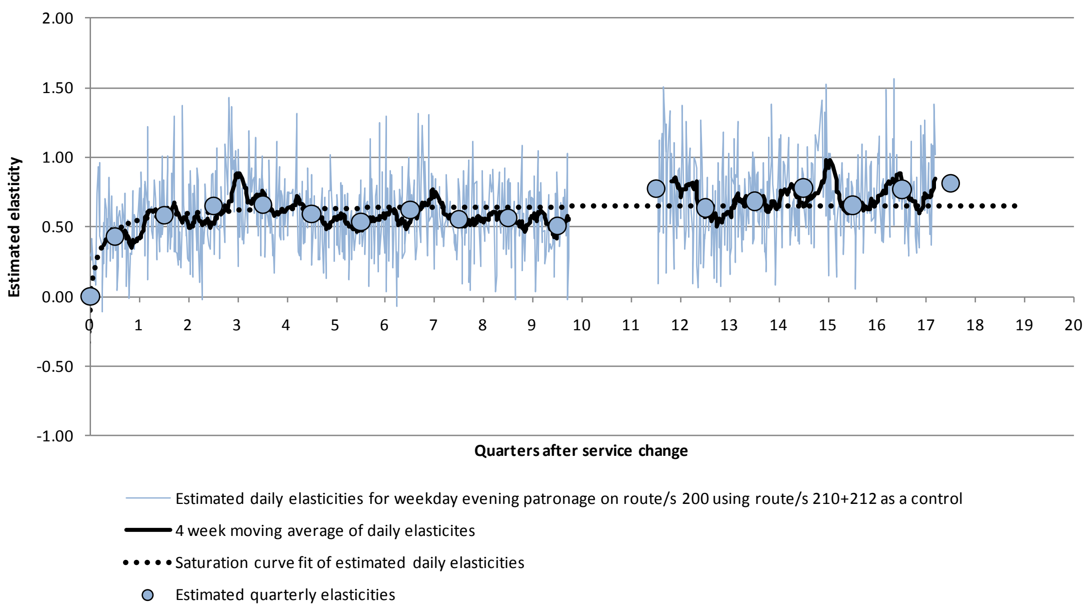


Table F.17 Elasticity estimation using control route method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Apr-05					0.00	0.00
Q1	Jul-05	379	87	2.06	1.27	0.43	0.42
Q2	Oct-05	454	86	2.31	1.21	0.58	0.58
Q3	Jan-06	476	93	2.54	1.21	0.65	0.61
Q4	Apr-06	495	87	2.31	1.08	0.66	0.62
Q5	Jul-06	512	98	2.78	1.43	0.59	0.63
Q6	Oct-06	536	106	2.72	1.50	0.53	0.64
Q7	Jan-07	546	108	2.85	1.43	0.62	0.64
Q8	Apr-07	576	114	2.67	1.41	0.55	0.64
Q9	Jul-07	584	114	3.14	1.66	0.56	0.64
Q10	Oct-07	579	119	2.89	1.64	0.51	0.65
Q11	Jan-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.65
Q12	Apr-08	581	88	2.49	1.06	0.78	0.65
Q13	Jul-08	572	105	3.13	1.56	0.64	0.65
Q14	Oct-08	696	117	3.56	1.66	0.68	0.65
Q15	Jan-09	755	125	4.12	1.67	0.78	0.65
Q16	Apr-09	776	135	3.57	1.67	0.66	0.65
Long run							0.66

Note: The ratio of route trips after the service change compared to prior to the service change was 3.20

F3.6.4 Elasticity estimation – route extrapolation method

An alternative set of elasticity estimates was made based on a 'control' created using an extrapolation growth rate of 3.25% per annum: this was the average growth rate of route 200 for the 52 weeks preceding the service change. The results are given in figure F.23 and table F.18.

Figure F.23 Elasticity estimation using extrapolation method

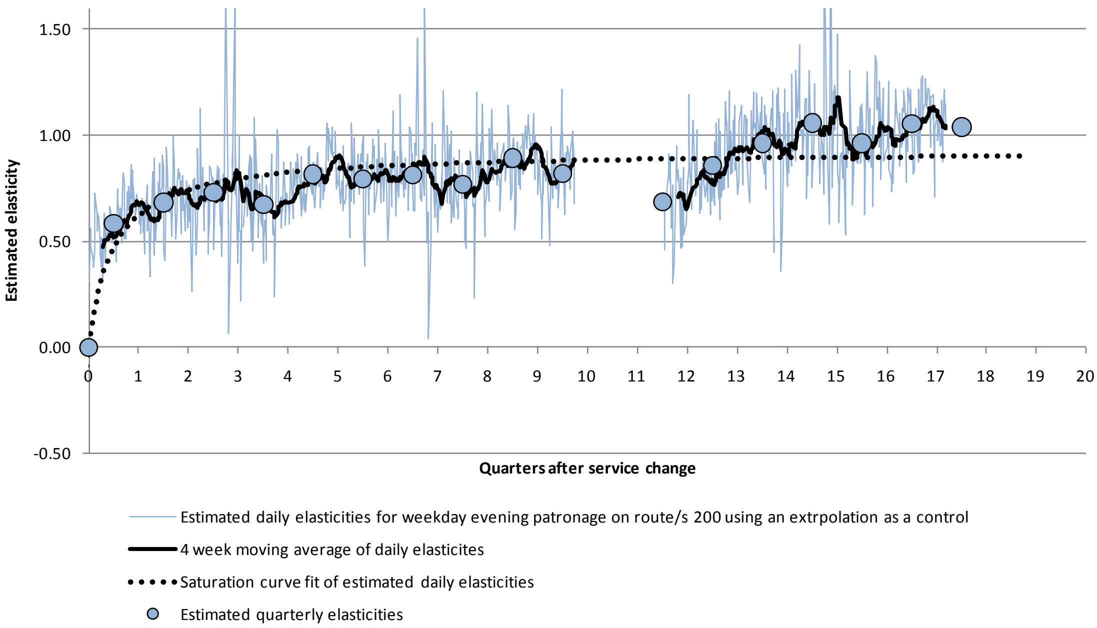


Table F.18 Elasticity estimation using extrapolation method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of extrapolated patronage this quarter to observed patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Apr-05					0.00	0.00
Q1	Jul-05	379	192	2.06	1.03	0.58	0.42
Q2	Oct-05	454	206	2.31	1.03	0.68	0.69
Q3	Jan-06	476	204	2.54	1.03	0.73	0.77
Q4	Apr-06	495	228	2.31	1.03	0.67	0.81
Q5	Jul-06	512	199	2.78	1.07	0.82	0.84
Q6	Oct-06	536	212	2.72	1.07	0.79	0.85
Q7	Jan-07	546	211	2.85	1.07	0.81	0.86
Q8	Apr-07	576	236	2.67	1.07	0.77	0.87
Q9	Jul-07	584	205	3.14	1.10	0.89	0.88
Q10	Oct-07	579	222	2.89	1.10	0.82	0.88
Q11	Jan-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.88
Q12	Apr-08	581	262	2.49	1.10	0.69	0.89
Q13	Jul-08	572	211	3.13	1.14	0.86	0.89
Q14	Oct-08	696	226	3.56	1.14	0.96	0.89
Q15	Jan-09	755	221	4.12	1.14	1.06	0.90
Long run							0.93

Note: The ratio of route trips after the service change compared to prior to the service change was 3.20

F3.6.5 Review and comments

The ‘control’ elasticity estimates appear to be reasonably well behaved; elasticity values appear to reach close to saturation after four quarters, but then with some indications of further growth after year three. The control route patronage generally appears to be growing at around 20% pa over most of the data period, generally faster than route 200 (except for the first year after the service change). This suggests that the ‘control’ elasticity estimates should be treated with caution, particularly after year one.

The ‘extrapolation’ elasticity estimates are based on an extrapolation growth rate of 3.3% pa, much lower than the control route patronage growth. This results in considerably higher elasticities beyond the initial period, and a much slower approach to saturation.

F3.6.6 Conclusions

A reasonable best estimate in this case would be to take the mean of the ‘control’ and the ‘extrapolation’ estimates. This would give the following results based on the actual estimates:

Q1 0.51, Q2 0.63, Q3 0.69, Q4 0.67

Y2 0.69, Y3 0.71, Y4 0.82

The corresponding mean saturation estimates would be:

Q1 0.51, Q2 0.64, Q3 0.68, Q4 0.70

Y2 0.72, Y3 0.74, Y4 0.74.

F3.7 Route 345 analysis

F3.7.1 Service change

The service change occurred on 20 February 2006, with services increasing by over 300%, from one trip per hour to over four trips per hour (each direction).

Table F.19 Details of service change

Date of service change for route/s 345:	Monday, 20 February 2006
Trips before	8
Trips afterwards	33
Ratio	4.13
Control route/s:	330

F3.7.2 Data availability and quantity

The data series began 5 January 2004 and went until 16 May 2008. The data from 18 May 2008 onwards was not provided due to major restructuring when the busway opened under the CBD.

We have slightly more than two years of data following the service change in February 2006.

As with previous routes, there was a 'gash' in the data from Mon 24 September 2007 to Fri 29 February 2008.

Figure F.24 Patronage on service route and control routes

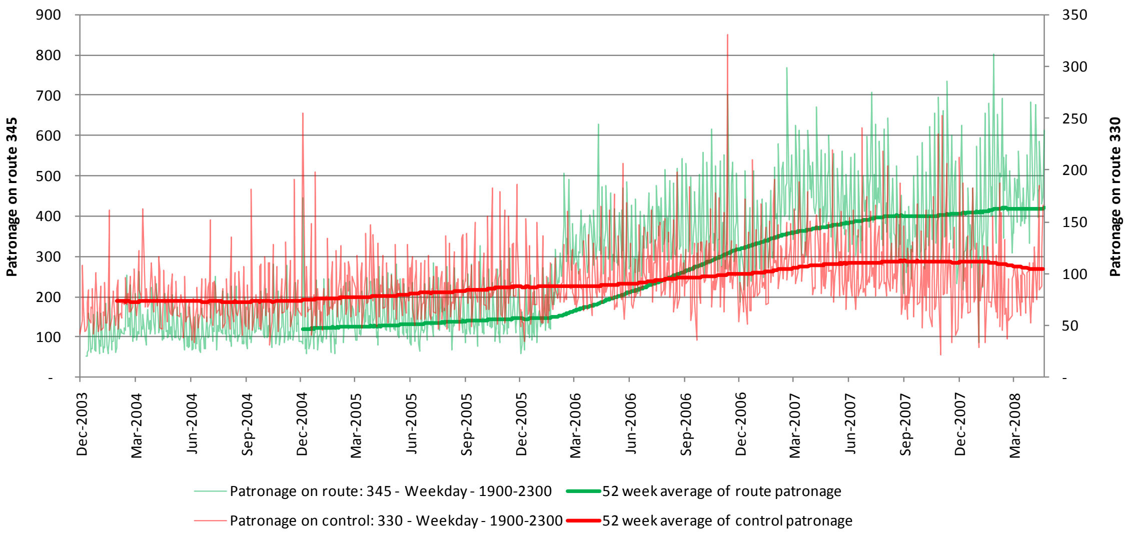
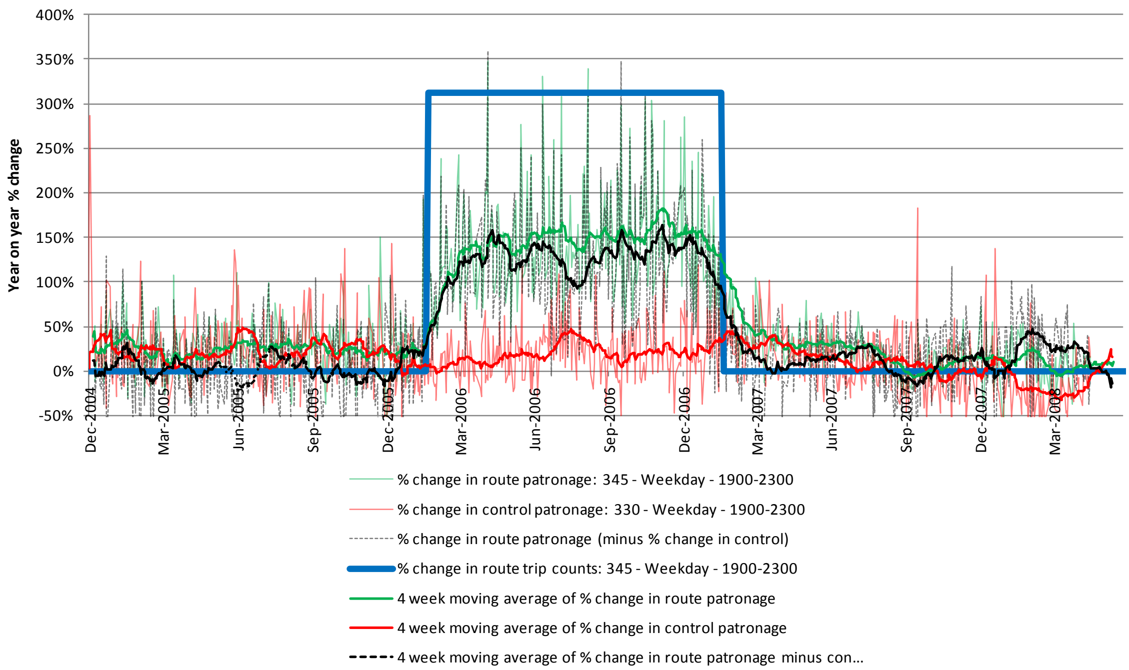


Figure F.25 Patronage growth rates on service route and control routes



F3.7.3 Elasticity estimation – control route method

Figure F.26 Elasticity estimation using control route method

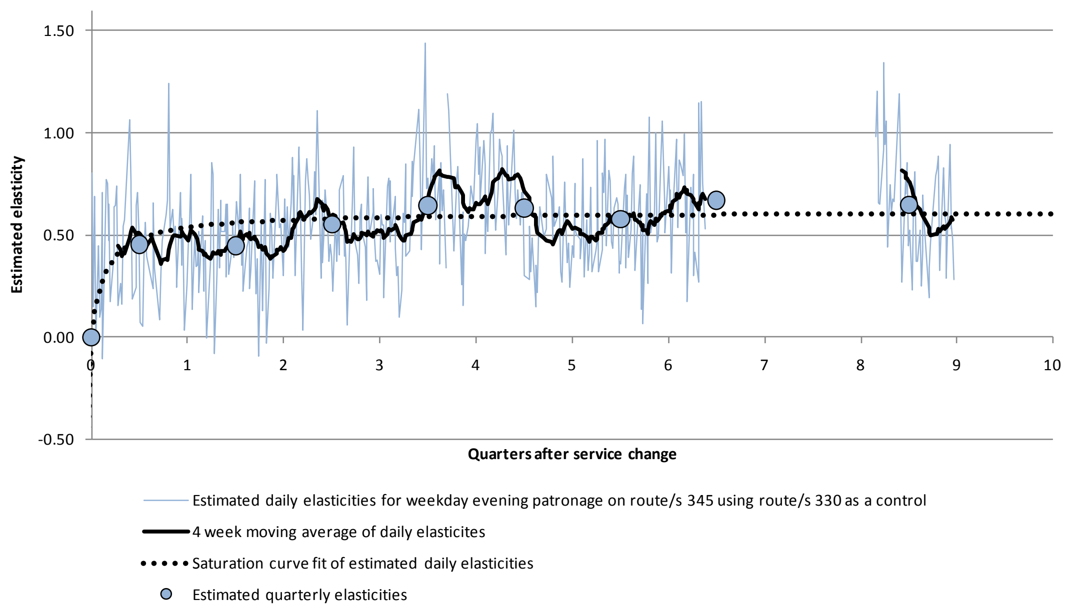


Table F.20 Elasticity estimation using control route method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-06					0.00	0.00
Q1	May-06	326	113	2.30	1.24	0.45	0.43
Q2	Aug-06	336	106	2.47	1.32	0.45	0.56
Q3	Nov-06	366	101	2.54	1.18	0.55	0.58
Q4	Feb-07	346	98	2.53	1.04	0.64	0.59
Q5	May-07	446	122	3.14	1.32	0.63	0.59
Q6	Aug-07	434	115	3.19	1.42	0.58	0.60
Q7	Nov-07	393	101	2.73	1.07	0.67	0.60
Q8	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.60
Q9	May-08	462	123	3.26	1.32	0.65	0.60
Long run							0.61

Note: The ratio of route trips after the service change compared to prior to the service change was 4.13

F3.7.4 Elasticity estimation – route extrapolation method

An alternative set of elasticity estimates was made, based on a 'control' created using an extrapolation of 23.66% per annum; this is the average growth rate of route 345 for the 52-week period preceding the service change.

Figure F.27 Elasticity estimation using extrapolation method

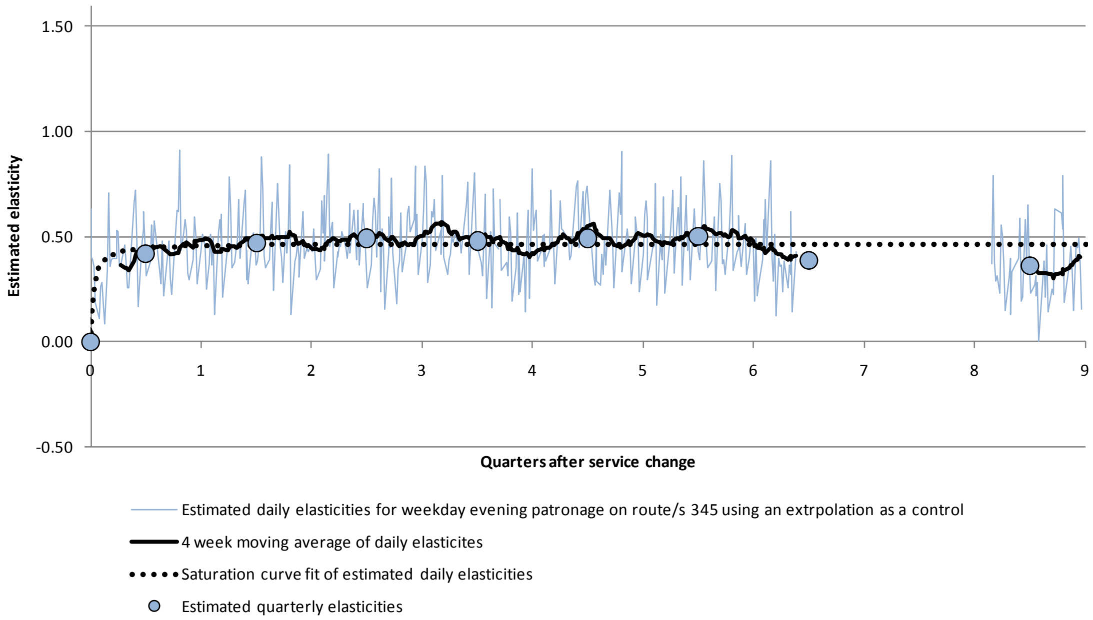


Table F.21 Elasticity estimation using extrapolation method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of extrapolated patronage this quarter to observed patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-06					0.00	0.00
Q1	May-06	326	184	2.30	1.24	0.42	0.42
Q2	Aug-06	336	179	2.47	1.24	0.47	0.46
Q3	Nov-06	366	189	2.54	1.24	0.49	0.46
Q4	Feb-07	346	181	2.53	1.24	0.48	0.46
Q5	May-07	446	228	3.14	1.53	0.49	0.47
Q6	Aug-07	434	222	3.19	1.53	0.50	0.47
Q7	Nov-07	393	232	2.73	1.53	0.39	0.47
Q8	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.47
Q9	May-08	462	284	3.26	1.89	0.36	0.47
Long run							0.47

Note: The ratio of route trips after the service change compared to prior to the service change was 4.13

However, it seems unlikely that patronage on the route 200 would have continued to grow at this rate in the absence of service changes. Therefore, the estimates in figure F.27 and table F.21 most likely underestimate the true impact of the service change.

F3.7.5 Review and comments

The 'control' dataset and elasticity estimates appear to be reasonably well behaved. Prior to the service change, the growth rates for the control route and route 345 were very similar (in the order of 20% pa), while by around two years after the service change they also became very similar again (suggesting effective saturation within about two years of the change).

The 'extrapolation' elasticity estimates are based on an extrapolation growth rate of 23.7% pa, and hence result in somewhat lower elasticities and some suggestion of decreasing values in the later part of the analysis period.

F3.7.6 Conclusions

We adopted the 'control' elasticity estimates as the most plausible values in this case.

F3.8 Summary of weekday evening results

Section F3 has analysed the impacts of five sets of service changes in weekday evenings. In two of these cases (route 140 and routes 190/199), the elasticities are 'abnormally' high, suggesting significant abstraction of passengers from competing routes. Our additional analyses, incorporating these competing routes, resulted in more 'normal' elasticities in both cases.

All the elasticity estimates derived are summarised in table F.22. This gives quarterly elasticity values for the first 12 months, then annual average values thereafter. Estimates derived from both the control route method and the extrapolation method are given, for both the actual best estimates and the saturation curve estimates.

Based on inspection of the data for each route (as discussed earlier), the estimates judged to be 'best' in each case are highlighted (in bold).

Further discussion of the findings is given in section F6, and in the main report section 4.6 and chapter 5..

Table F.22 Results summary– weekday (1900–2300) evenings

Route/s	Date of service change	Initial freq. per hr (ave dirn)	% freq. increase	Control/s		Q1	Q2	Q3	Q4	Q5–Q8 (2nd year)	Q9–Q12 (3rd year)	Q13-Q16 (4th year)	Long-run	Comment
140	23 February 2009	1.125	256%	120+170+180	Estimated elasticities:	0.88	1.11	0.97	0.88!	#N/A	#N/A	#N/A	#N/A	This elasticity of nearly 1.0 does not allow for patronage abstracted from the 130.
					Saturation curve fit:	0.87	0.87	0.97	0.98	#N/A	#N/A	#N/A	0.99	
				Extrapolation	Estimated elasticities:	1.09	1.19	1.09	0.95!	#N/A	#N/A	#N/A	#N/A	
					Saturation curve fit:	1.07	1.11	1.12	1.12	#N/A	#N/A	#N/A	1.12	
130+140 *	23 February 2009	5.75	50%	120+170+180	Estimated elasticities:	0.36	0.41	0.37	0.33!	#N/A	#N/A	#N/A	#N/A	These elasticity values are more 'normal', as they allow for the overall patronage effects on 130 and 140. The extrapolation elasticities are less reliable than the control estimates, as the elasticity appears to decrease over time. Refer section F3.2.
					Saturation curve fit:	0.29	0.39	0.41	0.41	#N/A	#N/A	#N/A	0.44	
				Extrapolation	Estimated elasticities:	0.95	0.80	0.69	0.49!	#N/A	#N/A	#N/A	#N/A	
					Saturation curve fit:	0.77	0.77	0.77	0.77	#N/A	#N/A	#N/A	0.77	
150	8 November 2004	1.125	278%	140	Estimated elasticities:	**0.26**	**0.22**	**0.30**	**0.46**	**0.41**	**0.47**	**0.53**	**#N/A**	Reasonable best estimate is mean of 'control' and 'extrapolation' values.
					Saturation curve fit:	**0.10**	**0.24**	**0.31**	**0.36**	**0.42**	**0.48**	**0.50**	**0.58**	
				Extrapolation	Estimated elasticities:	**0.41**	**0.41**	**0.46**	**0.56**	**0.61**	**0.69**	**0.74**	**#N/A**	
					Saturation curve fit:	**0.24**	**0.46**	**0.54**	**0.58**	**0.63**	**0.67**	**0.68**	**0.72**	

Route/s	Date of service change	Initial freq. per hr (ave dirn)	% freq. increase	Control/s		Q1	Q2	Q3	Q4	Q5–Q8 (2nd year)	Q9–Q12 (3rd year)	Q13-Q16 (4th year)	Long-run	Comment
190/199	20 February 2006	1.0	300%	375	Estimated elasticities:	#N/A	**0.75**	**0.79**	**0.82**	**0.90**	**1.04**	**1.18**	#N/A	These elasticity values are abnormally high, as they do not allow for patronage abstracted from route 191/196.
					Saturation curve fit:	**0.31**	**0.64**	**0.79**	**0.88**	**0.99**	**1.08**	**1.12**	**1.23**	
				Extrapolation	Estimated elasticities:	N/A	0.67	0.63	0.66	0.61	0.58	0.60	#N/A	
					Saturation curve fit:	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	
190+191 / 196+199 *	20 February 2006	2.0	194%	375	Estimated elasticities:	0.48	0.54	0.60	0.58	0.70	0.88	1.02	#N/A	These elasticities are more 'normal' than those for the 190/199 alone. However, they show a continuing strong increase in patronage for at least 3 years after the service change, which seems most likely attributable to other factors.
					Saturation curve fit:	0.21	0.47	0.61	0.70	0.81	0.91	0.95	1.08	
				Extrapolation	Estimated elasticities:	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
					Saturation curve fit:	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
190+191 / 196+199 * (cut off at Q6 ie 20 August 2007)	20 February 2006	2.0	194%	375	Estimated elasticities:	0.48	0.54	0.60	0.58	0.70	#DIV/0!	#DIV/0!	#N/A	Modification of the above results to ignore any data after Q6 – considered to give more plausible results for the saturation curve.
					Saturation curve fit:	0.49	0.60	0.62	0.62	0.63	0.63	0.64	0.64	
				Extrapolation	Estimated elasticities:	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
					Saturation curve fit:	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	

Route/s	Date of service change	Initial freq. per hr (ave dirn)	% freq. increase	Control/s		Q1	Q2	Q3	Q4	Q5–Q8 (2nd year)	Q9–Q12 (3rd year)	Q13-Q16 (4th year)	Long-run	Comment
200	18 April 2005	1.25	220%	210+212	Estimated elasticities:	**0.43**	**0.58**	**0.65**	**0.66**	**0.58**	**0.62**	**0.69**	**#N/A**	Reasonable best estimate is the mean of the of 'control' and 'extrapolation 'estimates.
					Saturation curve fit:	**0.59**	**0.59**	**0.59**	**0.59**	**0.59**	**0.59**	**0.59**	**0.59**	
				Extrapolation	Estimated elasticities:	**0.58**	**0.68**	**0.73**	**0.67**	**0.80**	**0.80**	**0.96**	**#N/A**	
					Saturation curve fit:	**0.42**	**0.69**	**0.77**	**0.81**	**0.85**	**0.88**	**0.89**	**0.93**	
345	20 February 2006	1.0	313%	330	Estimated elasticities:	**0.45**	**0.45**	**0.55**	**0.64**	**0.63**	#N/A	#N/A	#N/A	The control method produces the more plausible elasticities. The elasticity estimates produced based on an extrapolation of 24% growth are almost certainly underestimates.
					Saturation curve fit:	**0.43**	**0.56**	**0.58**	**0.59**	**0.60**	#N/A	#N/A	**0.61**	
				Extrapolation	Estimated elasticities:	0.42	0.47	0.49	0.48	0.46	#N/A	#DIV/0!	#N/A	
					Saturation curve fit:	0.42	0.46	0.46	0.46	0.47	0.47	0.47	0.47	

* Note – the route of interest was expanded to include routes where there were no service enhancements so we could explore 'abstraction' effects.

! Note – these quarters included only about one month of data, due to the data ending partway through the quarter. Hence, less weight should be given to these quarters.

F4 Saturday analyses

F4.1 Route 140 analysis

F4.1.1 Service change

The service change in February 2009 resulted in a doubling of service frequency on route 140, from two trips per hour to four trips per hour (each direction).

Table F.23 Details of service change

Date of service change for route/s 140:	Saturday, 28 February 2009
Trips before	32
Trips afterwards	64
Ratio	2.00
Control route/s:	120+170+180

F4.1.2 Data availability and quantity

As with previous routes, there was a 'gash' in the data from Sat 29 September 2007 to Sat 23 February 2008.

Figure F.28 Patronage on service route and control routes

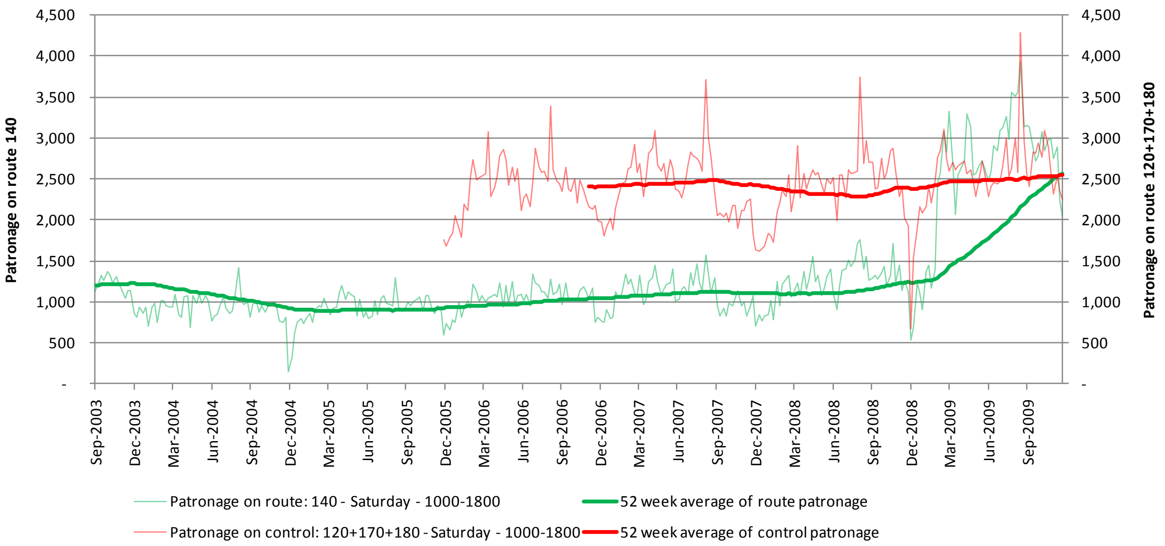
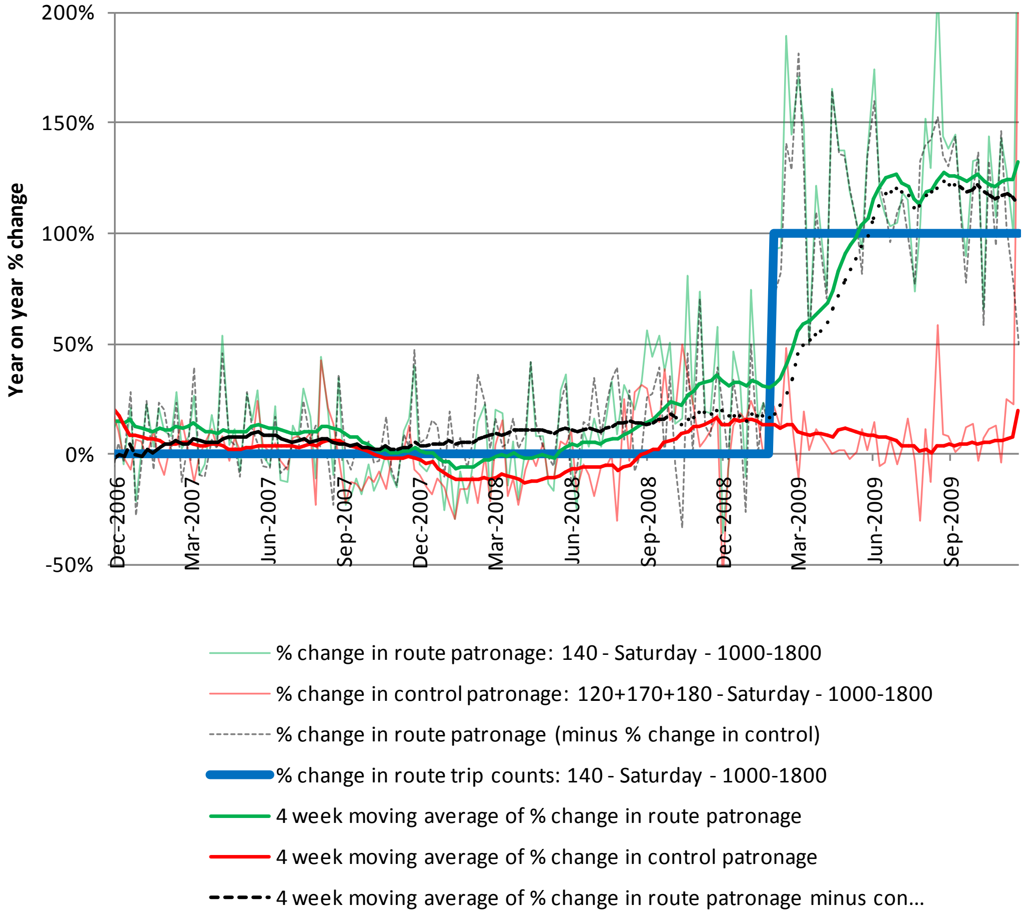


Figure F.29 Patronage growth rates on service route and control routes



F4.1.3 Elasticity estimation – control route method

Figure F.30 Elasticity estimation using control route method

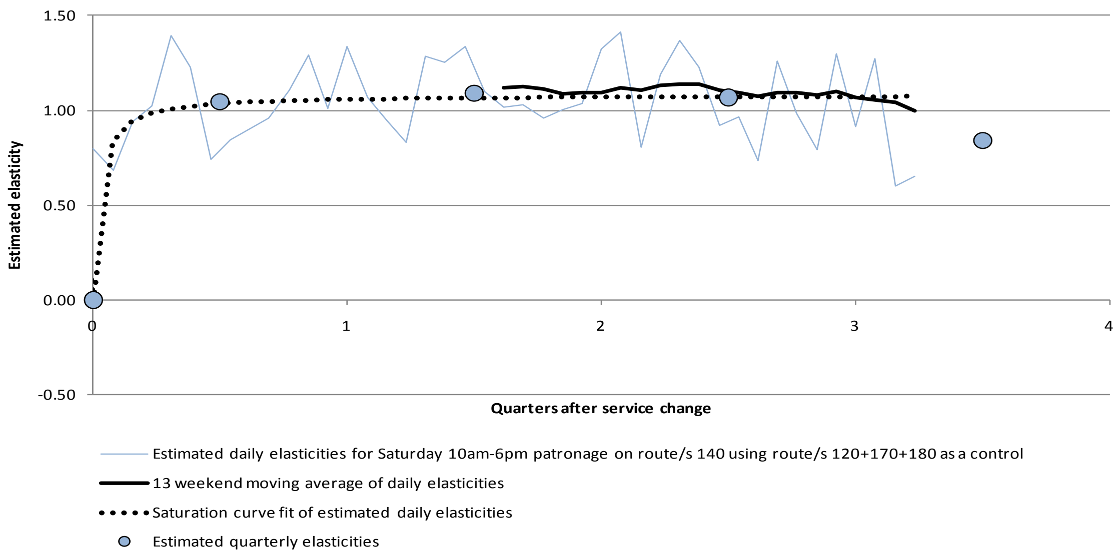


Table F.24 Elasticity estimation using control route method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-09					0.00	0.00
Q1	May-09	2,780	2,660	2.24	1.08	1.05	1.01
Q2	Aug-09	2,950	2,590	2.18	1.03	1.09	1.07
Q3	Nov-09	3,072	2,846	2.26	1.08	1.07	1.07
Q4	#N/A	2,388	2,377	2.05	1.13	0.84	1.07
Long run							1.08

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

We note that Q4 includes less than a month of data. Hence the estimated of elasticity of 0.84 for that quarter should not be given as much weight as the other quarters.

F4.1.4 Elasticity estimation – route extrapolation method

An alternative set of elasticity estimates was made, based on an extrapolation growth rate of 9.16% pa: this was derived as a weighted average of the average growth rate in the 52-week period prior to the service (weight=75%) and the average growth rate in the 52-week period ending a year before the service change (weight=25%), but excluding growth rates distorted by the 'gash' in the data. The results are given in figure F.31 and table F.25.

We note that Q4 includes less than a month of data. Hence the estimated of elasticity of 0.89 for that quarter should not be given as much weight as the other quarters.

Figure F.31 Elasticity estimation using extrapolation method

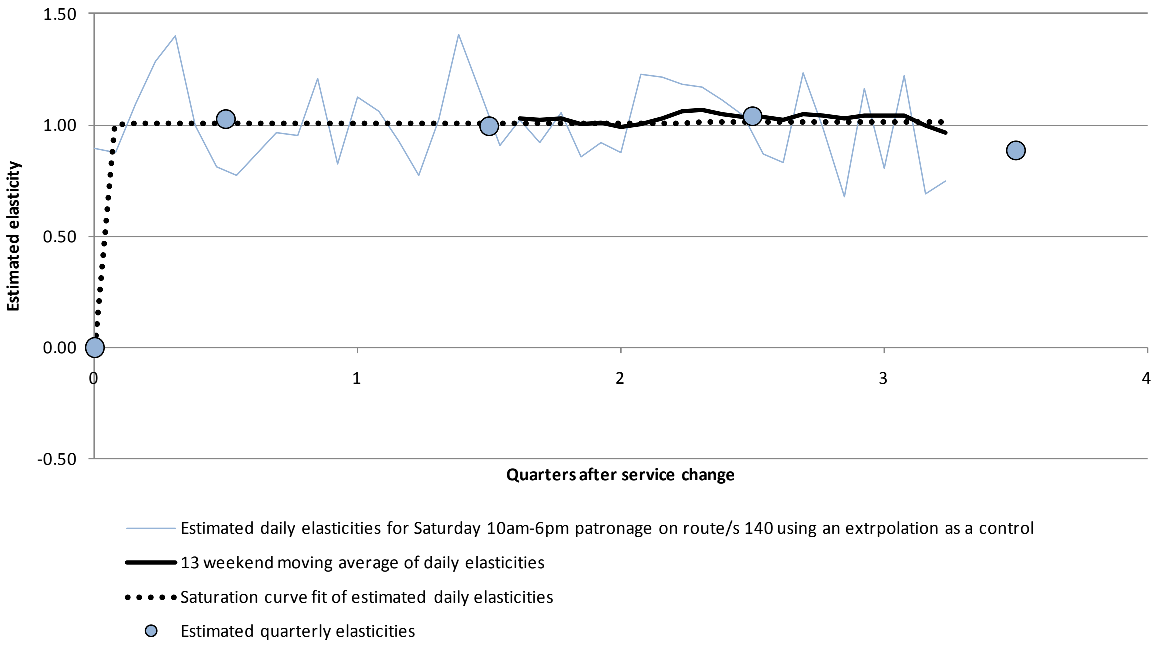


Table F.25 Elasticity estimation using extrapolation method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of extrapolated patronage this quarter to observed patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-09					0.00	0.00
Q1	May-09	2,780	1,361	2.24	1.09	1.03	1.01
Q2	Aug-09	2,950	1,496	2.18	1.09	0.99	1.01
Q3	Nov-09	3,072	1,494	2.26	1.09	1.04	1.01
Q4	#N/A	2,388	1,280	2.05	1.09	0.89	1.01
Long run							1.01

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

F4.1.5 Review and comments

The abnormally high elasticity estimates reflect that the service improvement on 140 appears to have abstracted a significant proportion of the additional passengers from 130. Hence it is desirable to consider the two routes together (as below).

Both the ‘control’ elasticity results and the ‘extrapolation’ elasticity results are reasonably well behaved, and similar to each other, with elasticities close to 1.0. In both cases, the Q4 results appear somewhat anomalous, with lower values than for the earlier periods. This may be due to data for Q4 not being complete.

F4.1.6 Conclusions

The data sets appear well behaved and both methods give similar results. However, because of the hypothesised abstraction effect, the elasticity values are abnormally high. The following section provides more useful results, by also incorporating the main competing route in the analyses.

F4.2 Route 130+140 analysis

F4.2.1 Service change

This is the same service change as considered in the previous section. Taking routes 130 and 140 together, the average frequency increases by one-third, from six trips per hour to eight trips per hour (average each direction).

Table F.26 Details of service change

Date of service change for route/s 130+140:	Saturday, 28 February 2009
Trips before	96
Trips afterwards	128
Ratio	1.33
Control route/s:	120+170+180

F4.2.2 Data availability and quantity

As with previous routes, there was a ‘gash’ in the data from Sat 29 September 2007 to Sat 23 February 2008.

Figure F32 Patronage on service route and control routes

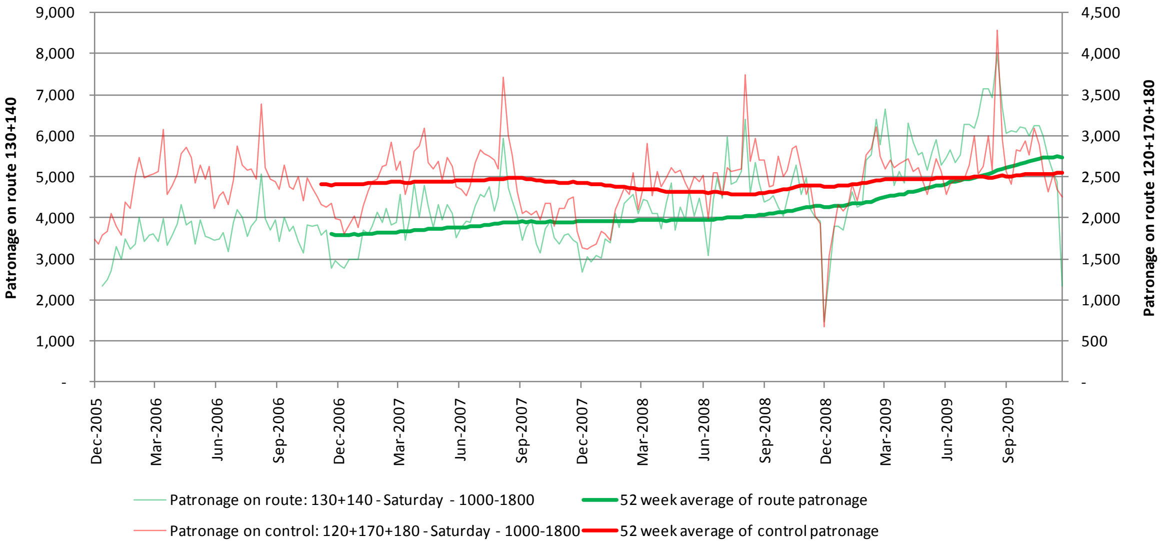
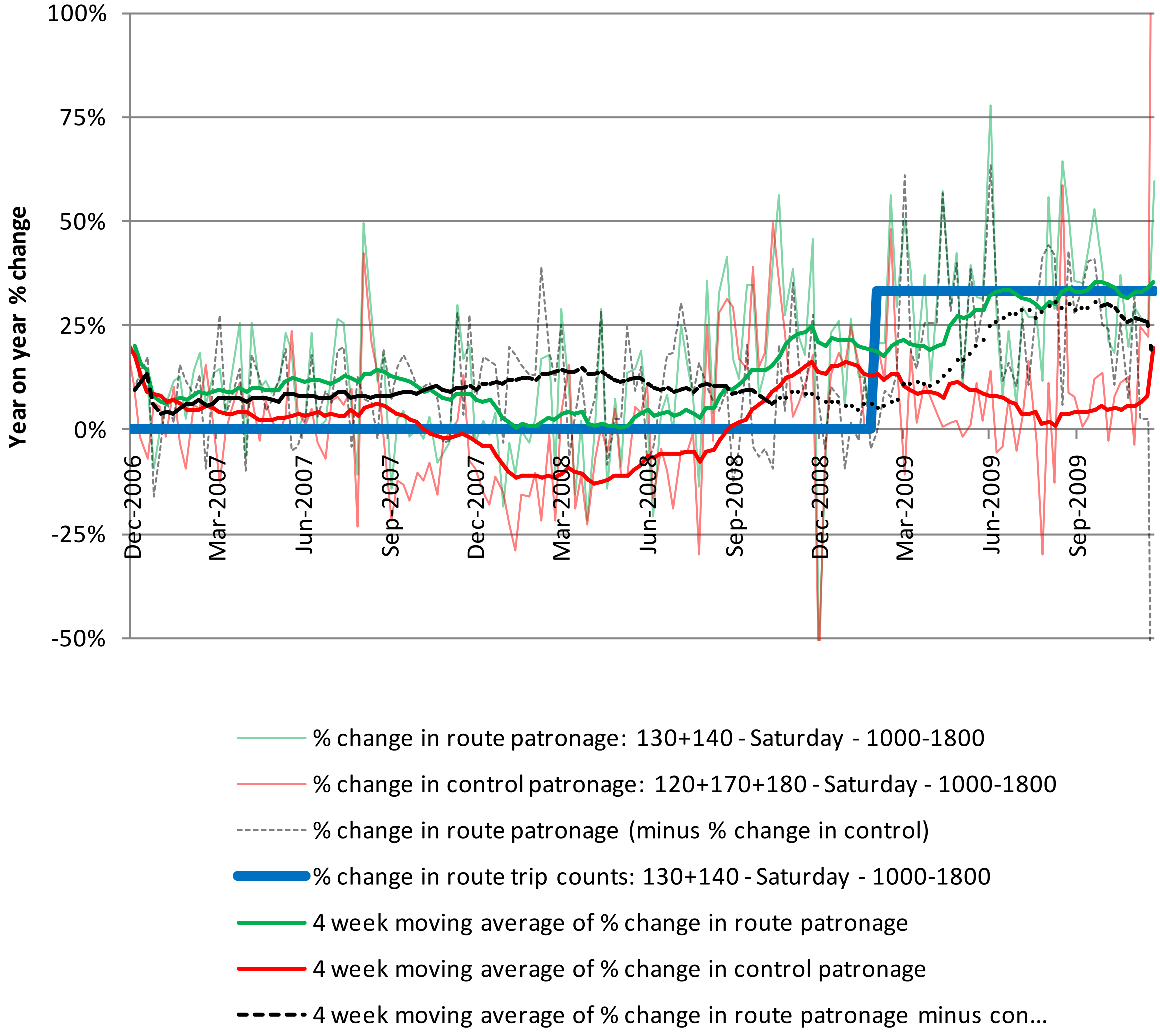


Figure F.33 Patronage growth rates on service route and control routes



F4.2.3 Elasticity estimation – control route method

Results for this method are given in figure F.34 and table F.27. We note that Q4 includes less than a month of data. Hence the estimated elasticity of 0.35 for that quarter should not be given as much weight as the other quarters.

Figure F.34 Elasticity estimation using control route method

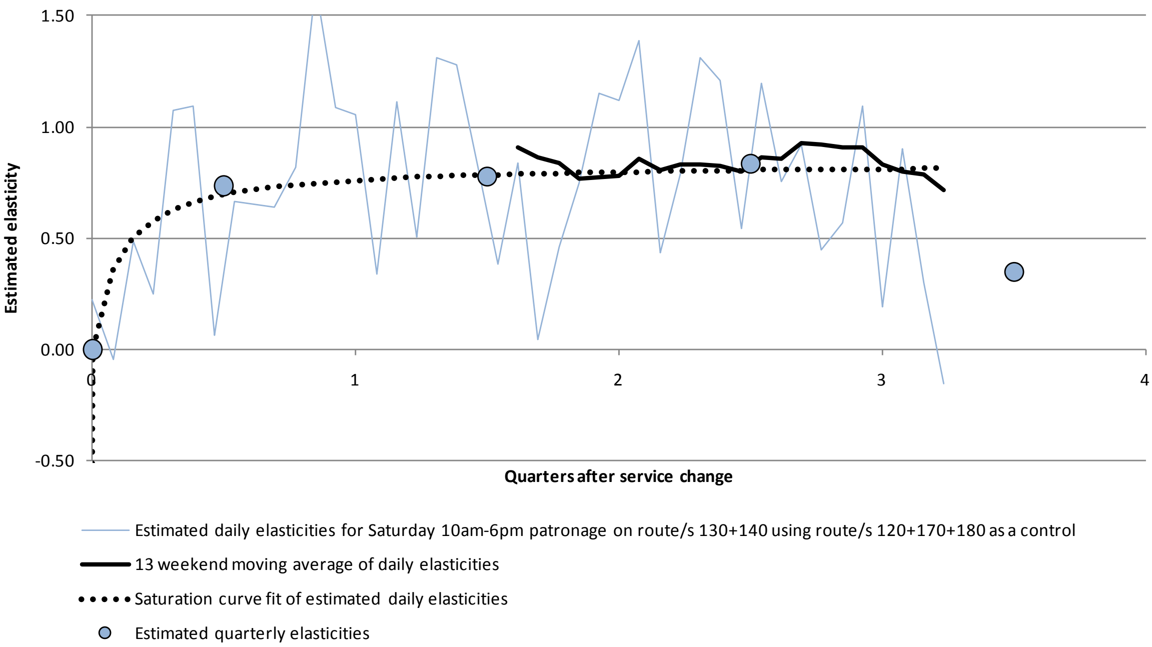


Table F.27 Elasticity estimation using control route method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-09					0.00	0.00
Q1	May-09	5,696	2,660	1.34	1.08	0.74	0.66
Q2	Aug-09	5,962	2,590	1.29	1.03	0.78	0.78
Q3	Nov-09	6,370	2,846	1.37	1.08	0.83	0.81
Q4	#N/A	5,067	2,377	1.25	1.13	0.35	0.81
Long run							0.84

F4.2.4 Elasticity estimation – route extrapolation method

An alternative set of elasticity estimates was made, based on an extrapolation growth rate of 8.39% pa: this was derived as a weighted average of the average growth rate in the 52-week period prior to the service change (weight=75%) and the average growth rate in the 52-week period ending a year before the service change (weight=25%), but excluding growth rates distorted by the 'gash' in the data. The results are given in figure F.35 and table F.28.

We note that Q4 includes less than a month of data. Hence the estimated of elasticity of 0.48 for that quarter should not be given as much weight as the other quarters.

Figure F.35 Elasticity estimation using extrapolation method

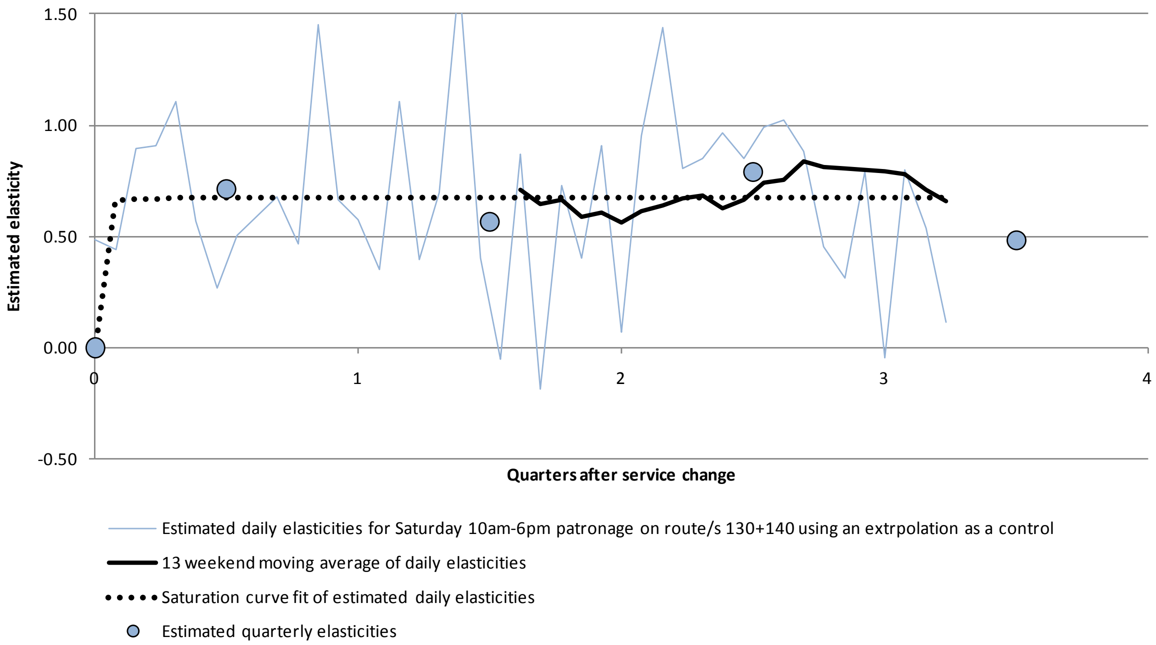


Table F.28 Elasticity estimation using extrapolation method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of extrapolated patronage this quarter to observed patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-09					0.00	0.00
Q1	May-09	5,696	4,634	1.34	1.08	0.71	0.67
Q2	Aug-09	5,962	5,117	1.29	1.08	0.57	0.67
Q3	Nov-09	6,370	5,059	1.37	1.08	0.79	0.67
Q4	#N/A	5,067	4,385	1.25	1.08	0.48	0.67
Long run							0.67

Note: The ratio of route trips after the service change compared to prior to the service change was 1.33

F4.2.5 Review and comments

Both the ‘control’ elasticity results and the ‘extrapolation’ results are reasonably well behaved, giving generally similar elasticities. However, in both cases, the Q4 patronage growth (and hence elasticity estimates) appear significantly lower than in the previous periods. This may be related to the limited data for the quarter, over a period when patronage tends to be particularly variable.

F4.2.6 Conclusions

In this case, we would adopt the ‘control’ elasticity results as the best estimates available; but, given the anomalous result for Q4, would rely on the saturation curve values rather than the quarterly estimates.

F4.3 Route 150 analysis

F4.3.1 Service change

The service change in November 2004 involved a doubling of frequency, from two trips per hour to four trips per hour (each direction).

Table F.29 Details of service change

Date of service change for route/s 150:	Saturday, 13 November 2004
Trips before	32
Trips afterwards	64
Ratio	2.00
Control route/s:	140

F4.3.2 Data availability and quantity

As with previous routes, there was a 'gash' in the data from Sat 29 September 2007 to Sat 23 February 2008.

Figure F.36 Patronage on service route and control routes

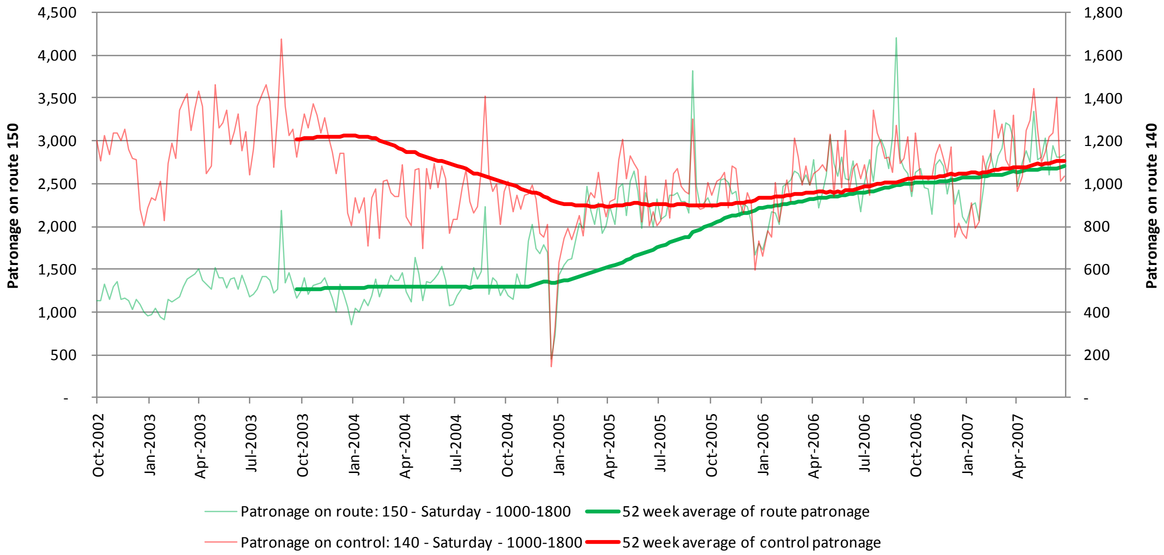
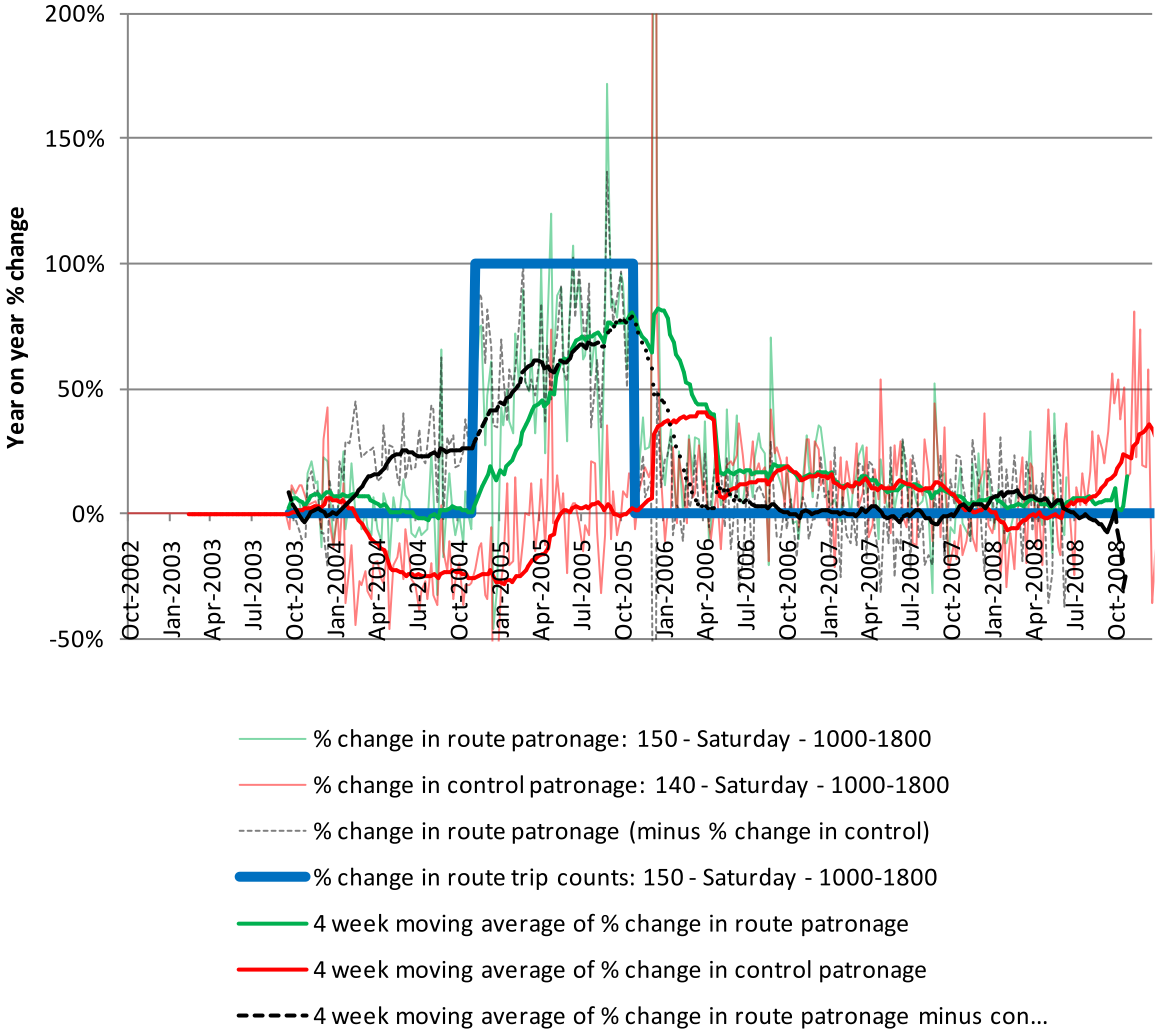


Figure F.37 Patronage growth rates on service route and control routes



F4.3.3 Elasticity estimation – control route method

The results for this method are shown in figure F.38 and table F.30. Given apparent data anomalies for the control route some nine months before the service change, no elasticity estimates have been made for Q1 and the corresponding quarter in the following years.

Figure F.38 Elasticity estimation using control route method

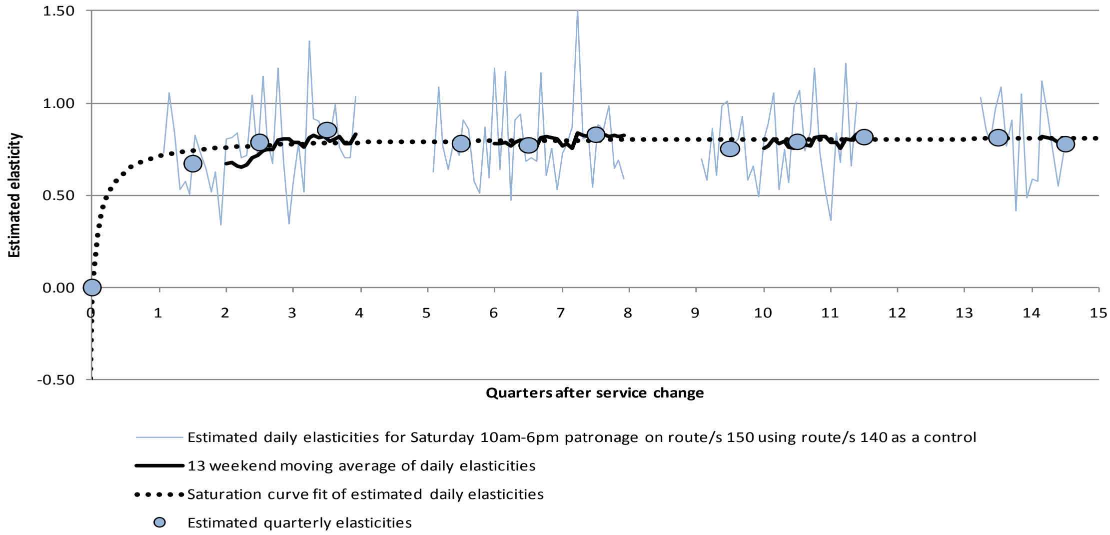


Table F.30 Elasticity estimation using control route method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Nov-04					0.00	0.00
Q1	Feb-05	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.59
Q2	May-05	2,211	977	1.66	1.05	0.67	0.74
Q3	Aug-05	2,276	945	1.73	1.01	0.79	0.77
Q4	Nov-05	2,474	984	1.86	1.01	0.85	0.78
Q5	Feb-06	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.79
Q6	May-06	2,592	1,059	1.96	1.15	0.78	0.79
Q7	Aug-06	2,657	1,115	2.01	1.19	0.77	0.80
Q8	Nov-06	2,727	1,098	2.03	1.13	0.83	0.80
Q9	Feb-07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.80
Q10	May-07	2,892	1,207	2.18	1.30	0.75	0.80
Q11	Aug-07	2,888	1,200	2.20	1.28	0.79	0.80
Q12	Nov-07	3,163	1,279	2.26	1.26	0.82	0.80
Q13	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.81
Q14	May-08	3,100	1,244	2.31	1.32	0.81	0.81
Q15	Aug-08	2,974	1,254	2.22	1.29	0.78	0.81
Long run							0.81

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

F4.3.4 Elasticity estimation – route extrapolation method

An alternative set of elasticity estimates was made based on an extrapolation growth rate of 2.31% pa: this was the average growth rate of route 150 for the 52-week period preceding the service change. The results are given in figure F.39 and table F.31.

Figure F.39 Elasticity estimation using extrapolation method

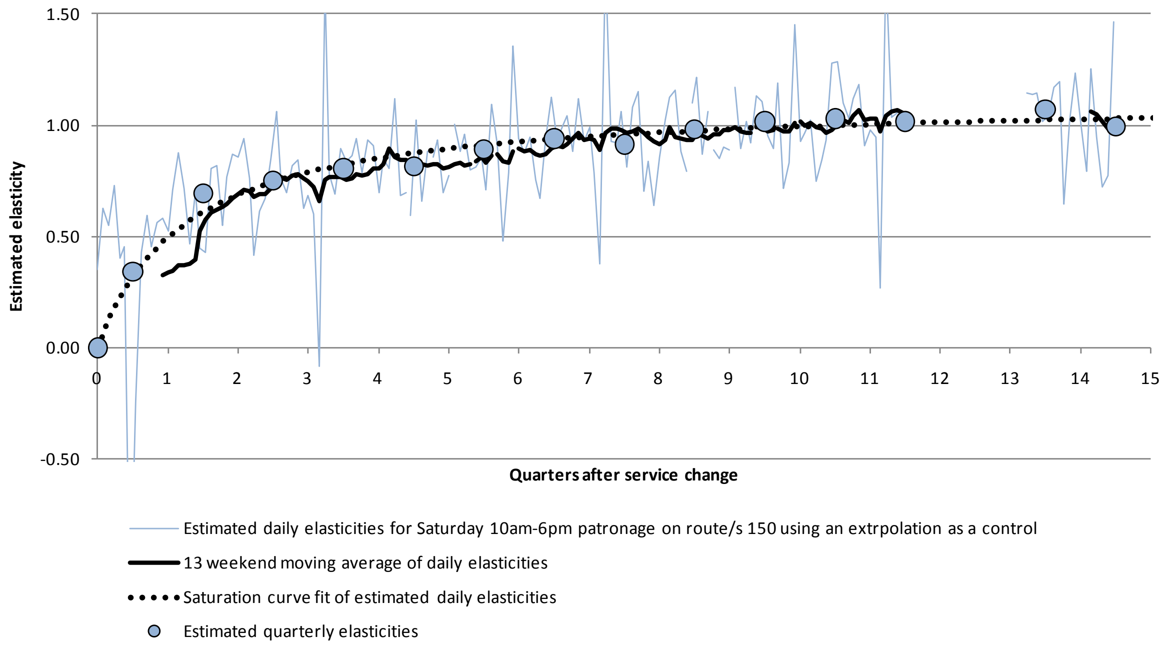


Table F.31 Elasticity estimation using extrapolation method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of extrapolated patronage this quarter to observed patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Nov-04					0.00	0.00
Q1	Feb-05	1,555	1,158	1.36	1.02	0.34	0.31
Q2	May-05	2,211	1,369	1.66	1.02	0.69	0.61
Q3	Aug-05	2,276	1,357	1.73	1.02	0.75	0.75
Q4	Nov-05	2,467	1,417	1.84	1.02	0.81	0.82
Q5	Feb-06	2,080	1,185	1.85	1.05	0.81	0.88
Q6	May-06	2,592	1,400	1.96	1.05	0.89	0.91
Q7	Aug-06	2,657	1,388	2.01	1.05	0.94	0.94
Q8	Nov-06	2,726	1,449	2.02	1.05	0.91	0.96
Q9	Feb-07	2,385	1,212	2.12	1.07	0.98	0.98
Q10	May-07	2,892	1,432	2.18	1.07	1.02	0.99
Q11	Aug-07	2,888	1,420	2.20	1.07	1.03	1.00
Q12	Nov-07	3,163	1,584	2.26	1.07	1.02	1.01
Q13	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	1.02
Q14	May-08	3,100	1,483	2.31	1.10	1.07	1.02
Q15	Aug-08	2,974	1,490	2.22	1.10	0.99	1.03
Long run							1.12

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

F4.3.5 Review and comments

Despite some data issues (primarily affecting the Q1 results), the 'control' elasticity estimates are reasonably well behaved, reaching close to saturation within the second year.

The ‘extrapolation’ elasticity estimates, based on a an extrapolation growth rate of 2.3% pa, indicate a somewhat more gradual approach to saturation, with the quarterly elasticity estimates fitting better to the saturation curve.

F4.3.6 Conclusions

A reasonable ‘best estimate’ set of elasticities would be the mean of the ‘control’ and ‘extrapolated’ values, as follows:

Estimated: Q1 (0.34), Q2 0.68, Q3 0.77, Q4 0.83

Y2 0.84, Y3 0.90, Y4 0.92.

Saturation curve: Q1 0.45, Q2 0.68, Q3 0.76, Q4 0.80

Y2 0.86, Y3 0.90, Y3 0.92.

F4.4 Route 190/199 analysis

F4.4.1 Service change

This route presented an interested opportunity for analysis because it showed two service changes on the same route. The first (February 2006) involved a 100% increase in service frequency, from two trips per hour to four trips per hour (each direction); the second (November 2008) involved a further frequency increase of 50%, up to six trips per hour.

Table F.32 Details of service changes

Date of service change for route/s 190+199:	Saturday, 25 February 2006	Saturday, 1 November 2008
Trips before	32	64
Trips afterwards	64	96
Ratio	2.00	1.50
Control route/s:	375	375

F4.4.2 Data availability and quantity

As with previous routes, there was a ‘gash’ in the data from Sat 29 September 2007 to Sat 23 February 2008.

There was also a gap in the data provided, from Sat 25 February 2006 to Sat 20 May 2006. We note that this gap immediately follows the first service change.

Figure F.40 Patronage on service route and control routes

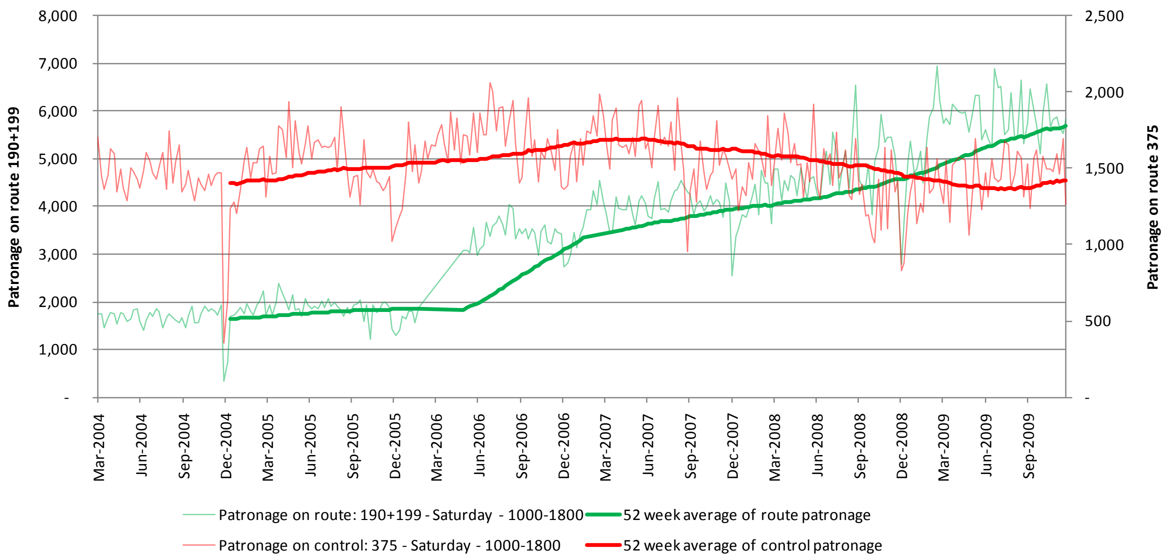


Figure F.41 Patronage growth rates on service route and control routes

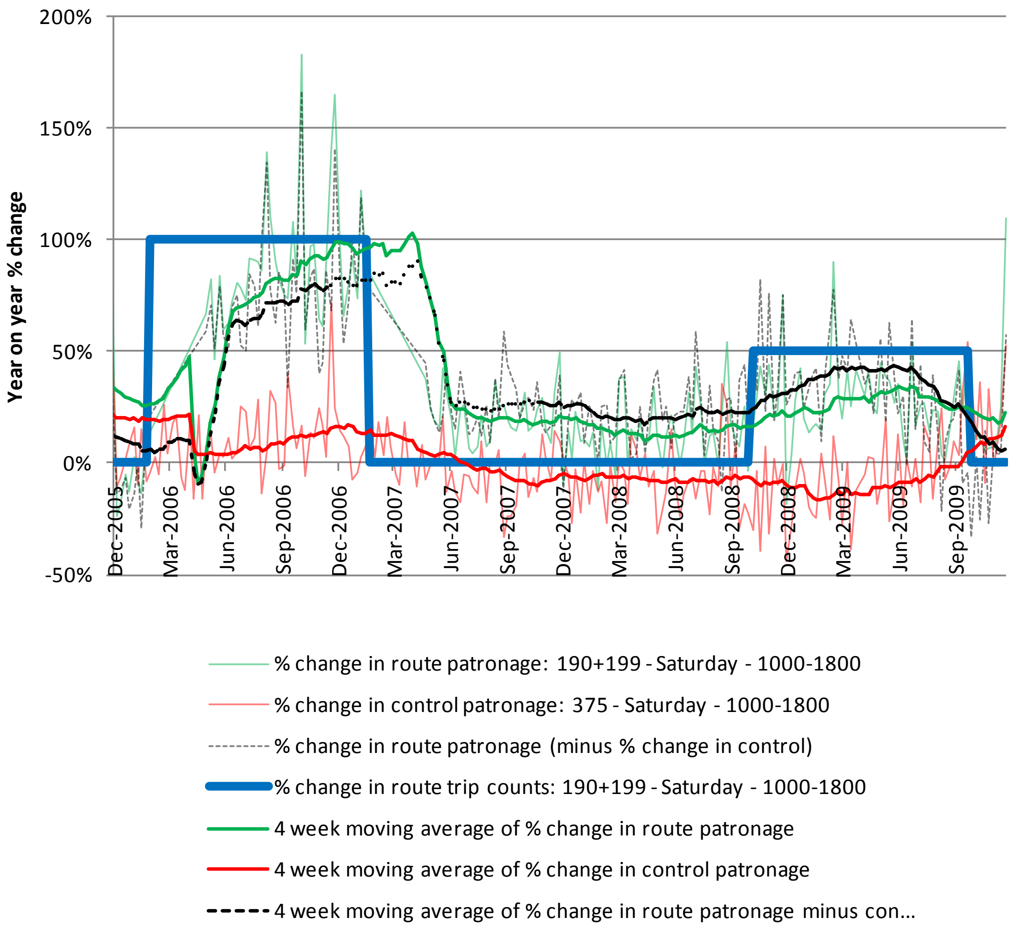


Figure F.41 clearly shows the impact of the two service changes.

However, the impact of the first service change is misrepresented somewhat by the bold moving average lines because they lag the actual growth rates on account of missing data. Therefore, in this case, the thin lines are more insightful:

- The thin green line is straight because the growth rates could not be calculated for the period immediately following the service change (ie 18 February 2006 to 27 May 2006) due to missing data.
- The thin green line is straight again at the point one year after the service change (ie from Sat 10 February 2007 to Sat 19 May 2007) again due to missing data.

F4.4.3 Elasticity estimation – control route method

The results using this method are shown in figure F.42a and table F.33a for the first service change; and in figure F.42b and table F.33b for the second change. Note that:

- for the first service change, there were data gaps or limited data for Q1 and Q7/Q8, so no reliable elasticity estimates were possible
- for the second service change, no reliable estimates were possible for Q1 because of the effect of the data gash 12 months earlier.

Figure F.42a Elasticity estimation using control route method (1st service change)

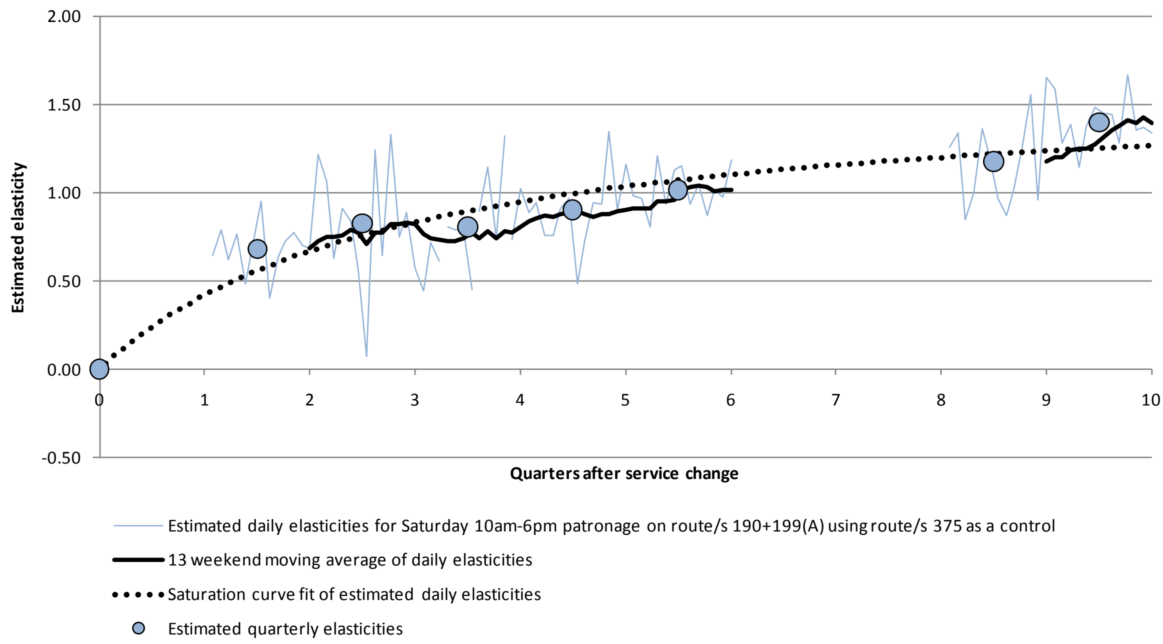


Table F.33a Elasticity estimation using control route method (1st service change)

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-06					0.00	0.00
Q1	May-06	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.25
Q2	Aug-06	3,386	1,795	1.77	1.10	0.68	0.56
Q3	Nov-06	3,495	1,655	1.97	1.11	0.83	0.76
Q4	Feb-07	3,351	1,564	2.00	1.14	0.81	0.90
Q5	May-07	3,991	1,733	2.02	1.09	0.90	1.00
Q6	Aug-07	4,038	1,703	2.11	1.04	1.02	1.07
Q7	Nov-07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	1.13
Q8	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	1.18
Q9	May-08	4,478	1,610	2.27	1.00	1.18	1.22
Q10	Aug-08	4,672	1,514	2.44	0.93	1.40	1.25
Long run							1.63

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

Figure F.42b Elasticity estimation using control route method (2nd service change)

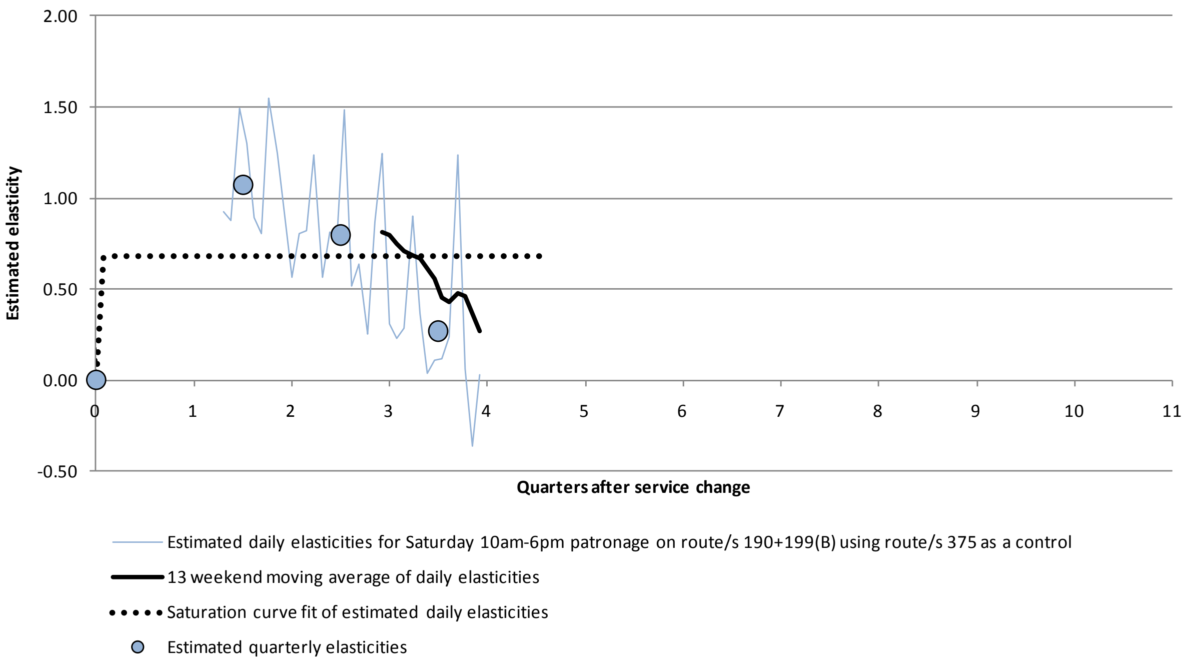


Table F.33b Elasticity estimation using control route method (2nd service change)

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Oct-08					0.00	0.00
Q1	Jan-09	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.68
Q2	May-09	6,059	1,414	1.37	0.88	1.07	0.68
Q3	Jul-09	5,975	1,424	1.30	0.95	0.80	0.68
Q4	Oct-09	5,779	1,500	1.22	1.10	0.27	0.68
Q5	#N/A	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.68
Long run							0.68

Note: The ratio of route trips after the service change compared to prior to the service change was 1.50

F4.4.4 Elasticity estimation – route extrapolation method

An alternative set of elasticity estimates was made based on an extrapolation growth rate of 16.87% pa for the first service change and 15.34% pa for the second change. These were the average growth rate of route 190 for the 52-week period preceding the relevant service change.

The results are given in figure F.43a and table F.34a for the first service change; and in figure F.43b and table F.34b for the second change.

Good quality elasticity estimates were not possible for several quarters, for the same reasons as noted earlier.

Figure F.43a Elasticity estimation using extrapolation method (1st service change)

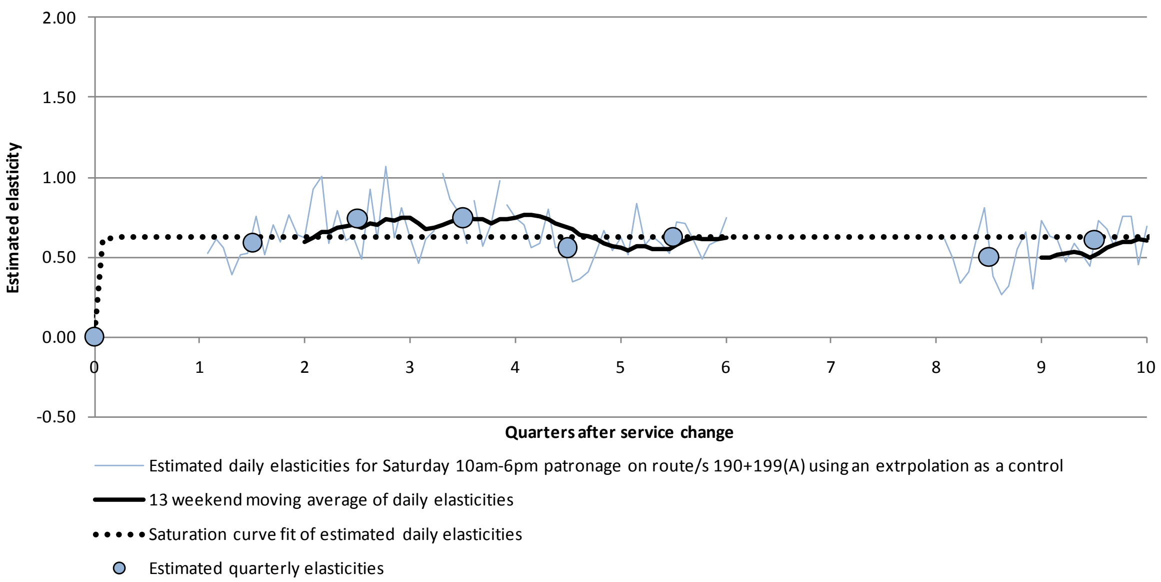


Table F.34a Elasticity estimation using extrapolation method (1st service change)

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of extrapolated patronage this quarter to observed patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-06					0.00	0.00
Q1	May-06	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.62
Q2	Aug-06	3,386	2,241	1.77	1.17	0.59	0.62
Q3	Nov-06	3,495	2,096	1.97	1.17	0.74	0.62
Q4	Feb-07	3,351	2,007	2.00	1.18	0.74	0.62
Q5	May-07	3,991	2,715	2.02	1.37	0.56	0.62
Q6	Aug-07	4,038	2,619	2.11	1.37	0.62	0.62
Q7	Nov-07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.62
Q8	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.62
Q9	May-08	4,478	3,173	2.27	1.60	0.50	0.62
Q10	Aug-08	4,672	3,061	2.44	1.60	0.61	0.62
Long run							0.62

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

Figure F.43b Elasticity estimation using extrapolation method (2nd service change)

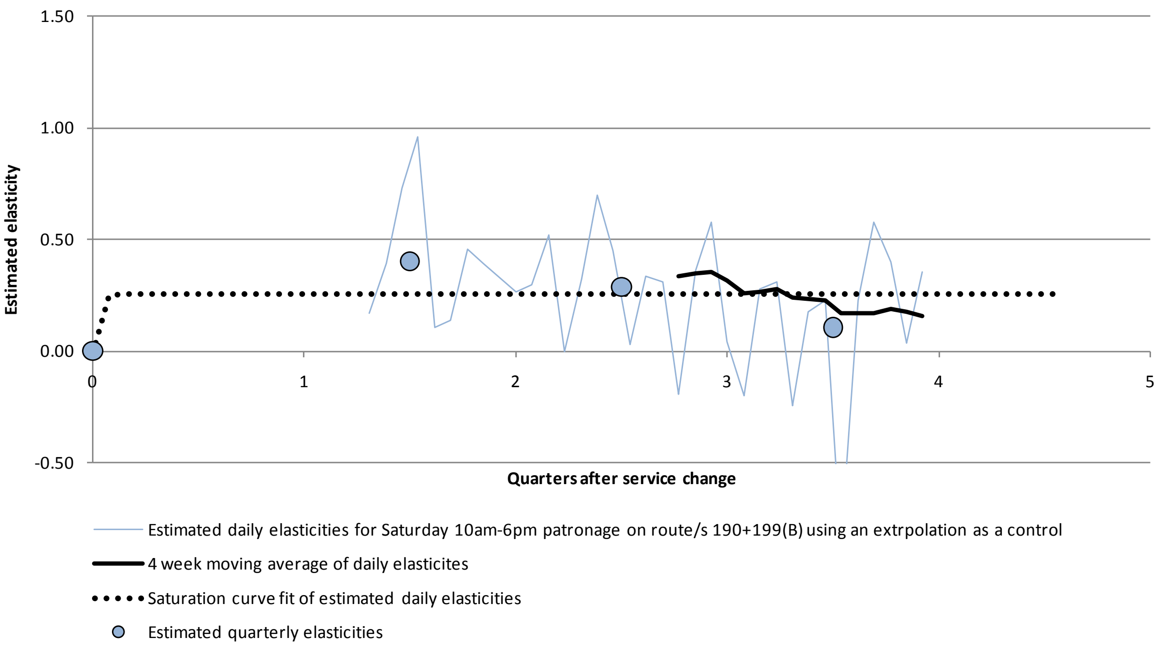


Table F.34b Elasticity estimation using extrapolation method (2nd service change)

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of extrapolated patronage this quarter to observed patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Oct-08					0.00	0.00
Q1	Jan-09	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.25
Q2	May-09	6,059	5,160	1.37	1.15	0.40	0.25
Q3	Jul-09	5,975	5,320	1.30	1.15	0.29	0.25
Q4	Oct-09	5,779	5,564	1.22	1.15	0.11	0.25
Long run							0.25

Note: The ratio of route trips after the service change compared to prior to the service change was 1.50

F4.4.5 Review and comments

First (2006) service change

These analyses are hampered by data gaps, both immediately after the service change and around 18 months later. The route patronage appears to grow quite strongly for at least two years after the service change, while the control patronage trends vary from a significant (c. 10% pa) rate of increase to a similar rate of decline over this period. One outcome is that the estimated 'control' elasticities appear to continue to increase strongly for the whole period (10 quarters) for which data are available, with the Q4 estimate of 0.81 increasing to 1.40 by Q10 (table F.33a).

The 'extrapolation' elasticity estimates, based on an extrapolated growth rate of 16.9% pa, appear more plausible, with effective saturation occurring after about Q4, at an elasticity estimate of around 0.7. However, we would expect the extrapolation elasticity estimates to be on the low side, especially in years two and three, as a continuing underlying growth rate of 16.9% pa seems unlikely.

Second (2008) service change

Analysis of this change is also hampered by data limitations, particularly the data 'gash' in the period September 2007–February 2008. Also, only 12 months 'after' data was available. The result is that elasticity estimates can be made for only three quarters (Q2, Q3, Q4).

Both the control and extrapolation elasticity estimates give unexpected results, with the elasticities declining from Q2 through Q3 to Q4. The two methods also give a wide elasticity range, Q2 1.07 (control) and 0.40 (extrapolation), Q3 0.80 and 0.29, Q4 0.27 and 0.11.

F4.4.6 Conclusions

First (2006) service change

For routes 190/199, we consider that a reasonable set of best estimates would be the mean of the 'control' and 'extrapolation' values, as follows:

Q1 0.68, Q2 0.64, Q3 0.79, Q4 0.78

Y2 0.90, Y3 1.07.

As for the route 190/199 weekday analyses, we suspect that these results include a significant element of passenger extraction from other routes. This is tested through examining the wider group of routes concerned (190/191 before, 196/199 after), as below.

Second (2008) service change

The results for routes 190/199 are unsatisfactory, both in terms of the elasticity trends over time and in terms of the wide differences in results between the two methods. Estimation of elasticities for the wider group of routes (190/191 before, 196/199 after) may give better results (below).

F4.5 Route 190+191/196+199 analysis

This analysis covers the same service changes as the previous analyses (section F4.4), but also incorporates patronage changes on routes 191 (before) and 196 (after), in order to allow for any 'abstraction' effects.

F4.5.1 Service change

For the combined routes, the first service change (February 2006) involved an effective 50% increase in service frequency, the second change a further 33% effective frequency increase.

Table F.35 Details of service change

Date of service change for route/s 190+191+196+199:	Saturday, 25 February 2006	Saturday, 1 November 2008
Trips before	64	96
Trips afterwards	96	128
Ratio	1.50	1.33
Control route/s:	375	375

F4.5.2 Data availability and quantity

As with previous routes, there was a 'gash' in the data from Sat 29 September 2007 to Sat 23 February 2008.

Figure F.44 Patronage on service route and control routes

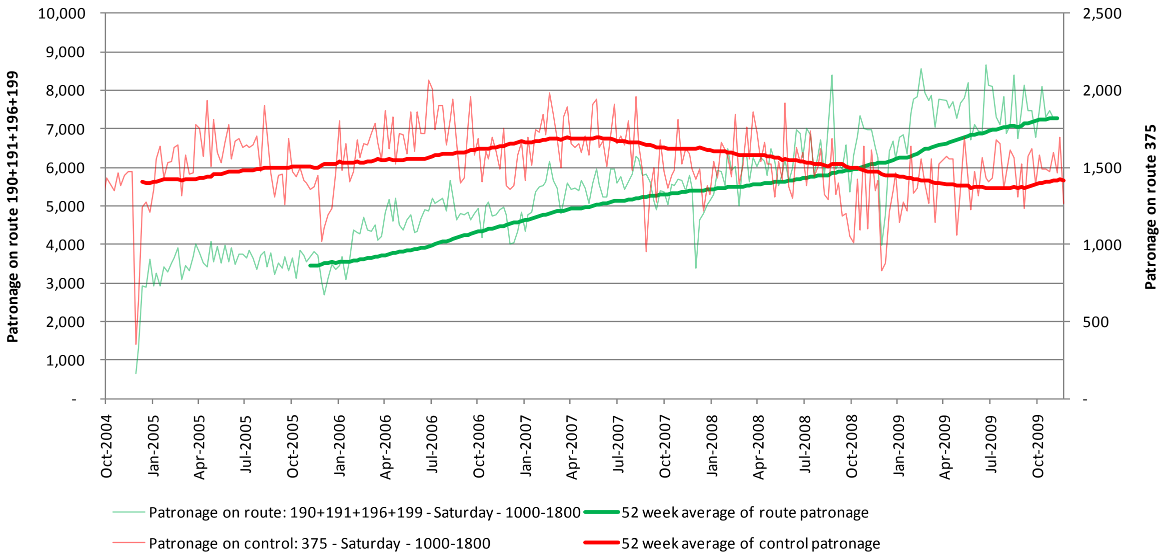
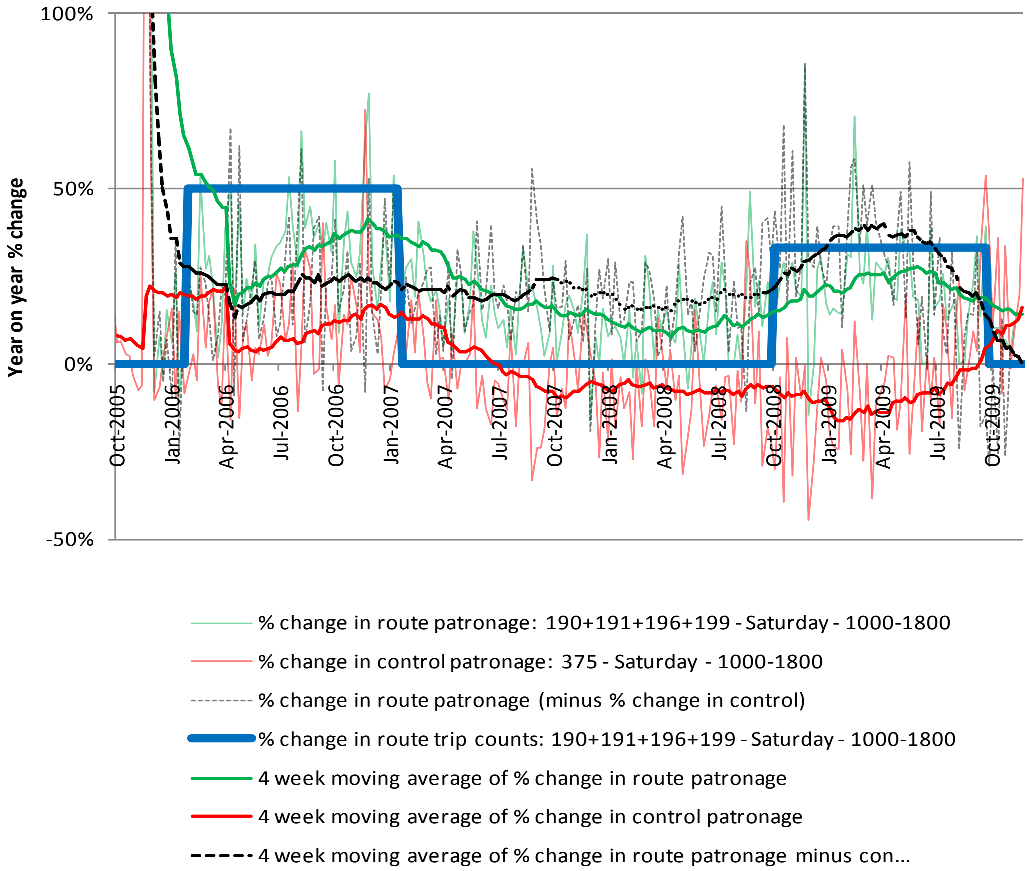


Figure F.45 Patronage growth rates on service route and control routes



F4.5.3 Elasticity estimation – control route method

As with the weekday evening service changes on these routes (section F3.5.3), it is notable that the route patronage appears to continue to increase strongly for the three years after the first service change (see figures F.45 and F.46a). This pattern of response is unusual and may well be the result of factors other than the service change: the data suggest a typical saturation curve pattern for the first four quarters, followed by a broadly linear rate of increase thereafter. We have therefore made an alternative assessment of the saturation curve, based on data up to/including Q4 only – this is shown in figure F.46b and table F.36b.

Figure F.46a Elasticity estimation using control route method (1st service change)- all data

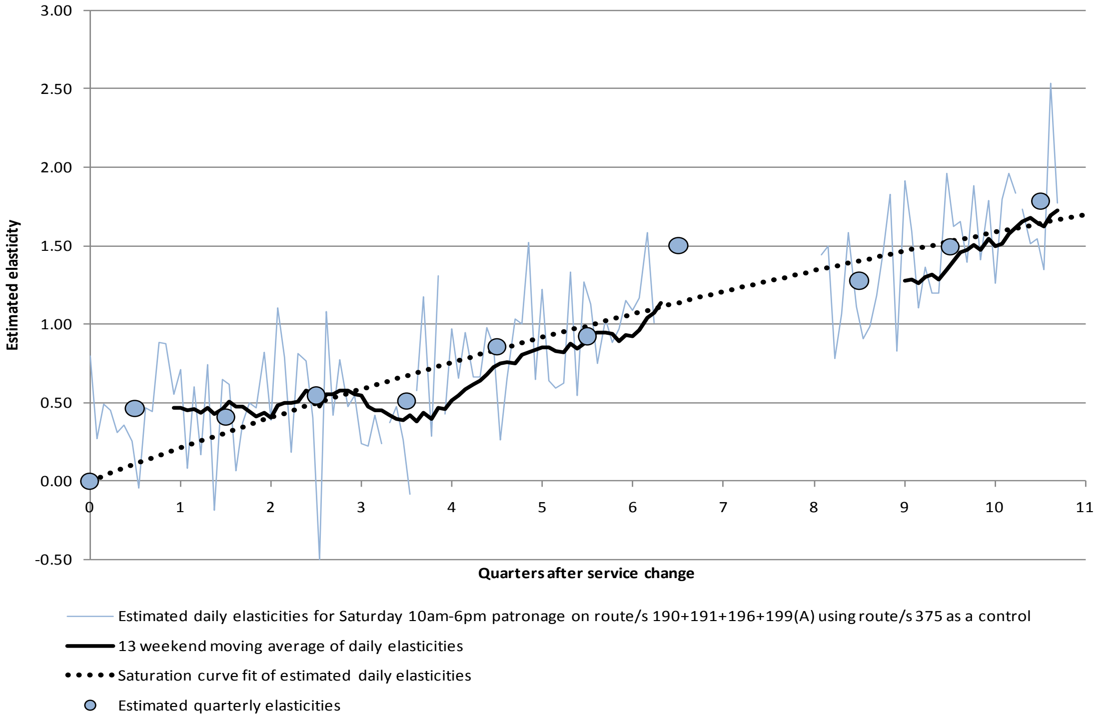


Figure F.46b Elasticity estimation using control route method (1st service change)- up to Q4 only

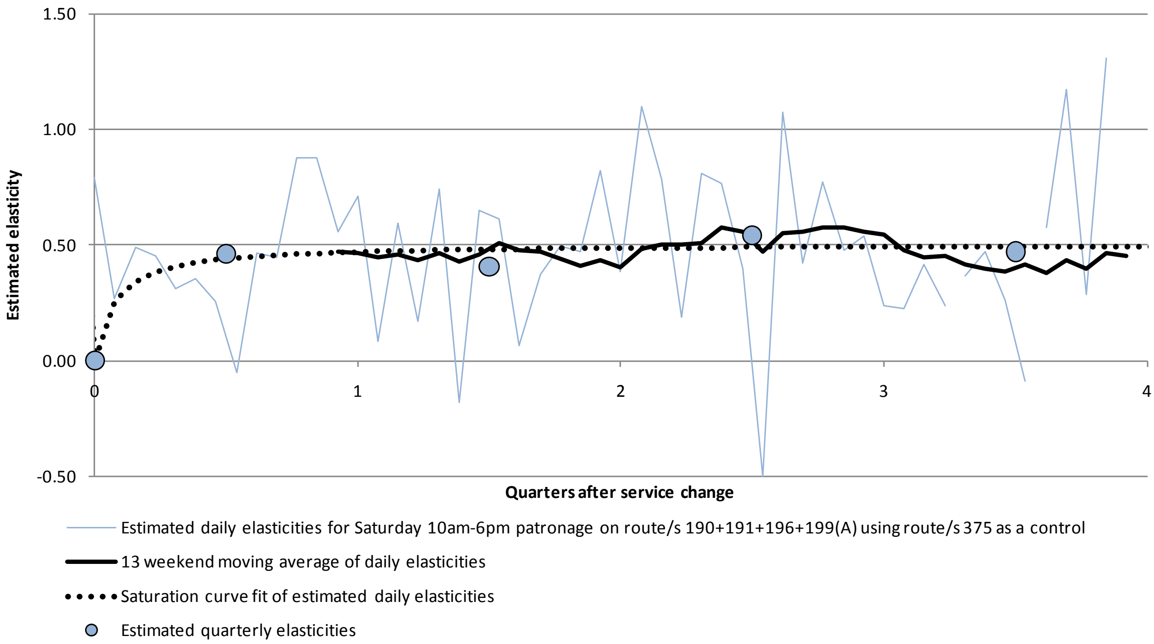


Table F.36a Elasticity estimation using control route method (1st service change) – all data

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-06					0.00	0.00
Q1	May-06	4,551	1,679	1.26	1.05	0.46	0.11
Q2	Aug-06	4,797	1,795	1.30	1.10	0.41	0.31
Q3	Nov-06	4,877	1,655	1.38	1.11	0.54	0.50
Q4	Feb-07	4,724	1,564	1.40	1.14	0.51	0.68
Q5	May-07	5,494	1,733	1.53	1.09	0.85	0.84
Q6	Aug-07	5,603	1,703	1.52	1.04	0.92	1.00
Q7	Nov-07	6,032	1,515	1.70	0.93	1.50	1.14
Q8	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	1.28
Q9	May-08	6,051	1,610	1.68	1.00	1.28	1.41
Q10	Aug-08	6,276	1,514	1.70	0.93	1.49	1.53
Q11	Nov-08	6,437	1,344	1.83	0.89	1.78	1.65
Long run							5.91

Note: The ratio of route trips after the service change compared to prior to the service change was 1.50

Table F.36b Elasticity estimation using control route method (1st service change) – up to Q4 only

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-06					0.00	0.00
Q1	May-06	4,551	1,679	1.26	1.05	0.46	0.42
Q2	Aug-06	4,797	1,795	1.30	1.10	0.41	0.48
Q3	Nov-06	4,877	1,655	1.38	1.11	0.54	0.49
Q4	Feb-07	4,724	1,564	1.40	1.14	0.51	0.49
Long run							0.50

Figure F.46c Elasticity estimation using control route method (2nd service change)

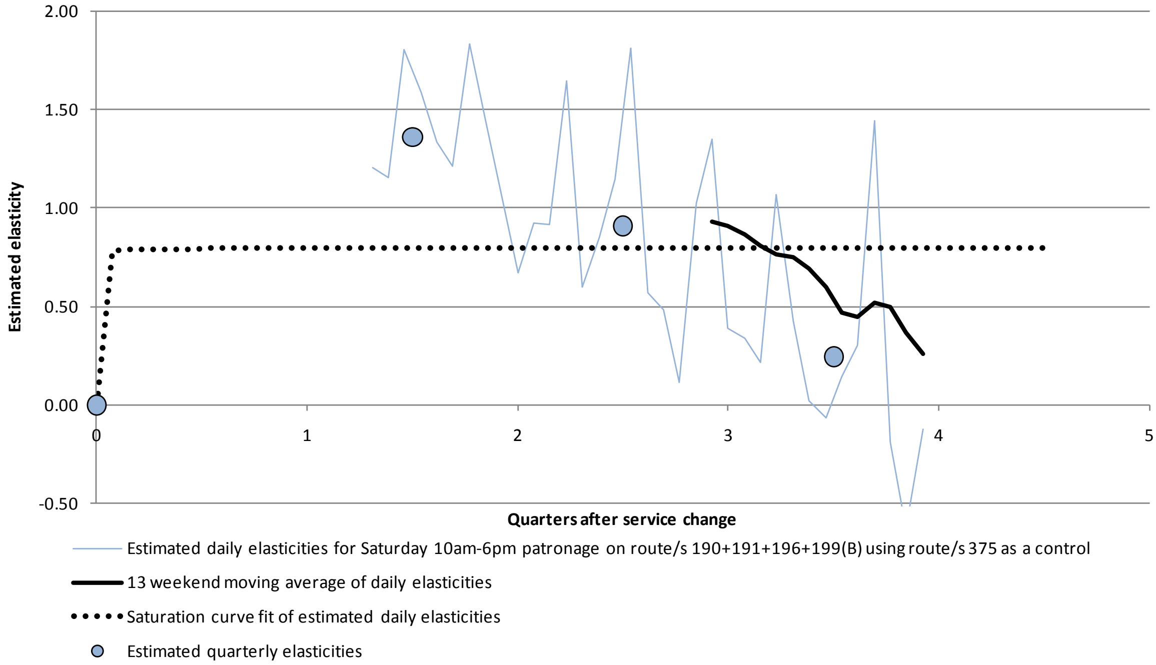


Table F.36c Elasticity estimation using control route method (2nd service change)

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Oct-08					0.00	0.00
Q1	Jan-09	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.79
Q2	May-09	7,811	1,414	1.30	0.88	1.36	0.80
Q3	Jul-09	7,602	1,424	1.23	0.95	0.91	0.80
Q4	Oct-09	7,400	1,500	1.17	1.10	0.25	0.80
Q5	#N/A	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.80
Long run							0.80

Note: The ratio of route trips after the service change compared to prior to the service change was 1.33

F4.5.4 Elasticity estimation – route extrapolation method

The extrapolation method could not be employed for analysis of route 190+191/196+199 because there was not enough patronage data (prior to the service change) that could be used to establish growth rates.

F4.5.5 Review and comments

First (2006) service change

As noted above, the patronage data and the resultant elasticity estimates appear to continue to grow strongly for the whole data period (approaching three years) after the service change. The most likely explanation is that this continuing growth after one year is the result of unrelated factors.

When the analysis is confined to the first four quarters only (figure F.46b), a much more 'normal' saturation curve results, with a saturation value of approximately 0.50. We consider this is the most plausible estimate in this case.

Second (2008) service change

Only three quarters of after data are available, and these show an abnormal pattern of elasticities (figure F.46c). While a saturation curve has been fitted to these elasticity values, the validity of this curve is very uncertain. For reasons that are unclear, the route patronage appears to decrease significantly after Q2, while the control patronage is increasing. Data for several more quarters would be needed to shed more light on the effect of this service change.

F4.5.6 Conclusions

The results for both these service changes are somewhat unsatisfactory. For the first change, we consider that the most plausible results are those for the first four quarters, with elasticities around 0.5 at Q4.

For the second change, the most plausible results are those for the saturation curve, with a Q4 elasticity value of around 0.80. However, this figure is subject to considerable uncertainty.

F4.6 Route 200 analysis

F4.6.1 Service change

The service change occurred on 23 April 2005, with service frequencies doubling from two trips per hour to four trips per hour (each direction).

Table F.37 Details of service change

Date of service change for route/s 200:	Saturday, 23 April 2005
Trips before	32
Trips afterwards	64
Ratio	2.00
Control route/s:	210+212

F4.6.2 Data availability and quantity

As with previous routes, there was a 'gash' in the data from Sat 29 September 2007 to Sat 23 February 2008.

Figure F.47 Patronage on service route and control routes

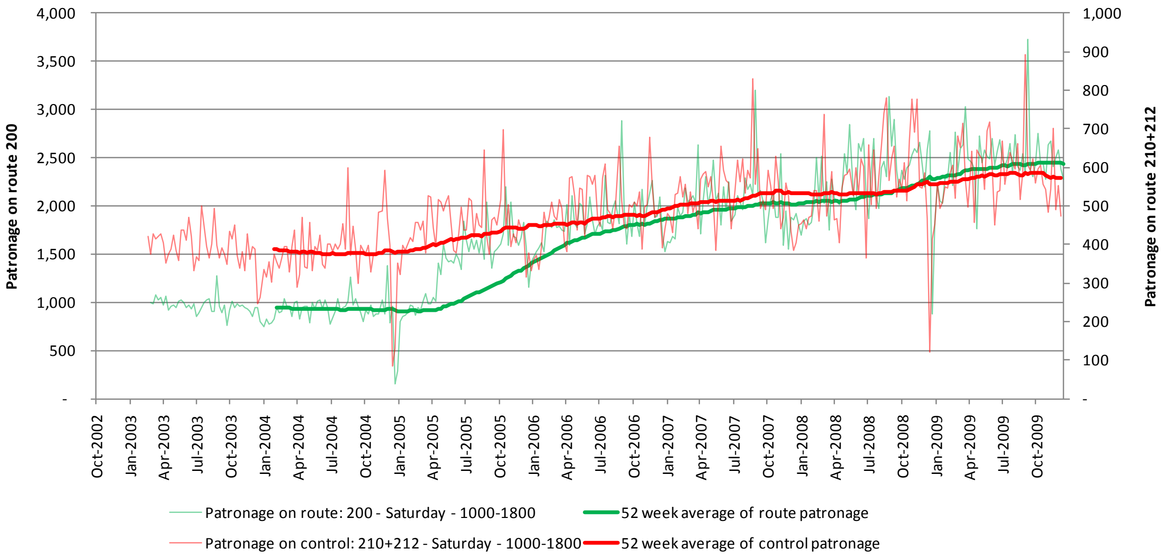
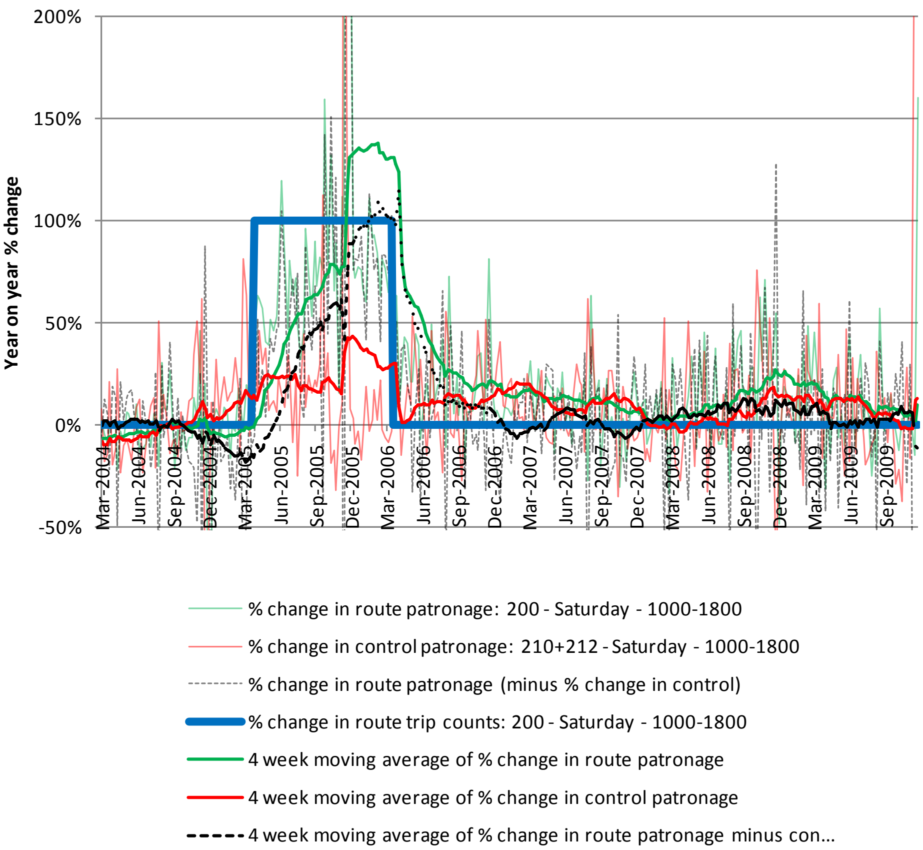


Figure F.48 Patronage growth rates on service route and control routes



F4.6.3 Elasticity estimation – control route method

The gap in the line in figure F.49 around Q11 is due to the 'gash' in the data from Sat 29 September 2007 to Sat 23 February 2008.

Figure F.49 Elasticity estimation using control route method

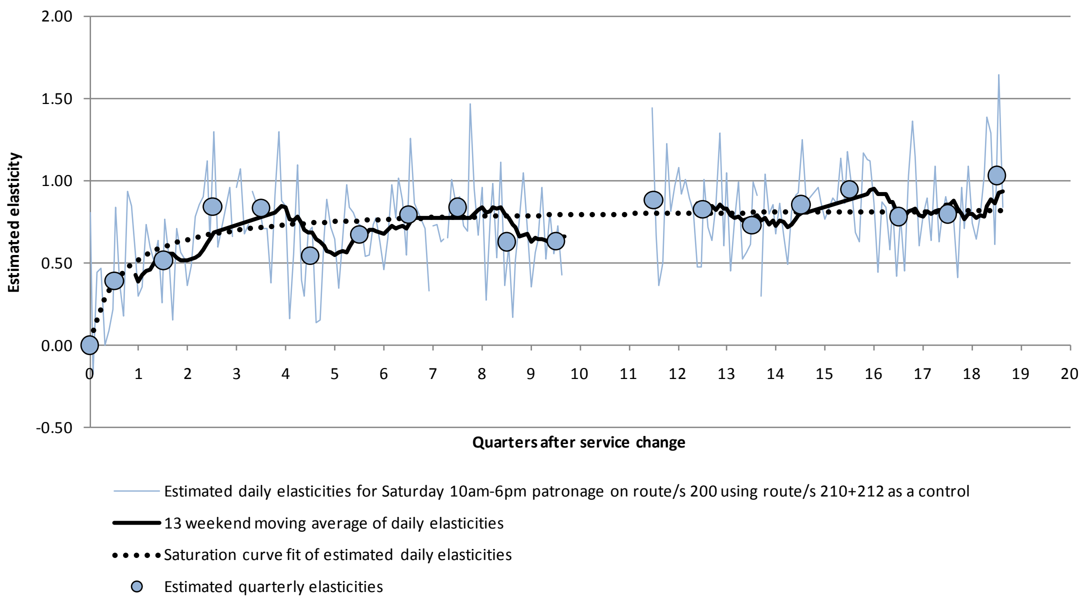


Table F.38 Elasticity estimation using control route method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Apr-05					0.00	0.00
Q1	Jul-05	1,504	468	1.63	1.24	0.39	0.36
Q2	Oct-05	1,650	488	1.73	1.23	0.52	0.60
Q3	Jan-06	1,659	416	1.84	1.03	0.84	0.68
Q4	Apr-06	1,786	457	1.84	1.04	0.84	0.72
Q5	Jul-06	1,883	525	2.03	1.40	0.55	0.74
Q6	Oct-06	1,930	506	2.02	1.27	0.68	0.76
Q7	Jan-07	1,926	499	2.13	1.23	0.79	0.77
Q8	Apr-07	2,048	519	2.11	1.18	0.84	0.78
Q9	Jul-07	2,069	547	2.23	1.45	0.63	0.79
Q10	Oct-07	2,255	601	2.29	1.49	0.63	0.79
Q11	Jan-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.80
Q12	Apr-08	2,122	533	2.12	1.16	0.88	0.80
Q13	Jul-08	2,377	547	2.56	1.45	0.83	0.80
Q14	Oct-08	2,418	614	2.53	1.54	0.73	0.81
Q15	Jan-09	2,372	595	2.61	1.46	0.86	0.81
Q16	Apr-09	2,467	582	2.54	1.32	0.95	0.81
Q17	Jul-09	2,481	590	2.69	1.56	0.78	0.81
Q18	Oct-09	2,568	621	2.70	1.55	0.80	0.81
Q19	#N/A	2,488	560	2.67	1.32	1.03	0.82
Long run							0.84

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

F4.6.4 Elasticity estimation – route extrapolation method

An alternative set of elasticity estimates was made based on an extrapolation growth rate of -1.18% pa. This is the average growth rate of route 200 for the 52 weeks preceding the service change. The results are given in figure F.50 and table F.39.

Figure F.50 Elasticity estimation using extrapolation method

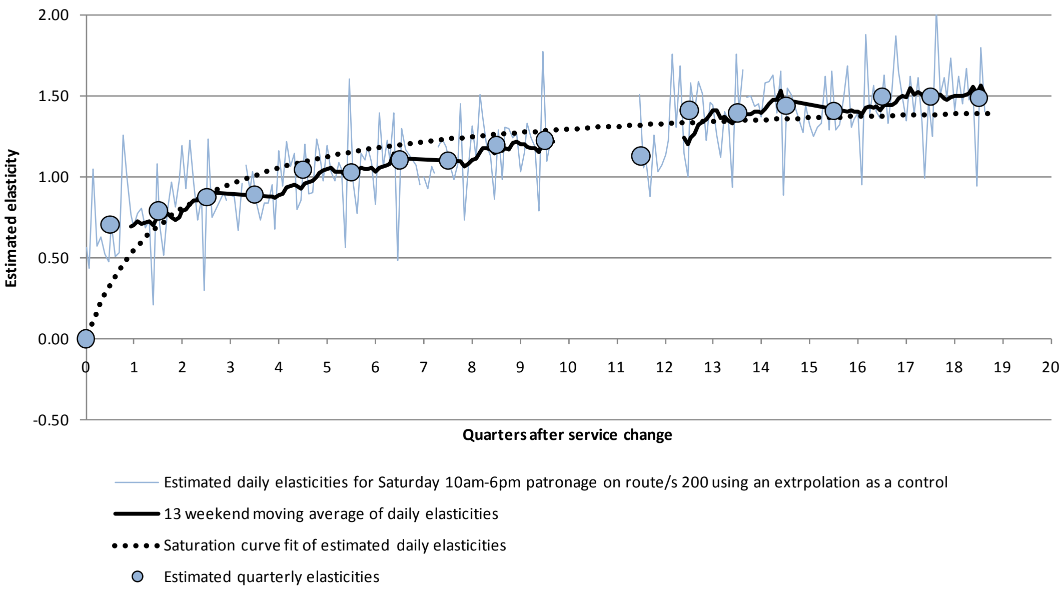


Table F.39 Elasticity estimation using extrapolation method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of extrapolated patronage this quarter to observed patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Apr-05					0.00	0.00
Q1	Jul-05	1,504	924	1.63	0.99	0.70	0.34
Q2	Oct-05	1,650	952	1.73	0.99	0.79	0.70
Q3	Jan-06	1,659	912	1.84	0.99	0.88	0.89
Q4	Apr-06	1,786	962	1.84	0.99	0.89	1.01
Q5	Jul-06	1,883	913	2.03	0.98	1.05	1.09
Q6	Oct-06	1,930	940	2.02	0.98	1.03	1.15
Q7	Jan-07	1,926	901	2.13	0.98	1.10	1.20
Q8	Apr-07	2,048	951	2.11	0.98	1.10	1.23
Q9	Jul-07	2,069	902	2.23	0.97	1.20	1.26
Q10	Oct-07	2,255	959	2.29	0.97	1.23	1.28
Q11	Jan-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	1.30
Q12	Apr-08	2,122	966	2.12	0.96	1.13	1.32
Q13	Jul-08	2,377	891	2.56	0.95	1.41	1.34
Q14	Oct-08	2,418	918	2.53	0.95	1.39	1.35
Q15	Jan-09	2,372	880	2.61	0.95	1.44	1.36
Q16	Apr-09	2,467	928	2.54	0.95	1.41	1.37
Q17	Jul-09	2,481	881	2.69	0.94	1.49	1.38
Q18	Oct-09	2,568	908	2.70	0.94	1.50	1.38
Q19	#N/A	2,488	900	2.67	0.94	1.49	1.39
Long run							1.52

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

F4.6.5 Review and comments

The 'control' elasticity estimates appear to be reasonably well behaved, with a largely complete data series for four to five years after the service change. The control route patronage increased more or less continuously throughout the period. While the resulting elasticities show a considerably smaller quarter-by-quarter growth, they are consistent with saturation being largely reached after about eight quarters.

The 'extrapolation' elasticity analysis is based on an extrapolation rate of -1.2% pa, based on the average route 200 patronage growth rate prior to the service change (April 2005). However, all the signs are that this rate is unrealistically low for reasonable extrapolation purposes, and it results in continually increasing elasticities, to reach values of around 1.4 by the fourth year.

F4.6.6 Conclusions

For these routes, we adopt the 'control' elasticity estimates as the best estimates available.

F4.7 Route 345 analysis

F4.7.1 Service change

The service change occurred on 25 February 2006, with services doubling from two trips per hour to four trips per hour (each direction).

Table F.40 Details of service change

Date of service change for route/s 345:	Saturday, 25 February 2006
Trips before	32
Trips afterwards	64
Ratio	2.00
Control route/s:	330

F4.7.2 Data availability and quantity

As with previous routes, there was a 'gash' in the data from Sat 29 September 2007 to Sat 23 February 2008.

Figure F.51 Patronage on service route and control routes

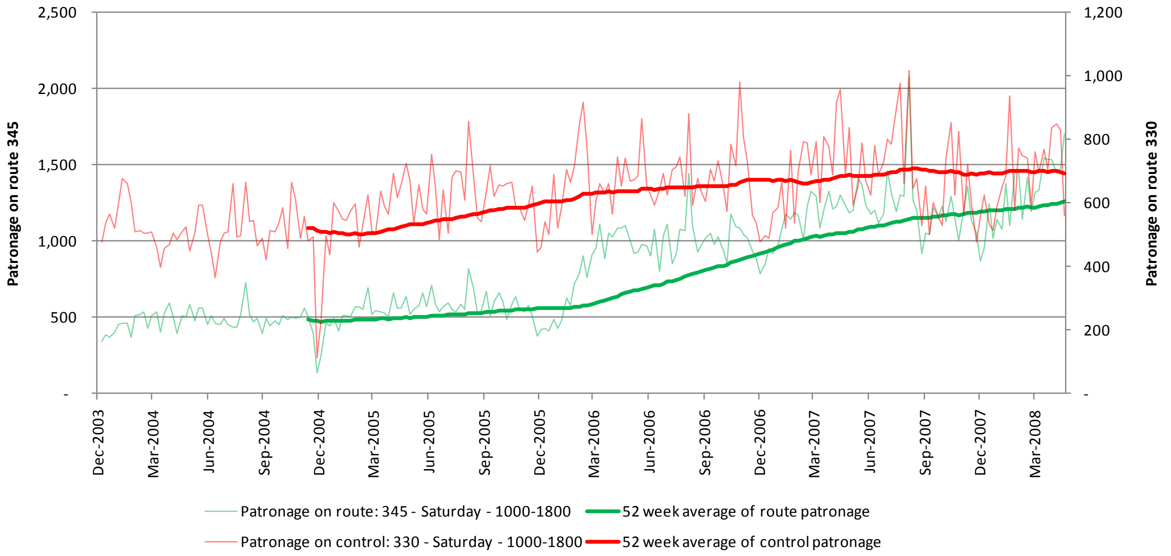
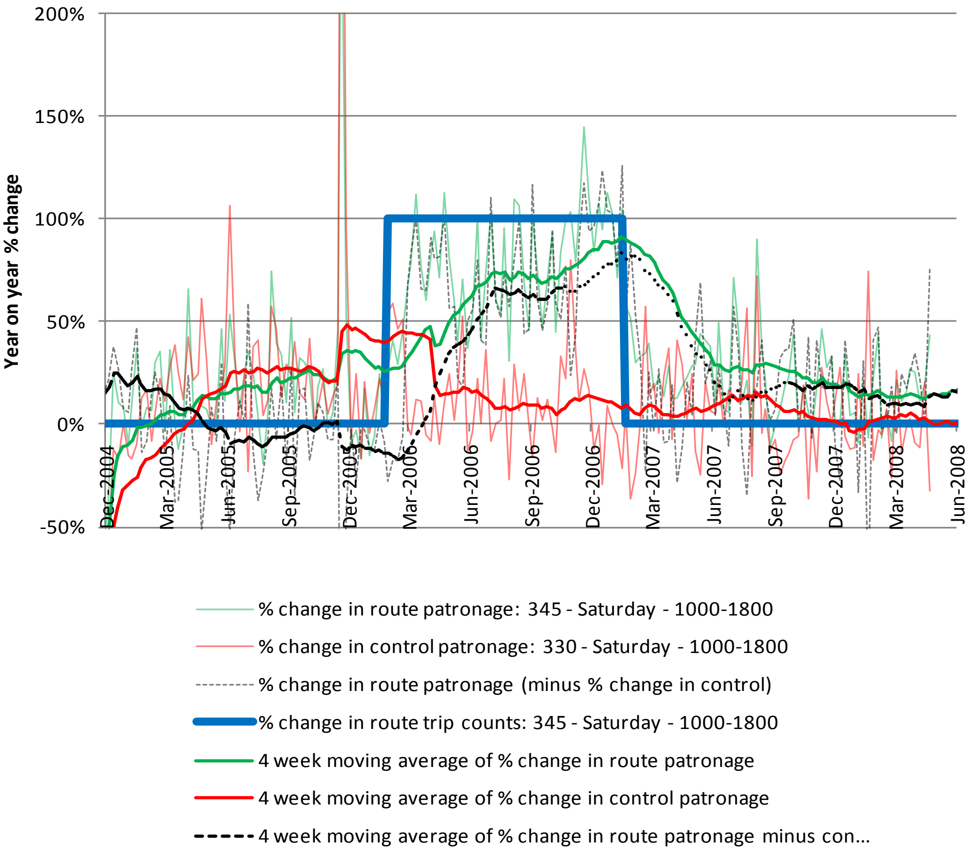


Figure F.52 Patronage growth rates on service route and control routes



F4.7.3 Elasticity estimation – control route method

Figure F.53 Elasticity estimation using control route method

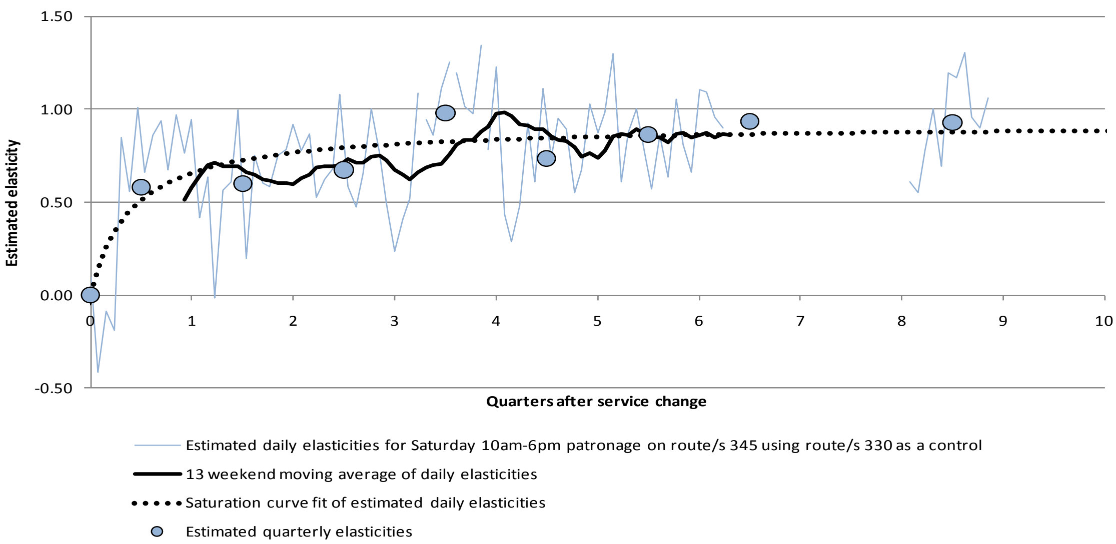


Table F.41 Elasticity estimation using control route method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-06					0.00	0.00
Q1	May-06	974	689	1.74	1.17	0.58	0.48
Q2	Aug-06	973	679	1.68	1.11	0.60	0.72
Q3	Nov-06	1,051	707	1.74	1.10	0.67	0.79
Q4	Feb-07	997	595	2.03	1.04	0.98	0.83
Q5	May-07	1,216	772	2.16	1.31	0.74	0.84
Q6	Aug-07	1,268	742	2.18	1.21	0.86	0.86
Q7	Nov-07	1,366	717	2.08	1.08	0.93	0.87
Q8	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.87
Q9	May-08	1,401	754	2.49	1.31	0.93	0.88
Long run							0.92

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

F4.7.4 Elasticity estimation – route extrapolation method

An alternative set of elasticity estimates was made, based on an extrapolation growth rate of 21% pa; this was the average growth rate of route 345 for the 52 weeks preceding the service change. The results are given in figure F.54 and table F.42.

Figure F.54 Elasticity estimation using extrapolation method

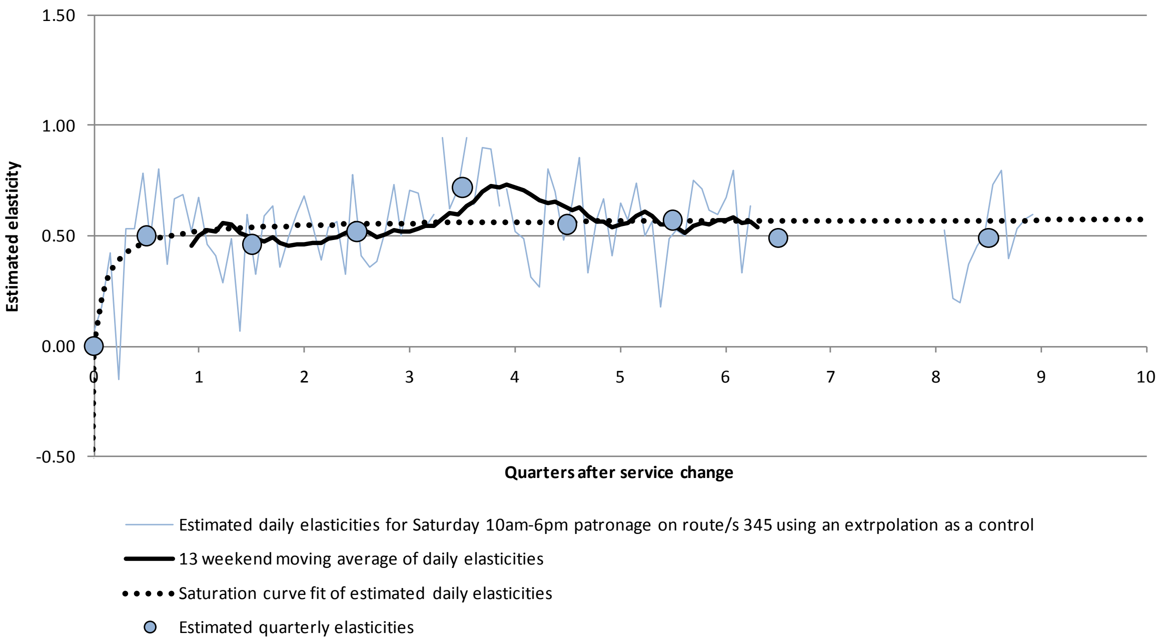


Table F.42 Elasticity estimation using extrapolation method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of extrapolated patronage this quarter to observed patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-06					0.00	0.00
Q1	May-06	974	687	1.74	1.21	0.50	0.45
Q2	Aug-06	973	706	1.68	1.21	0.46	0.54
Q3	Nov-06	1,051	734	1.74	1.21	0.52	0.55
Q4	Feb-07	997	610	2.03	1.23	0.72	0.56
Q5	May-07	1,216	831	2.16	1.46	0.55	0.56
Q6	Aug-07	1,268	854	2.18	1.46	0.57	0.57
Q7	Nov-07	1,366	945	2.08	1.46	0.49	0.57
Q8	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.57
Q9	May-08	1,426	1,013	2.51	1.77	0.49	0.57
Long run							0.58

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

F4.7.5 Review and comments

The 'control' elasticity estimates are reasonably well behaved, although with some significant quarter-to-quarter fluctuations. Both the route patronage trends and the control patronage trends are also well behaved, with the control showing gradually increasing patronage (in the order of 15% pa) for at least the first 18 months after the service change.

The 'extrapolation' elasticities are based on an extrapolated growth rate of 21% pa, derived from trends in the two years prior to the service change. Inspection of the data indicates that this rate is significantly higher than the patronage trends on the control route and it results in decreasing elasticities after the first year.

F4.7.6 Conclusions

For route 345, we adopted the control elasticity estimates as the best available.

F4.8 Summary of Saturday results

Section F4 has analysed the impacts of six sets of Saturday service changes (five routes or route groups). For two of these route groups (route 140 and routes 190/199), the elasticities are 'abnormally' high, suggesting significant abstraction of passengers from competing routes: our additional analyses, incorporating these competing routes, result in more 'normal' elasticities in both cases.

All the elasticity estimates derived are summarised in table F.45. This gives quarterly elasticity values for the first 12 months, then annual average values thereafter. Estimates derived from both the control route method and the extrapolation method are given, for both actual best estimates and the saturation curve estimates.

Based on inspection of the data for each route (as discussed earlier), the estimates judged to be the 'best' in each case are highlighted (in bold).

Further discussion of these findings is given in section F.6 (following), and in the main report section 4.6 and chapter 5.

Table F.45 Results summary – Saturday (1000-1800) daytime

Route/s	Date of service change	Initial freq. per hr (ave dirn)	% freq. increase	Control/s		Q1	Q2	Q3	Q4	Q5-Q8 (2nd yr)	Q9-Q12 (3rd yr)	Q13-Q16 (4th yr)	Long-run	Comment
140	28 February 2009	2	100%	120+170+180	Estimated elasticities:	1.05	1.09	1.07	0.84!	#N/A	#N/A	#N/A	#N/A	High elasticity – no allowance for abstraction from 130.
					Saturation curve fit:	1.01	1.07	1.07	1.07	#N/A	#N/A	#N/A	1.08	
				Extrapolation	Estimated elasticities:	1.03	0.99	1.04	0.89!	#N/A	#N/A	#N/A	#N/A	
					Saturation curve fit:	1.01	1.01	1.01	1.01	#N/A	#N/A	#N/A	1.01	
130+140*	28 February 2009	6	33%	120+170+180	Estimated elasticities:	0.74	0.78	0.83	0.35!	#N/A	#N/A	#N/A	#N/A	More normal elasticity values. 'Control' elasticity values appear more reliable, using saturation values.
					Saturation curve fit:	0.66	0.78	0.81	0.81	#N/A	#N/A	#N/A	0.84	
				Extrapolation	Estimated elasticities:	0.71	0.57	0.79	0.48!	#N/A	#N/A	#N/A	#N/A	
					Saturation curve fit:	0.67	0.67	0.67	0.67	#N/A	#N/A	#N/A	0.67	
150	13 November 2004	2	100%	140	Estimated elasticities:	#N/A	0.67	0.79	0.85	0.79	0.79	0.79	#N/A	Preferred values are mean of control and extrapolation results, with actual estimates and saturation curve giving similar results.
					Saturation curve fit:	0.59	0.74	0.77	0.78	0.79	0.80	0.81	0.81	
				Extrapolation	Estimated elasticities:	0.34	0.69	0.75	0.81	0.89	1.01	1.03	#N/A	
					Saturation curve fit:	0.31	0.61	0.75	0.82	0.92	0.99	1.03	1.12	
190/199 (1st service change)	25 February 2006	2	100%	375	Estimated elasticities:	#N/A	0.68	0.83	0.81	0.96	1.29	#DIV/0!	#N/A	Elasticity estimates on high side, most likely because of abstraction effects.
					Saturation curve fit:	0.25	0.56	0.76	0.90	1.10	1.24	N/A	1.63	

Route/s	Date of service change	Initial freq. per hr (ave dirn)	% freq. increase	Control/s		Q1	Q2	Q3	Q4	Q5-Q8 (2nd yr)	Q9-Q12 (3rd yr)	Q13-Q16 (4th yr)	Long-run	Comment
				Extrapolation	Estimated elasticities:	#N/A	0.59	0.74	0.74	0.62	0.56	#DIV/0!	#N/A	
					Saturation curve fit:	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	
199 (2nd service change)	1 Nov-ember 2008	4	50%	375	Estimated elasticities:	#N/A	1.07	0.80	0.27	#N/A	#N/A	#N/A	#N/A	Unsatisfactory results.
					Saturation curve fit:	0.68	0.68	0.68	0.68	#N/A	#N/A	#N/A	0.68	
				Extrapolation	Estimated elasticities:	#N/A	0.40	0.29	0.11	#N/A	#N/A	#N/A	#N/A	
					Saturation curve fit:	0.25	0.25	0.25	0.25	#N/A	#N/A	#N/A	0.25	
190+191/ 196+199* (1st service change)	25 February 2006	4	50%	375	Estimated elasticities:	0.46	0.41	0.54	0.51	1.09	1.52	#DIV/0!	#N/A	Full period results are abnormal, suggesting other factors continuing to cause patronage growth. Analysis for periods up to Q4 only gives more plausible results – quarterly estimates and saturation curve values are very similar.
					Saturation curve fit:	0.11	0.31	0.50	0.68	1.06	1.58	2.00	5.91	
				Extrapolation	Estimated elasticities:	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
					Saturation curve fit:	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
190+191/ 196+199* (1st service change) (up to end Q4)	25 February 2006	4	50%	375	Estimated elasticities:	0.46	0.41	0.54	0.51	#N/A	#DIV/0!	#DIV/0!	#N/A	
					Saturation curve fit:	0.42	0.48	0.49	0.49	0.50	0.50	0.50	0.50	
				Extrapolation	Estimated elasticities:	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
					Saturation curve fit:	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	

Route/s	Date of service change	Initial freq. per hr (ave dirn)	% freq. increase	Control/s		Q1	Q2	Q3	Q4	Q5-Q8 (2nd yr)	Q9-Q12 (3rd yr)	Q13-Q16 (4th yr)	Long-run	Comment
190+191/ 196+199* (2nd service change)	1 November 2008	6	33%	375	Estimated elasticities:	#N/A	1.36	0.91	0.25	#N/A	#N/A	#N/A	#N/A	The saturation curve gives the most plausible results. However, the underlying trend is very uncertain and this value should not be relied on.
					Saturation curve fit:	0.79	0.80	0.80	0.80	#N/A	#N/A	#N/A	0.80	
				Extrapolation	Estimated elasticities:	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
					Saturation curve fit:	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
200	23 April 2005	2	100%	210+212	Estimated elasticities:	**0.39**	**0.52**	**0.84**	**0.84**	**0.72**	**0.71**	**0.84**	#N/A	Control elasticities appear more reliable, with quarterly values and saturation 'estimates' being similar.
					Saturation curve fit:	**0.36**	**0.60**	**0.68**	**0.72**	**0.75**	**0.80**	**0.81**	**0.84**	
				Extrapolation	Estimated elasticities:	0.70	0.79	0.88	0.89	1.07	1.18	1.41	#N/A	
					Saturation curve fit:	0.34	0.70	0.89	1.01	1.17	1.29	1.36	1.52	
345	25 February 2006	2	100%	330	Estimated elasticities:	**0.58**	**0.60**	**0.67**	**0.98**	**0.84**	#N/A	#N/A	#N/A	Control elasticities appear more reliable, with quarterly values and saturation estimates being similar.
					Saturation curve fit:	**0.48**	**0.72**	**0.79**	**0.83**	**0.89**	**0.89**	**0.90**	**0.92**	
				Extrapolation	Estimated elasticities:	0.50	0.46	0.52	0.72	0.54	0.49	#N/A	#N/A	
					Saturation curve fit:	0.45	0.54	0.55	0.56	0.57	0.57	0.57	0.58	

** Note – the route of interest was expanded to include routes where there were not service enhancements so we could explore 'abstraction' effects.*

! Note – these quarters included only about a month of data, due to the data ending partway through the quarter. Hence, less weight should be given to these quarters.

F5 Sunday analyses

F5.1 Route 140 analysis

F5.1.1 Service change

The service change in March 2009 resulted in an increase in service frequency on route 140 from 1.5 trips per hour to four trips per hour (each direction).

Table F.46 Details of service change

Date of service change for route/s 140:	Sunday, 1 March 2009
Trips before	23
Trips afterwards	64
Ratio	2.78
Control route/s:	120+170+180

F5.1.2 Data availability and quantity

As with previous routes, there was a 'gash' in the data from Sat 29 September 2007 to Sat 23 February 2008.

Figure F.55 Patronage on service route and control routes

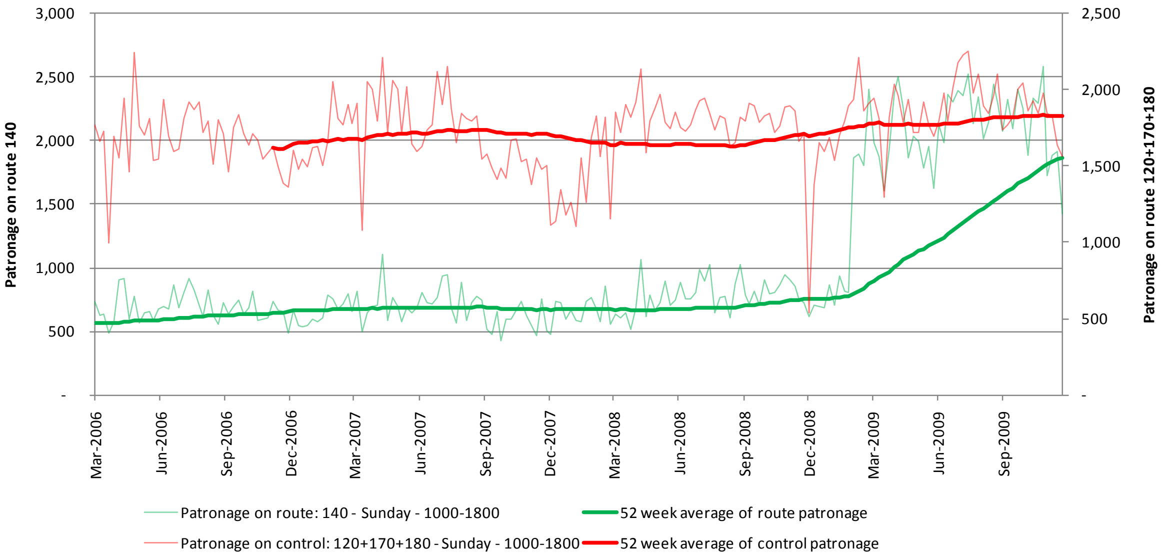
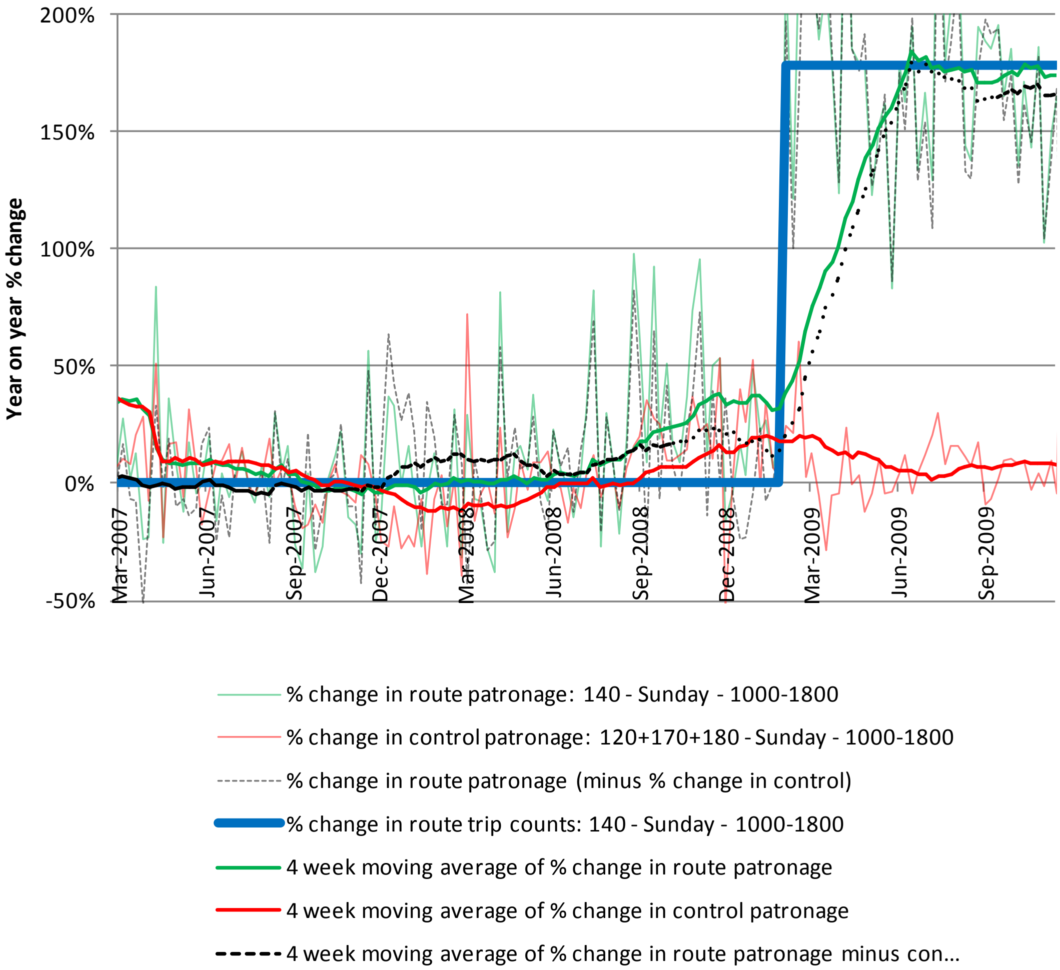


Figure F.56 Patronage growth rates on service route and control routes



F5.1.3 Elasticity estimation – control route method

Figure F.57 Elasticity estimation using control route method

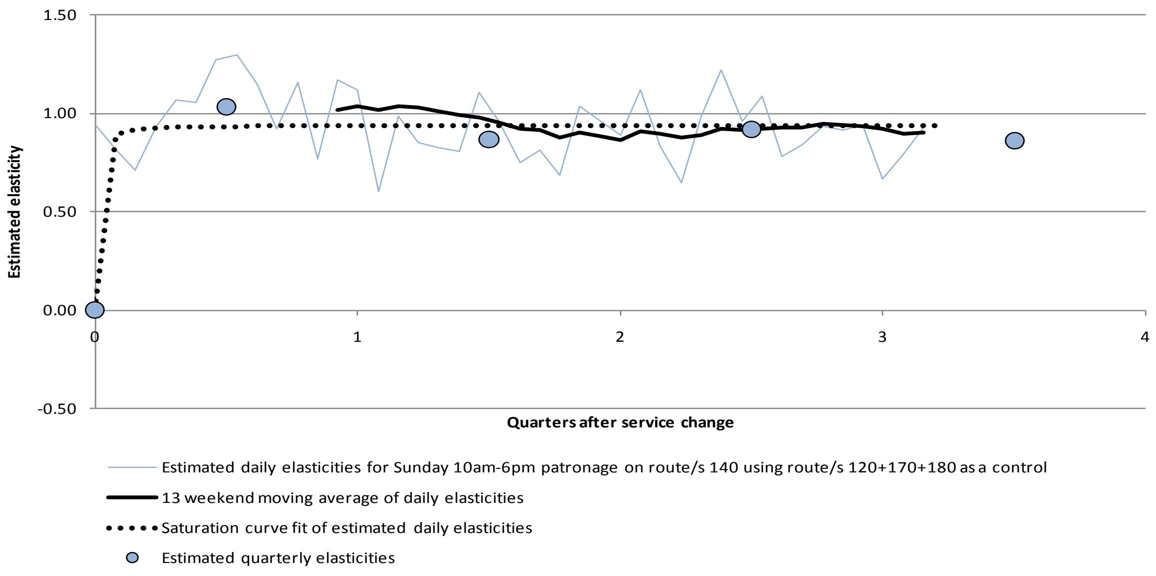


Table –F.47 Elasticity estimation using control route method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-09					0.00	0.00
Q1	May-09	2,039	1,847	3.06	1.07	1.03	0.93
Q2	Aug-09	2,147	1,969	2.65	1.08	0.87	0.94
Q3	Nov-09	2,220	1,902	2.73	1.06	0.92	0.94
Q4	#N/A	1,901	1,732	2.38	0.98	0.86	0.94
Long run							0.94

Note: The ratio of route trips after the service change compared to prior to the service change was 2.78

Note that Q4 includes less than a month of data: hence the estimated elasticity of 0.86 for that quarter should not be given as much weight as the other quarters.

F5.1.4 Elasticity estimation – route extrapolation method

An alternative set of elasticity estimates was made, based on an extrapolation growth rate of 5.80% pa. This was derived as the weighted average of the average growth rate in the 52-week period prior to the service (weight=75%) and the average growth rate in the 52-week period ending a year before the service change (weight=25%), but excluding growth rates distorted by the 'gash' in the data. The results are given in figure F.58 and table F.48.

Note that Q4 includes less than a month of data: hence the estimated of elasticity of 0.79 for that quarter should not be given as much weight as the other quarters.

Figure F.58 Elasticity estimation using extrapolation method

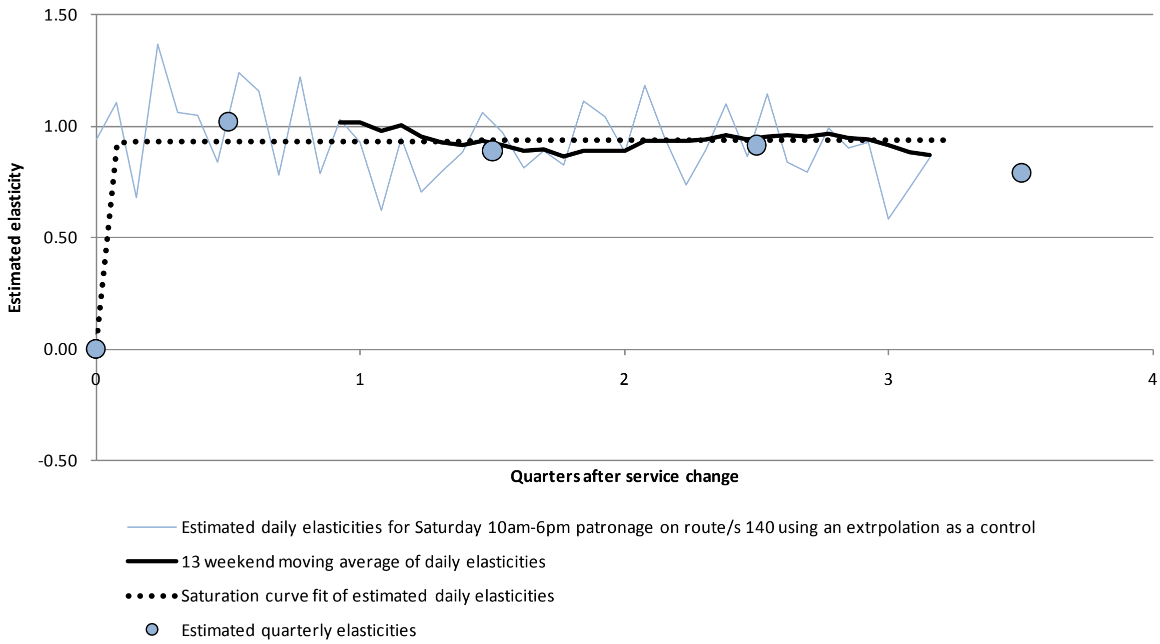


Table F.48 Elasticity estimation using extrapolation method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of extrapolated patronage this quarter to observed patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-09					0.00	0.00
Q1	May-09	2,039	728	3.06	1.06	1.02	0.93
Q2	Aug-09	2,147	866	2.65	1.06	0.89	0.93
Q3	Nov-09	2,220	873	2.73	1.06	0.91	0.93
Q4	#N/A	1,901	850	2.38	1.06	0.79	0.93
Long run							0.93

F5.1.5 Review and comments

As for the evening and Saturday analyses, the abnormally high elasticity values most likely reflect some abstraction of patronage from route 130 in particular – this effect is addressed through the analyses below.

F5.1.6 Conclusions

These results are considered 'abnormal', because of expected abstraction of patronage from route 130: this is addressed in the following section.

F5.2 Route 130+140 analysis

F5.2.1 Service change

This is the same service change as considered in the previous section. Taking routes 130 and 140 together, the average frequency increases by nearly 50%, from 5.4 trips per hour to eight trips per hour (average each direction).

Table F.49 Details of service change

Date of service change for route/s 130+140:	Sunday, 1 March 2009
Trips before	87
Trips afterwards	128
Ratio	1.47
Control route/s:	120+170+180

F5.2.2 Data availability and quantity

As with previous routes, there was a 'gash' in the data from Sat 29 September 2007 to Sat 23 February 2008.

Figure F.59 Patronage on service route and control routes

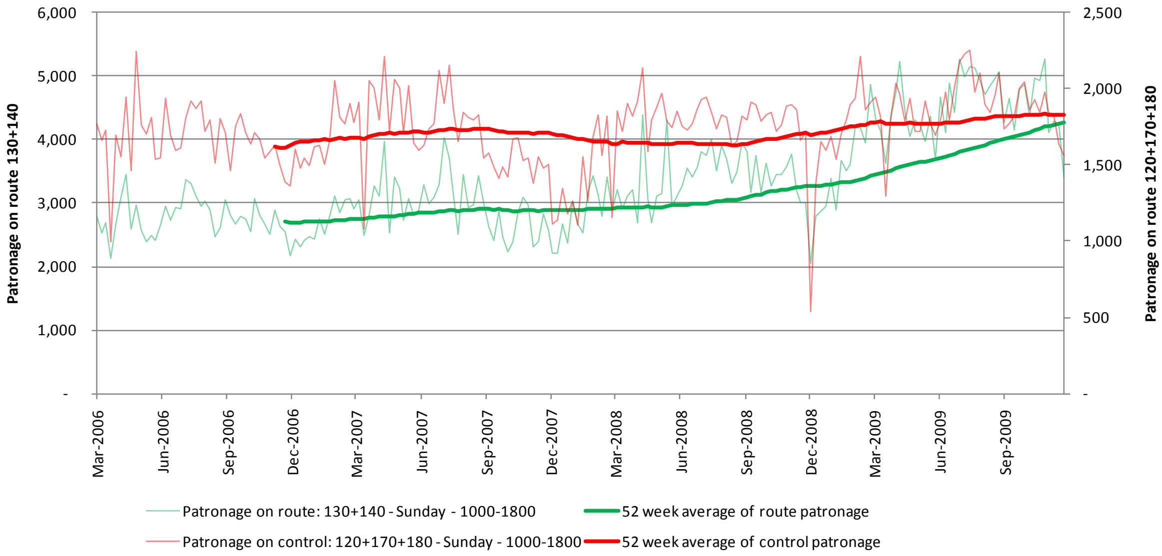
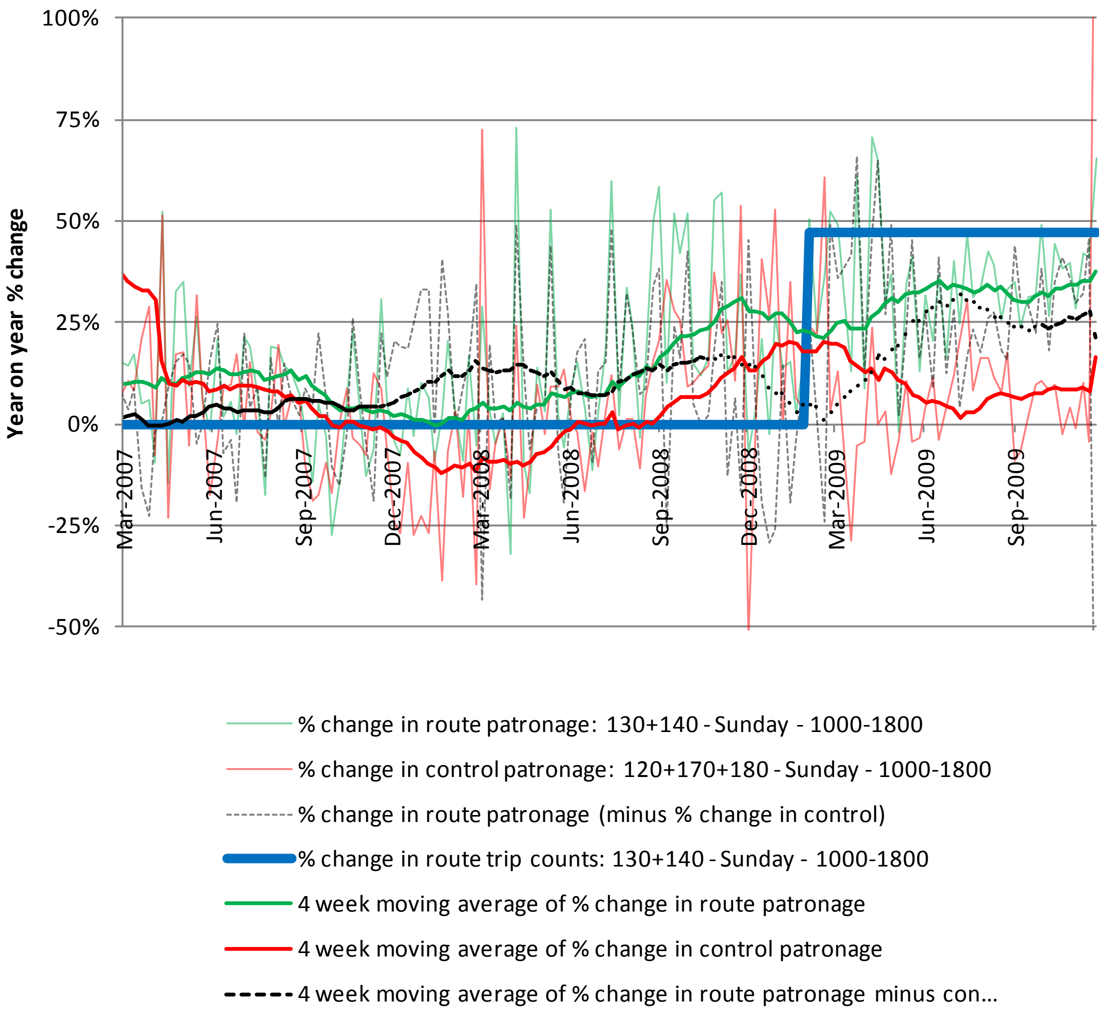


Figure F.60 Patronage growth rates on service route and control routes



F5.2.3 Elasticity estimation – control route method

Results for this method are given in figure F.61 and table F.50. Note that Q4 includes less than a month of data: hence the estimated elasticity of 0.87 for that quarter should not be given as much weight as the other quarters.

Figure F.61 Elasticity estimation using control route method

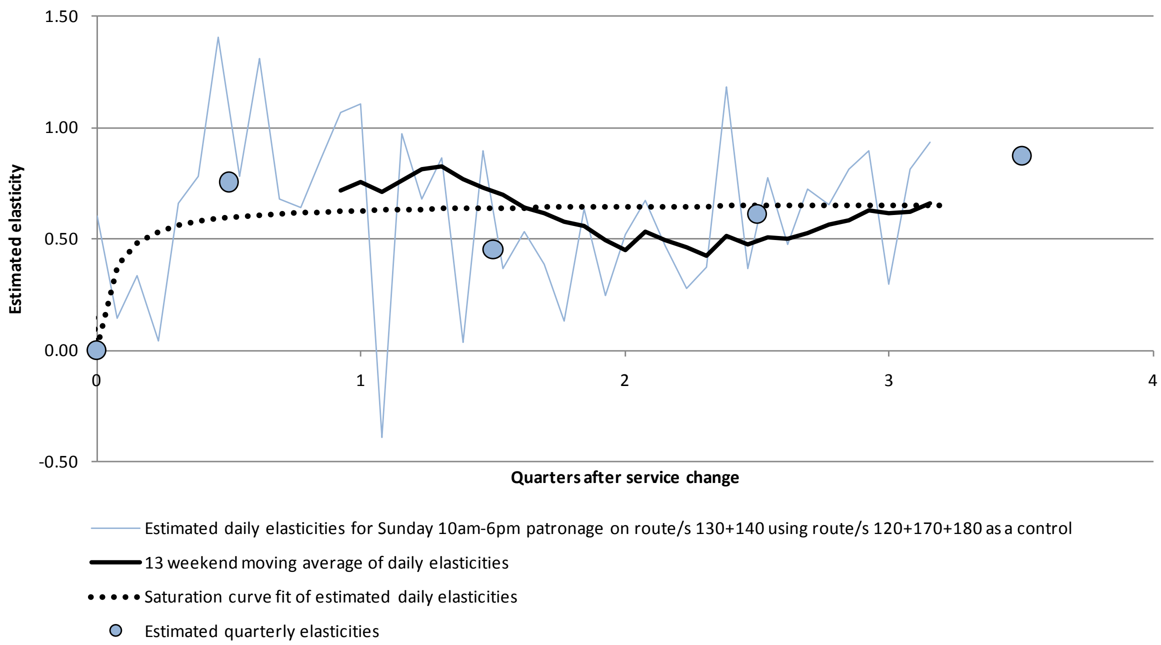


Table F.50 Elasticity estimation using control route method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-09					0.00	0.00
Q1	May-09	4,340	1,847	1.41	1.07	0.75	0.57
Q2	Aug-09	4,638	1,969	1.30	1.08	0.45	0.64
Q3	Nov-09	4,710	1,902	1.35	1.06	0.61	0.65
Q4	#N/A	4,268	1,732	1.38	0.98	0.87	0.65
Long run							0.66

Note: The ratio of route trips after the service change compared to prior to the service change was 1.47

F5.2.4 Elasticity estimation – route extrapolation method

An alternative set of elasticity estimates was made, based on an extrapolation growth rate of 10.14% pa. This was derived as the weighted average of the average growth rate in the 52-week period prior to the service (weight=75%) and the average growth rate in the 52-week period ending a year before the service change (weight=25%), but excluding growth rates distorted by the 'gash' in the data. The results are given in figure F.62 and table F.51.

Note that Q4 includes less than a month of data: hence the estimated of elasticity of 0.58 for that quarter should not be given as much weight as the other quarters.

Figure F.62 Elasticity estimation using extrapolation method

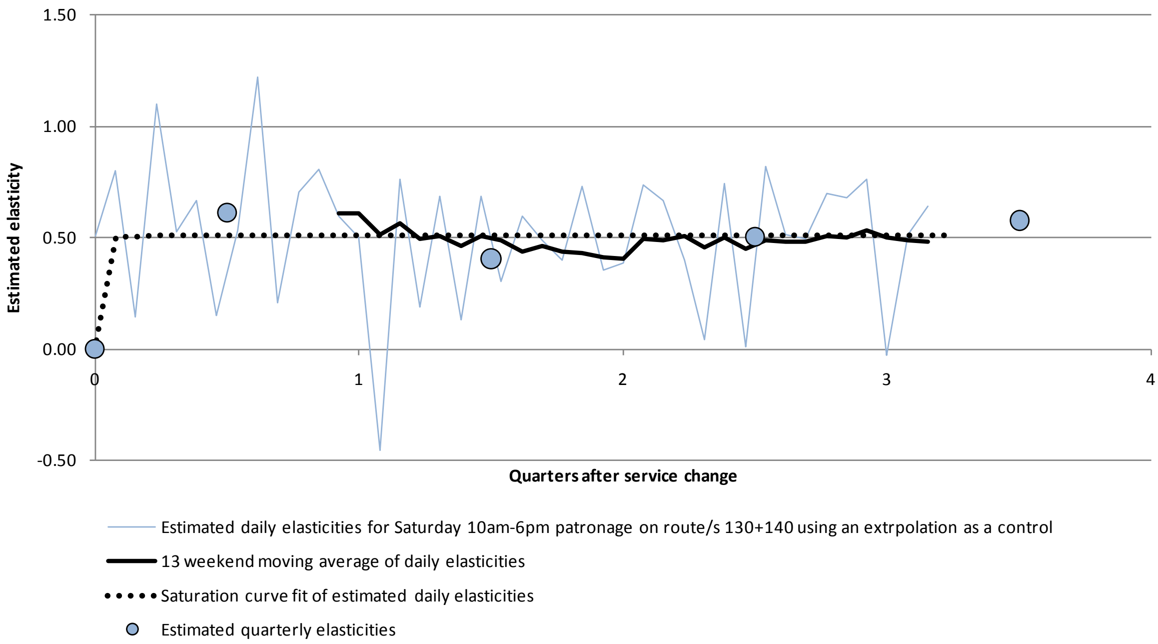


Table F.51 Elasticity estimation using extrapolation method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of extrapolated patronage this quarter to observed patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-09					0.00	0.00
Q1	May-09	4,340	3,440	1.41	1.10	0.61	0.51
Q2	Aug-09	4,638	3,967	1.30	1.10	0.40	0.51
Q3	Nov-09	4,710	3,877	1.35	1.10	0.50	0.51
Q4	#N/A	4,268	3,417	1.38	1.10	0.58	0.51
Long run							0.51

Note: The ratio of route trips after the service change compared to prior to the service change was 1.47

F5.2.5 Review and comments

Both the ‘control’ and ‘extrapolation’ elasticity estimates are reasonably well behaved, although with the highest values occurring in Q1 and some decline in Q2, Q3, Q4.

The differences in results between the two sets of estimates are relatively small, with the extrapolation method involving a growth rate of 10.1% pa.

F5.2.6 Conclusions

We adopted the ‘control’ elasticity results as the best estimates, while noting some significant variations between the quarterly actual estimates and the saturation curve values.

F5.3 Route 150 analysis

F5.3.1 Service change

The service change in November 2004 involved a frequency increase approaching three-fold, from 1.4 trips per hour to four trips per hour (average each direction).

Table F.52 Details of service change

Date of service change for route/s 150:	Sunday, 14 November 2004
Trips before	23
Trips afterwards	64
Ratio	2.78
Control route/s:	140

F5.3.2 Data availability and quantity

As with previous routes, there was a 'gash' in the data from Sat 29 September 2007 to Sat 23 February 2008.

Figure F.63 Patronage on service route and control routes

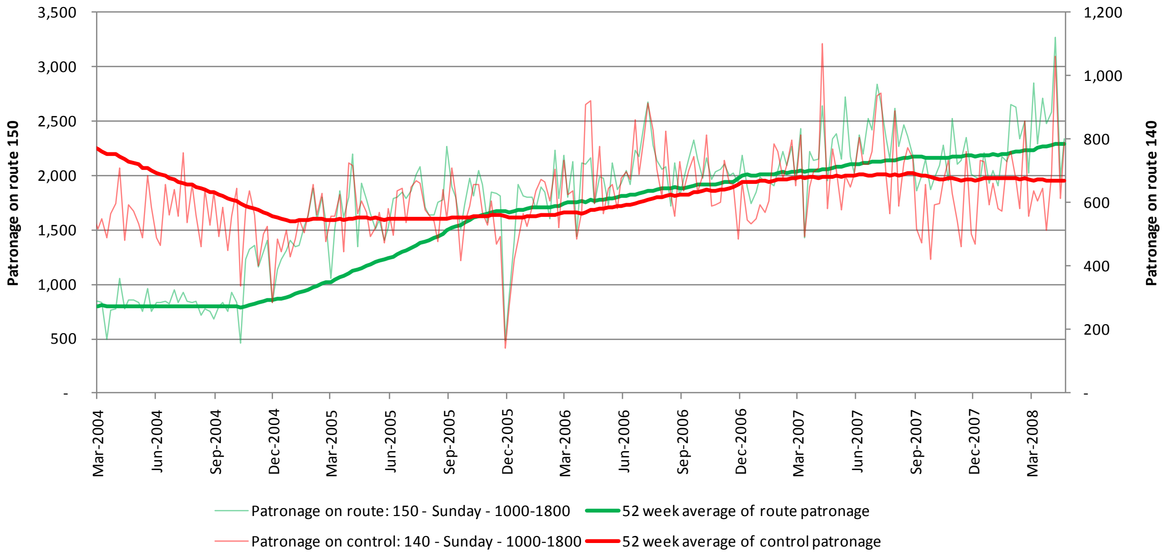
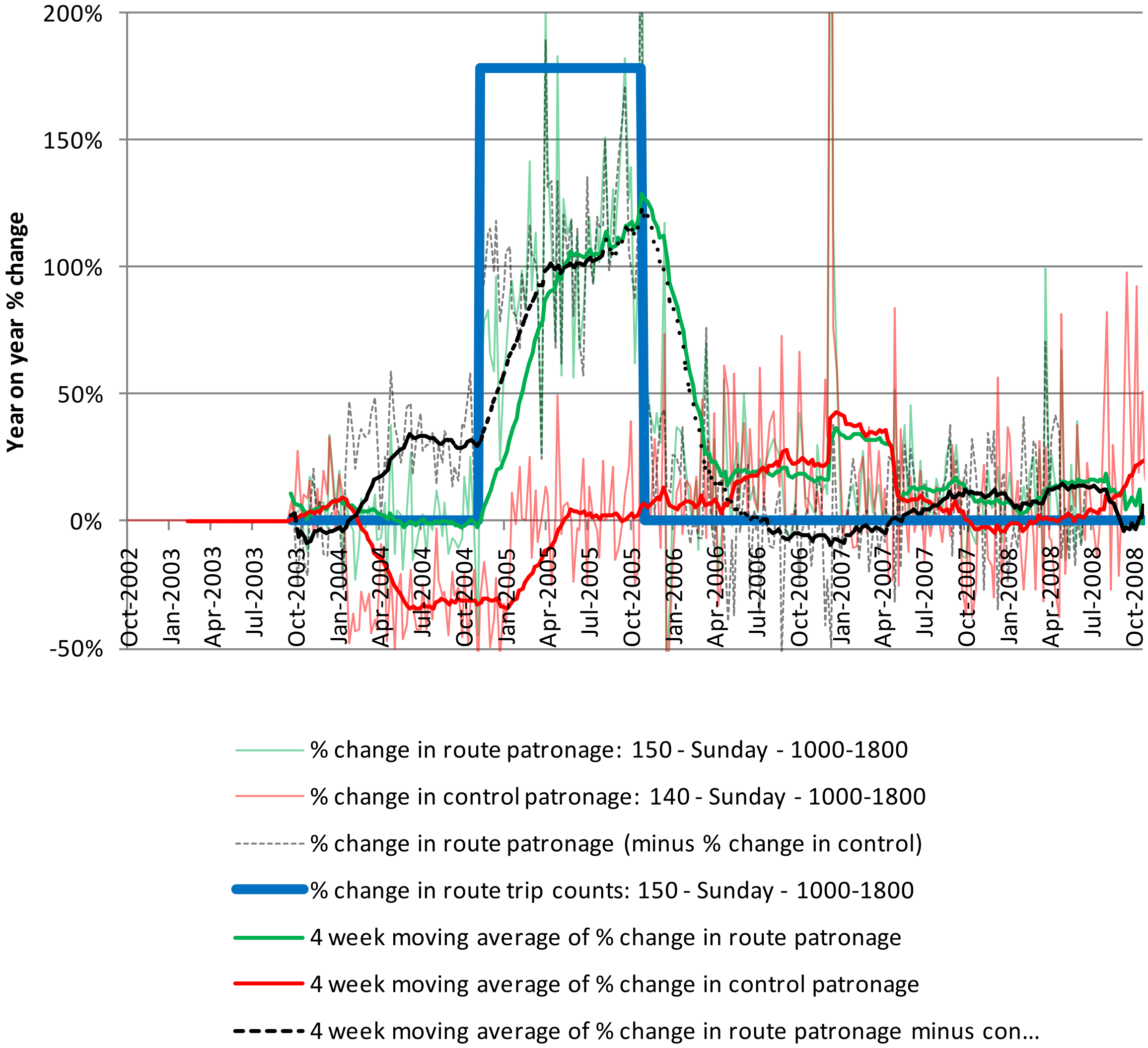


Figure F.64 Patronage growth rates on service route and control routes



F5.3.3 Elasticity estimation – control route method

The results for this method are shown in figure F.65 and table F.53. Given apparent data anomalies for the control route some nine months before the service change, no elasticity estimates have been attempted for Q1 and the corresponding quarters in the following years.

Figure F.65 Elasticity estimation using control route method

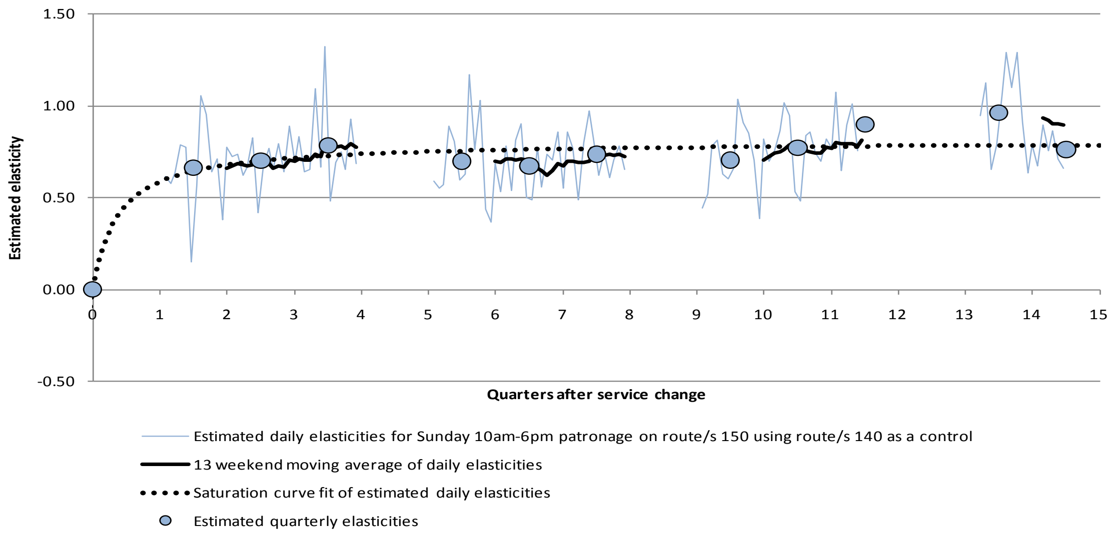


Table F.53 Elasticity estimation using control route method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Nov-04					0.00	0.00
Q1	Feb-05	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.44
Q2	May-05	1,674	591	2.12	1.06	0.66	0.65
Q3	Aug-05	1,740	577	2.05	1.01	0.70	0.70
Q4	Nov-05	1,792	574	2.41	1.09	0.78	0.73
Q5	Feb-06	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.74
Q6	May-06	1,925	665	2.45	1.20	0.70	0.75
Q7	Aug-06	2,107	721	2.49	1.26	0.67	0.76
Q8	Nov-06	2,053	689	2.76	1.32	0.73	0.77
Q9	Feb-07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.77
Q10	May-07	2,112	725	2.64	1.31	0.70	0.78
Q11	Aug-07	2,395	742	2.83	1.30	0.77	0.78
Q12	Nov-07	2,340	714	3.07	1.25	0.90	0.78
Q13	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.78
Q14	May-08	2,512	675	3.21	1.22	0.96	0.78
Q15	Aug-08	2,466	755	2.96	1.36	0.76	0.79
Long run							0.81

Note: The ratio of route trips after the service change compared to prior to the service change was 2.78

F5.3.4 Elasticity estimation – route extrapolation method

An alternative set of elasticity estimates was made, based on an extrapolation growth rate of 1.09% pa. This was the average growth rate of route 150 for the 52-week period preceding the service change. The results are given in figure F.66 and table F.54.

Figure F.66 Elasticity estimation using extrapolation method

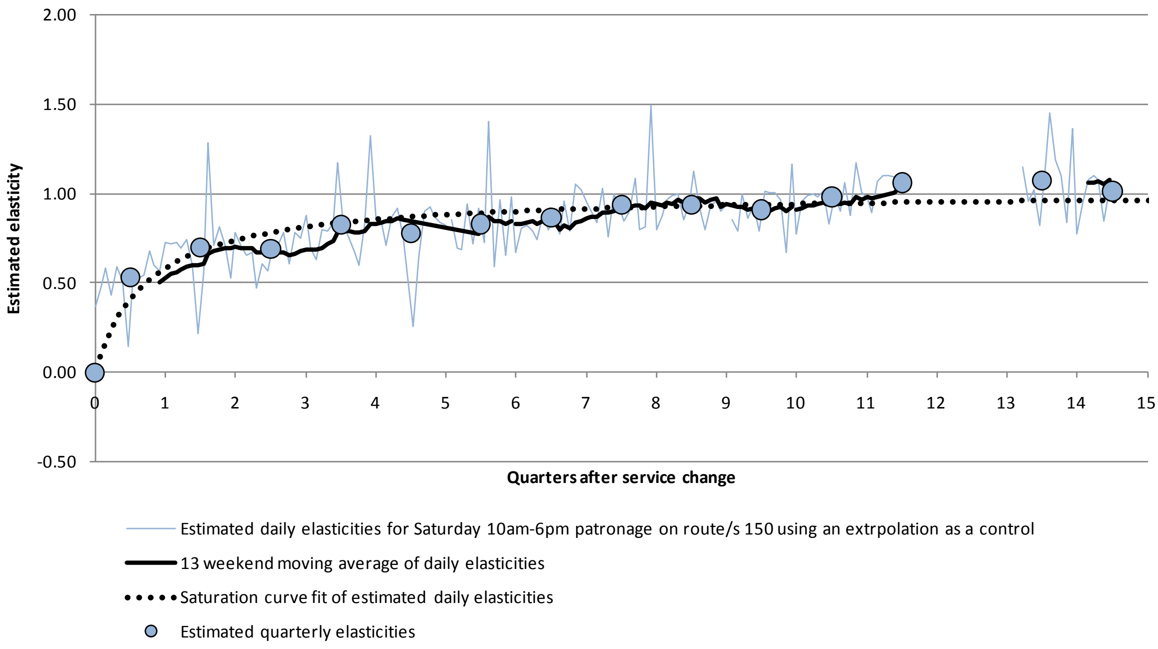


Table F.54 Elasticity estimation using extrapolation method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of extrapolated patronage this quarter to observed patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Nov-04					0.00	0.00
Q1	Feb-05	1,282	740	1.75	1.01	0.53	0.39
Q2	May-05	1,674	817	2.12	1.01	0.70	0.68
Q3	Aug-05	1,740	858	2.05	1.01	0.69	0.78
Q4	Nov-05	1,811	782	2.41	1.01	0.83	0.84
Q5	Feb-06	1,693	750	2.30	1.02	0.78	0.87
Q6	May-06	1,925	826	2.45	1.02	0.83	0.89
Q7	Aug-06	2,107	867	2.49	1.02	0.86	0.91
Q8	Nov-06	2,046	790	2.73	1.02	0.94	0.92
Q9	Feb-07	1,974	756	2.70	1.03	0.94	0.93
Q10	May-07	2,112	835	2.64	1.03	0.91	0.94
Q11	Aug-07	2,395	877	2.83	1.03	0.98	0.94
Q12	Nov-07	2,340	791	3.07	1.03	1.06	0.95
Q13	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.95
Q14	May-08	2,512	840	3.21	1.04	1.07	0.96
Q15	Aug-08	2,466	868	2.96	1.04	1.01	0.96
Q16	Nov-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.96
Long run							1.01

Note: The ratio of route trips after the service change compared to prior to the service change was 2.78

F5.3.5 Review and comments

Data issues arise in relation to the control dataset, as the apparent sudden drop in control patronage in January 2004 affects the control patronage estimates for Q1 and the same quarter in subsequent years

(Q5, Q9 etc). The data ‘gash’ in the period September 2007–February 2008 also limits any elasticity estimates for that period.

Apart from these issues, the ‘control’ elasticity estimates are reasonably well-behaved, with indications of patronage being close to saturation after about four quarters.

The ‘extrapolation’ elasticity estimates are based on an extrapolated growth rate of 1.1% pa. Inspection of the data suggests that this understates the underlying patronage trends, for both route 150 and the control route, in the after period (eg 2006, 2007). However, in the short term (Q1–Q4) after the service change, there is little difference between the two sets of elasticity estimates.

F5.3.6 Conclusions

We adopted the control elasticity estimates as the best estimates in this case.

F5.4 Route 190/199 analysis

F5.4.1 Service change

The service change in February 2006 involved a doubling of frequency on this route, from two trips per hour to four trips per hour (each direction).

Table F.55 Details of service changes

Date of service change for route/s 190+199:	Sunday, 26 February 2006
Trips before	32
Trips afterwards	64
Ratio	2.00
Control route/s:	375

F5.4.2 Data availability and quantity

As with previous routes, there was a ‘gash’ in the data from Sat 29 September 2007 to Sat 23 February 2008.

There was also a gap in the data provided, from Sat 25 February 2006 to Sat 20 May 2006. This gap immediately follows the service change.

Figure F.67 Patronage on service route and control routes

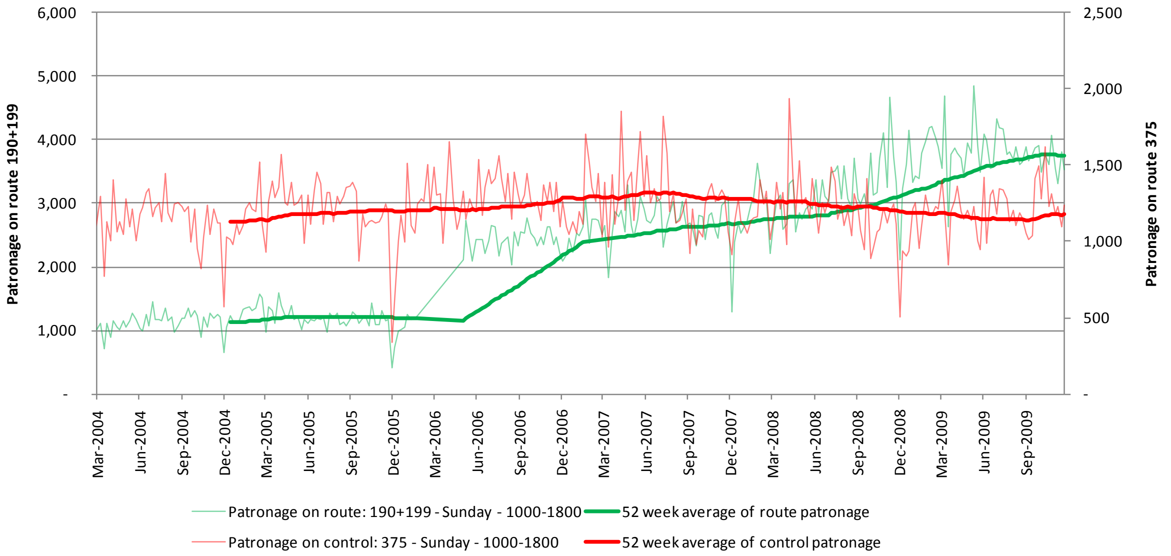
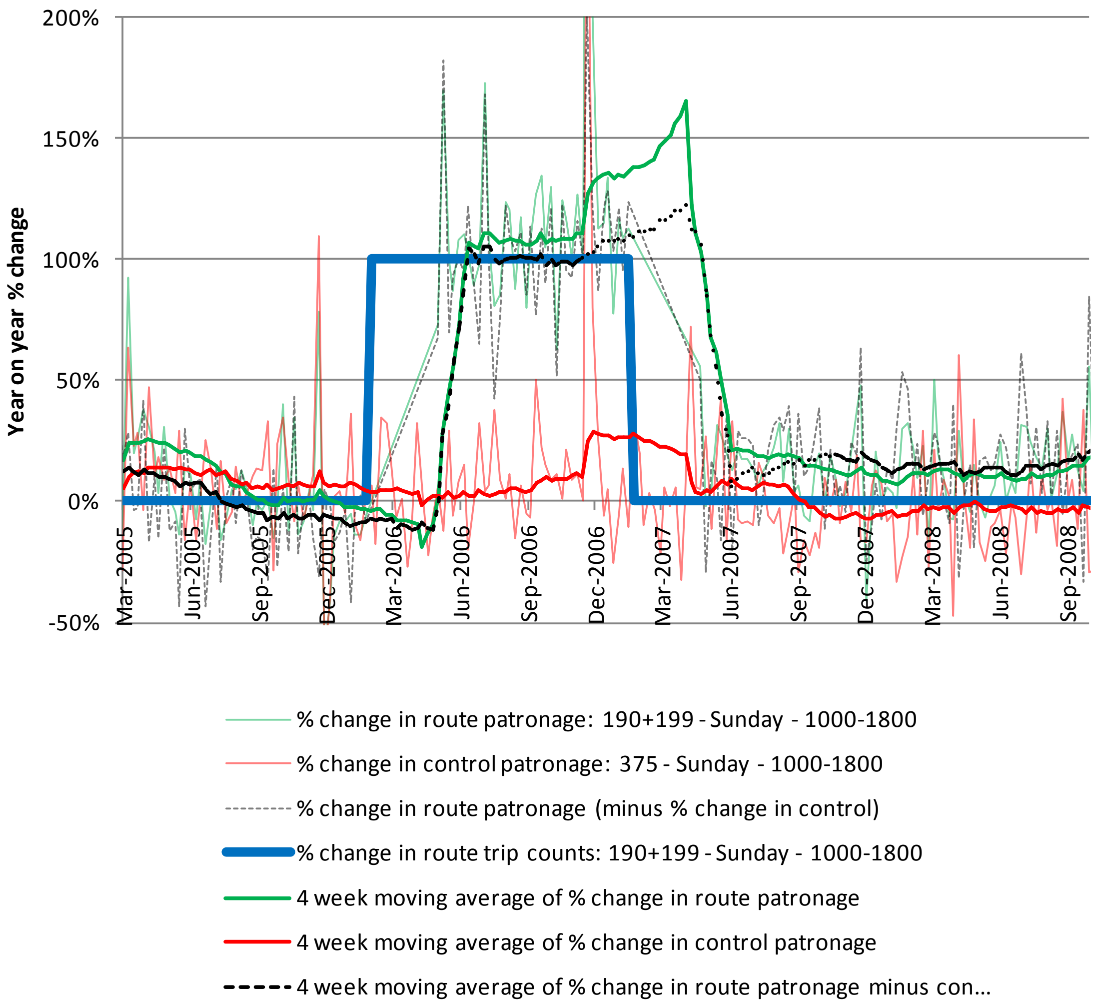


Figure F.68 Patronage growth rates on service route and control routes



F5.4.3 Elasticity estimation – control route method

The results using this method are shown in figure F.69a and table F.56a.

We note that the elasticity for the first quarter following the service change could not be estimated because of the 'gash' in the data from Sat 29 September 2007 to Sat 23 February 2008. Data deficiencies were also identified in Q7.

We also note that in figure F.69a there appears to be a second growth spurt that starts around quarter 10 - 11. It is possible that this reflects some 'flow-over' impact of enhancements on the Saturday route from 27 October 2008 (although it may be the result of other, unexplained, factors). Therefore, figure F.69b and table F.56b exclude data from this point onwards.

Figure F.69a Elasticity estimation using control route method (all data)

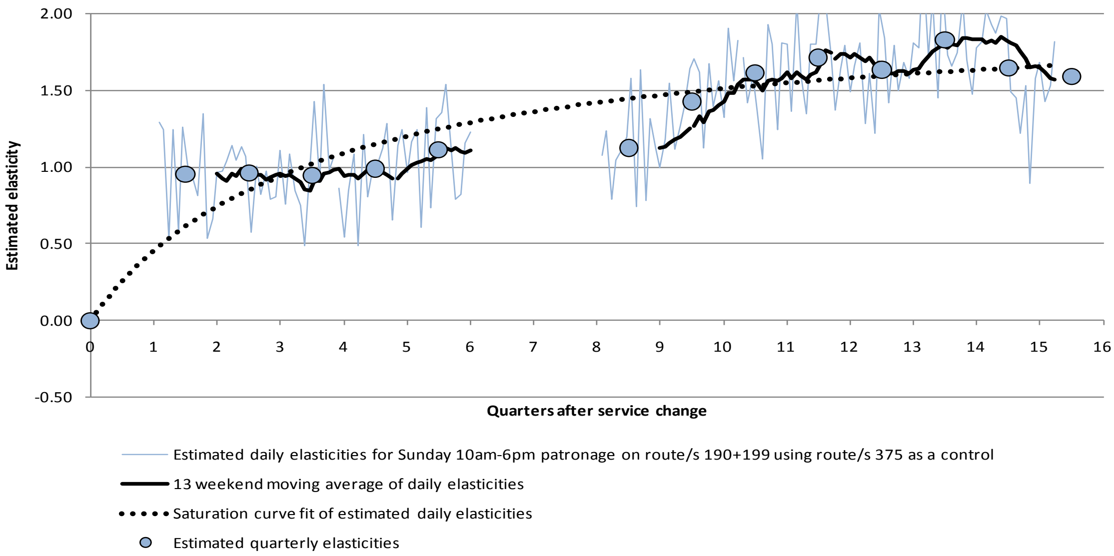


Table F.56a Elasticity estimation using control route method (all data)

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-06					0.00	0.00
Q1	May-06	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.26
Q2	Aug-06	2,408	1,340	2.08	1.08	0.95	0.62
Q3	Nov-06	2,463	1,297	2.12	1.10	0.96	0.86
Q4	Feb-07	2,441	1,244	2.45	1.32	0.94	1.03
Q5	May-07	2,675	1,323	2.05	1.04	0.99	1.15
Q6	Aug-07	2,800	1,403	2.41	1.13	1.11	1.25
Q7	Nov-07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	1.33
Q8	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	1.39
Q9	May-08	2,915	1,315	2.24	1.04	1.13	1.45
Q10	Aug-08	3,143	1,259	2.72	1.01	1.43	1.49
Q11	Nov-08	3,333	1,116	2.88	0.94	1.62	1.53
Q12	Feb-09	3,538	1,060	3.55	1.12	1.71	1.57
Q13	May-09	3,822	1,200	2.94	0.95	1.63	1.60
Q14	Aug-09	3,961	1,203	3.44	0.97	1.83	1.62
Q15	Nov-09	3,758	1,239	3.23	1.05	1.65	1.64
Q16	#N/A	3,555	1,166	2.94	0.97	1.59	1.66
Long run							2.04

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

Figure F.69b Elasticity estimation using control route method (excluding post-27 October 2008)

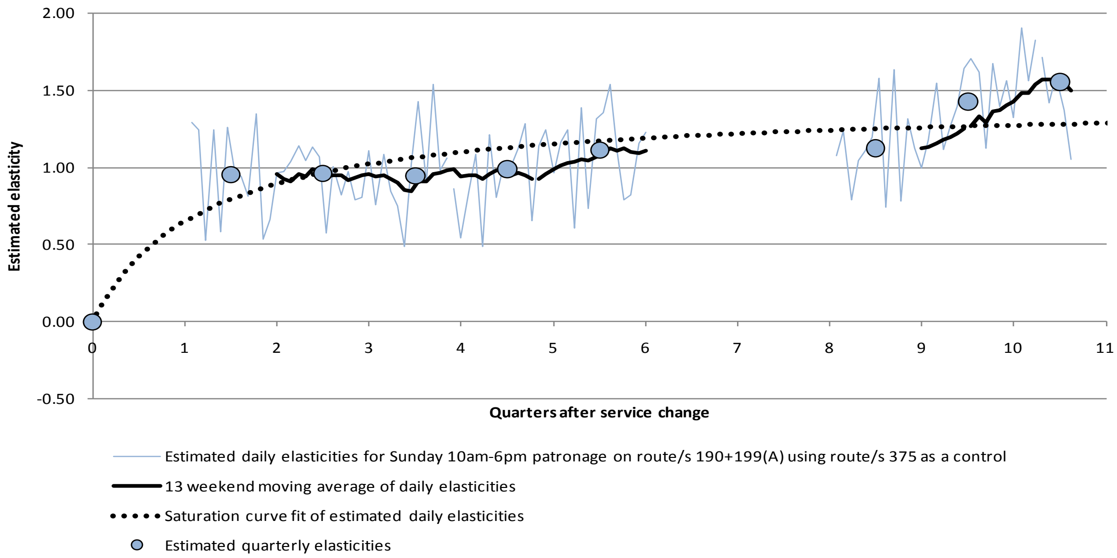


Table F.56b Elasticity estimation using control route method (excluding post-27 October 2008)

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-06					0.00	0.00
Q1	May-06	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.42
Q2	Aug-06	2,408	1,340	2.08	1.08	0.95	0.80
Q3	Nov-06	2,463	1,297	2.12	1.10	0.96	0.97
Q4	Feb-07	2,441	1,244	2.45	1.32	0.94	1.07
Q5	May-07	2,675	1,323	2.05	1.04	0.99	1.13
Q6	Aug-07	2,800	1,403	2.41	1.13	1.11	1.17
Q7	Nov-07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	1.21
Q8	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	1.23
Q9	May-08	2,915	1,315	2.24	1.04	1.13	1.25
Q10	Aug-08	3,143	1,259	2.72	1.01	1.43	1.27
Q11	Nov-08	3,179	1,163	2.75	0.94	1.55	1.28
Long run							1.43

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

F5.4.4 Elasticity estimation – route extrapolation method

An alternative set of elasticity estimates was made, based on an extrapolation growth rate of 4.56% pa. This is the average growth rate of route 190 for the 52-week period preceding the service change. The results for the full dataset are given in figure F.70a and table F.57a.

Note again that there appears to be a growth spurt in figure F.72a from Q10–Q11 onwards. Therefore, figure F.70b and table F.57b excluded data post 27 October 2008.

Figure F.70a Elasticity estimation using extrapolation method (all data)

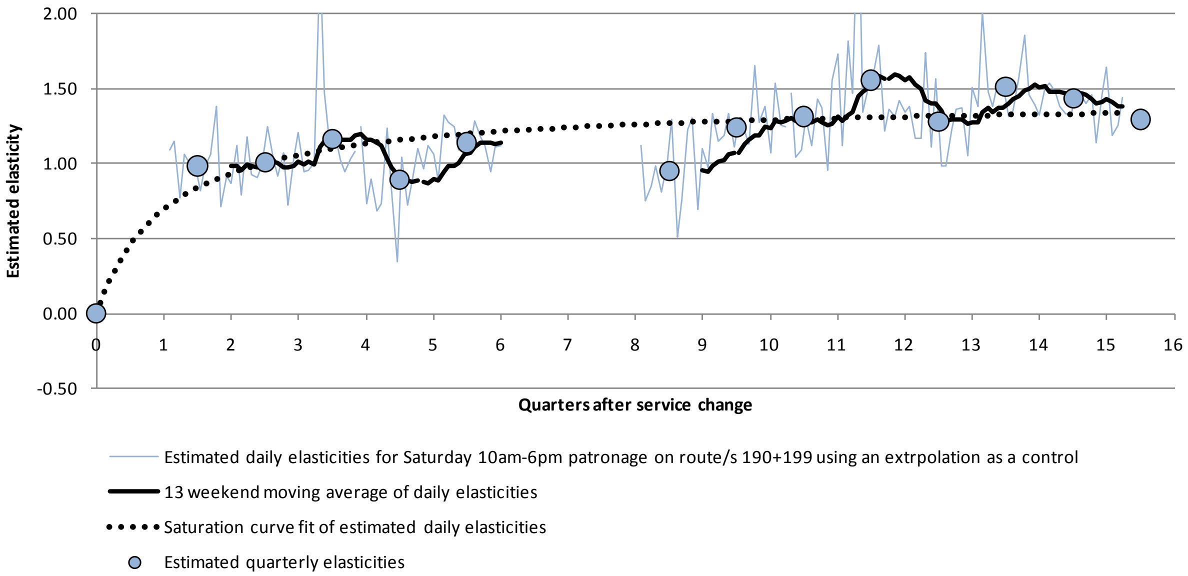


Table F.57a Elasticity estimation using extrapolation method (all data)

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of extrapolated patronage this quarter to observed patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-06					0.00	0.00
Q1	May-06	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.45
Q2	Aug-06	2,408	1,217	2.08	1.05	0.98	0.84
Q3	Nov-06	2,463	1,223	2.12	1.05	1.01	1.01
Q4	Feb-07	2,441	1,130	2.45	1.05	1.16	1.10
Q5	May-07	2,675	1,443	2.05	1.09	0.89	1.16
Q6	Aug-07	2,800	1,272	2.41	1.09	1.14	1.20
Q7	Nov-07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	1.23
Q8	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	1.25
Q9	May-08	2,915	1,508	2.24	1.14	0.95	1.27
Q10	Aug-08	3,143	1,330	2.72	1.14	1.24	1.29
Q11	Nov-08	3,333	1,337	2.88	1.14	1.31	1.30
Q12	Feb-09	3,538	1,235	3.55	1.15	1.55	1.31
Q13	May-09	3,822	1,577	2.94	1.20	1.28	1.32
Q14	Aug-09	3,961	1,391	3.44	1.20	1.51	1.32
Q15	Nov-09	3,758	1,398	3.23	1.20	1.43	1.33
Q16	#N/A	3,555	1,451	2.94	1.20	1.29	1.33
Long run							1.43

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

Figure F.70b Elasticity estimation using extrapolation method (excluding post-27 October 2008)

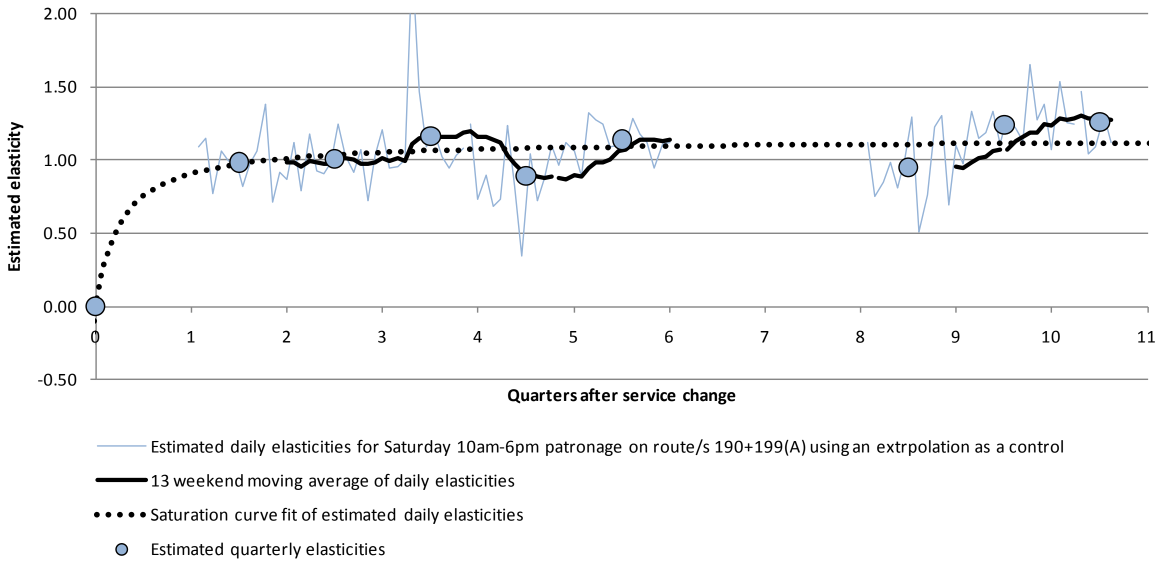


Table F.57b Elasticity estimation using extrapolation method (excluding post-27 October 2008)

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of extrapolated patronage this quarter to observed patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-06					0.00	0.00
Q1	May-06	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.71
Q2	Aug-06	2,408	1,217	2.08	1.05	0.98	0.97
Q3	Nov-06	2,463	1,223	2.12	1.05	1.01	1.04
Q4	Feb-07	2,441	1,130	2.45	1.05	1.16	1.06
Q5	May-07	2,675	1,443	2.05	1.09	0.89	1.08
Q6	Aug-07	2,800	1,272	2.41	1.09	1.14	1.09
Q7	Nov-07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	1.10
Q8	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	1.10
Q9	May-08	2,915	1,508	2.24	1.14	0.95	1.11
Q10	Aug-08	3,143	1,330	2.72	1.14	1.24	1.11
Q11	Nov-08	3,179	1,328	2.75	1.14	1.26	1.12
Long run							1.14

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

F5.4.5 Review and comments

One interesting aspect of these results is the apparent quite substantial increase in patronage on route 199 at around October 2008, at a time when patronage on the control route was decreasing. A possible explanation for this effect is that it resulted from the increase in route 199 Saturday services (27 October 2008). Prior to this date, the Sunday elasticities appear to have been stabilising (as expected) at around 1.1–1.15 (refer table F.56a). After this date, they appear to have increased quite sharply, to a new level of around 1.6–1.8 (ie about 50% greater). However, this second growth spurt appears to have started somewhat prior to the Saturday service increase, so may be the result of other, unexplained, factors.

The following comments focus on the results up to period 10, prior to the Saturday service increase. Up to this period, the control route method gives somewhat higher elasticities than the extrapolation method (reflecting relatively low growth on the control route). We would suggest taking the mean of these two sets of data as the best estimate, if required.

F5.4.6 Conclusions

The best estimates derived from these analyses are for elasticities in the range 1.0–1.1 for Q4 after the service change. This result is abnormally high. As for the weekday evening and Saturday analyses on these routes, it indicates the need to examine a wider group of routes (ie including 191 and 196) to explore any abstraction effects. This is covered in the next section.

F5.5 Route 190+191/196+199 analysis

This analysis covers the same service change as the previous analysis (section F5.4), but also incorporates patronage changes on routes 191 (before) and 196 (after), in order to allow for any 'abstraction' effects.

F5.5.1 Service change

The service change on the combined routes involved the service frequency increasing by 50%, from four trips per hour to six trips per hour (each direction).

Table F.58 Details of service change

Date of service change for route/s 190+191+196+199:	Sunday, 26 February 2006
Trips before	64
Trips afterwards	96
Ratio	1.50
Control route/s:	375

F5.5.2 Data availability and quantity

As with previous routes, there was a 'gash' in the data from Sat 29 September 2007 to Sat 23 February 2008.

Figure F.71 Patronage on service route and control routes

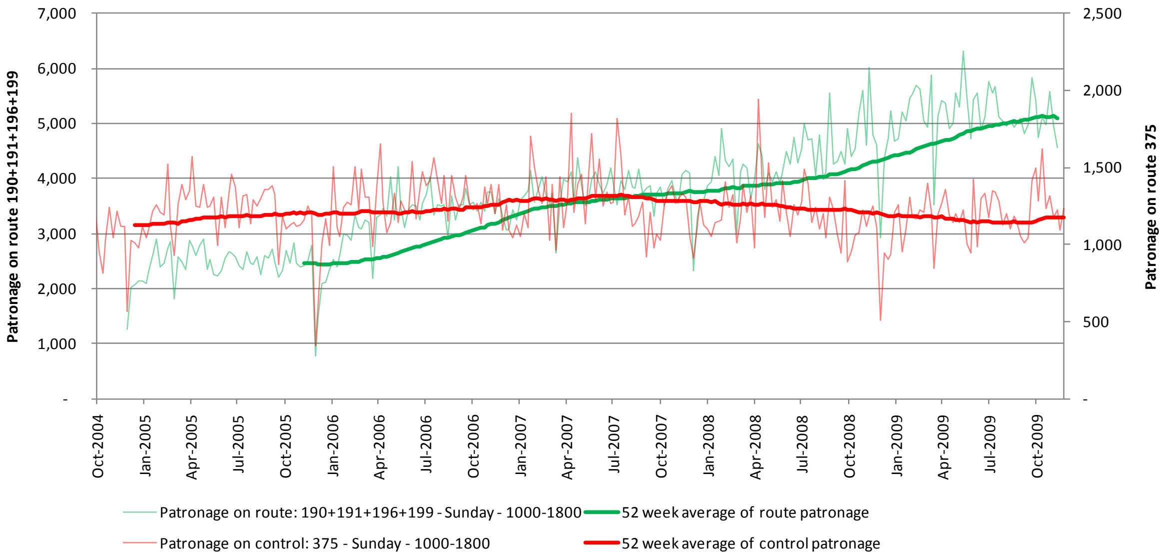
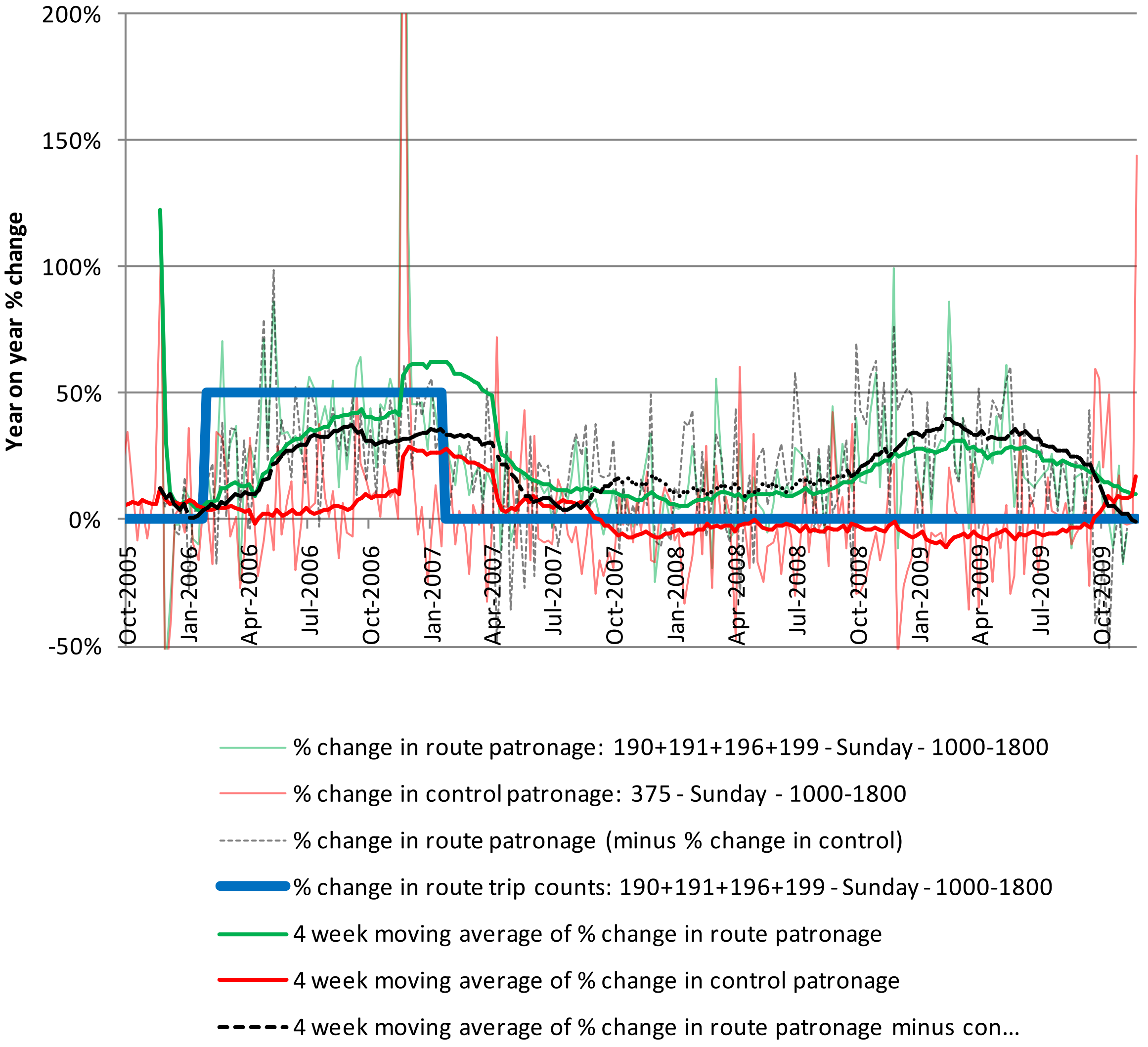


Figure F.72 Patronage growth rates on service route and control routes



F5.5.3 Elasticity estimation – control route method

As for the similar weekday evening service change (section F3.5.3), it is notable that the route patronage appears to continue to increase strongly for at least three years after the service change (refer figure F.73a). This pattern of response is unusual and may well be the result of factors other than the service change. We have therefore made an alternative assessment of the saturation curve, based on data up to/including Q6 only – this is shown in figure F.73b and table F.59b: it results in a more typical shape for the saturation curve.

As discussed in section F5.4, it is possible that the increase in Saturday services (27 October 2008 – in Q11) has had some influence on the continuing growth in patronage well after the Sunday service change. However, this is unclear as the apparent patronage growth spurt around Q9/10 pre-dates the Saturday service change.

Figure F.73a Elasticity estimation using control route method (all data)

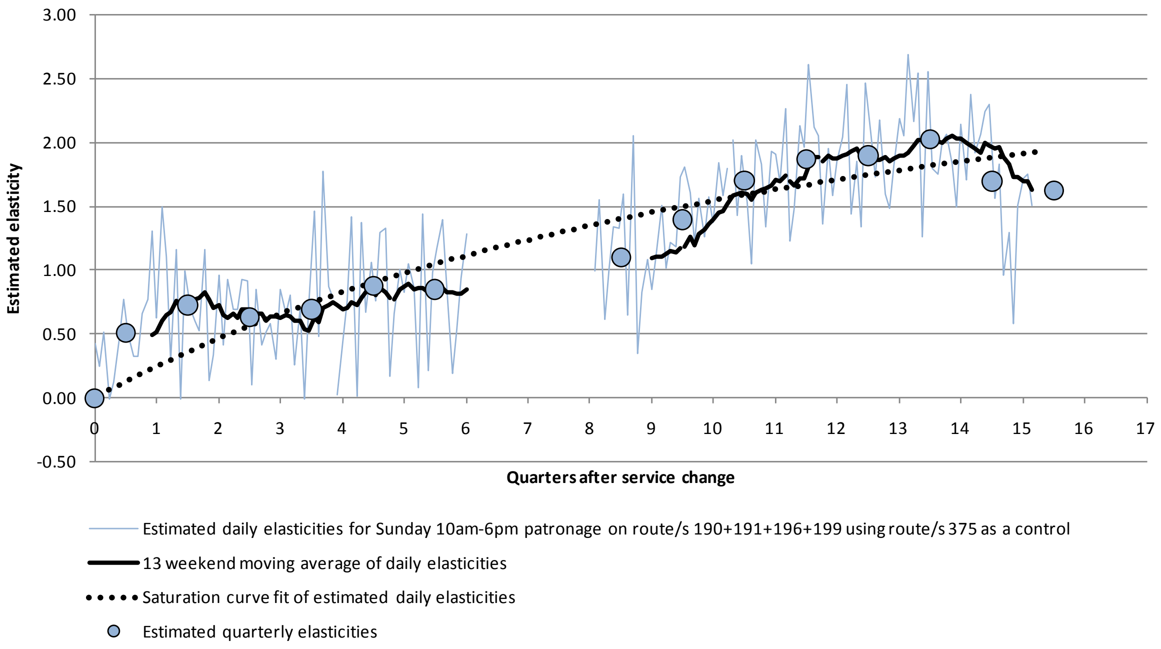


Figure F.73b Elasticity estimation using control route method (up to Q6 only)

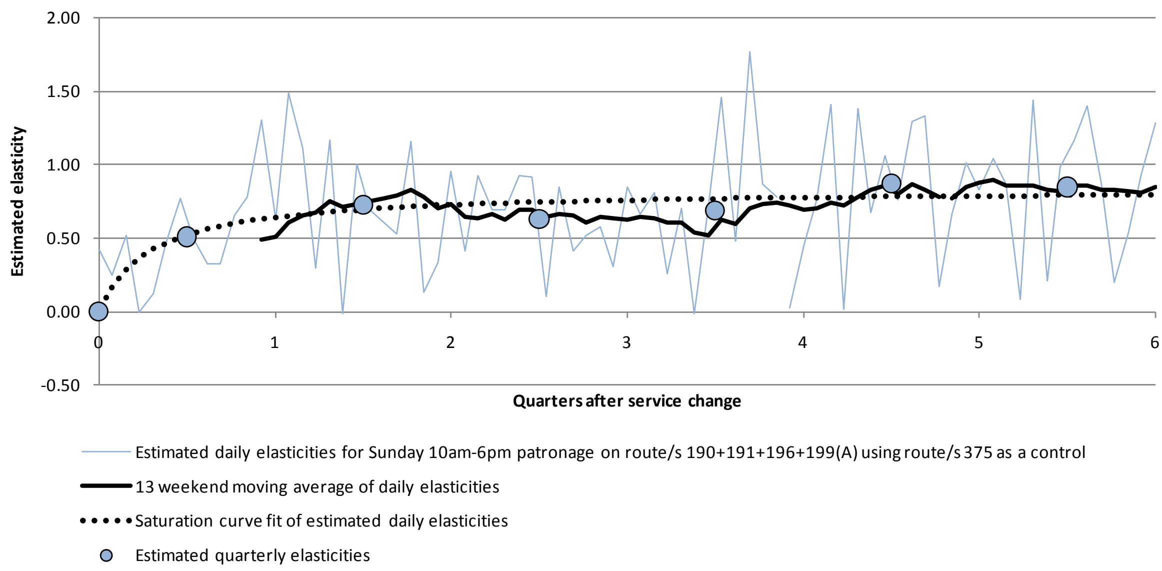


Table F.59a Elasticity estimation using control route method (all data)

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-06					0.00	0.00
Q1	May-06	3,210	1,301	1.25	1.03	0.51	0.14
Q2	Aug-06	3,550	1,340	1.44	1.08	0.73	0.37
Q3	Nov-06	3,499	1,297	1.40	1.10	0.63	0.57
Q4	Feb-07	3,512	1,244	1.71	1.32	0.69	0.75
Q5	May-07	3,759	1,323	1.47	1.04	0.87	0.91
Q6	Aug-07	3,877	1,403	1.57	1.13	0.85	1.05
Q7	Nov-07	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	1.18
Q8	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	1.30
Q9	May-08	4,079	1,315	1.59	1.04	1.10	1.41
Q10	Aug-08	4,377	1,259	1.78	1.01	1.40	1.50
Q11	Nov-08	4,647	1,116	1.86	0.94	1.70	1.59
Q12	Feb-09	4,798	1,060	2.33	1.12	1.87	1.67
Q13	May-09	5,202	1,200	2.04	0.95	1.90	1.75
Q14	Aug-09	5,376	1,203	2.19	0.97	2.03	1.82
Q15	Nov-09	5,116	1,239	2.06	1.05	1.70	1.88
Q16	#N/A	4,754	1,201	1.93	1.00	1.63	1.92
Long run							3.66

Note: The ratio of route trips after the service change compared to prior to the service change was 1.50

Table F.59b Elasticity estimation using control route method (up to Q6 only)

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-06					0.00	0.00
Q1	May-06	3,210	1,301	1.25	1.03	0.51	0.49
Q2	Aug-06	3,550	1,340	1.44	1.08	0.73	0.70
Q3	Nov-06	3,499	1,297	1.40	1.10	0.63	0.75
Q4	Feb-07	3,512	1,244	1.71	1.32	0.69	0.77
Q5	May-07	3,759	1,323	1.47	1.04	0.87	0.78
Q6	Aug-07	3,877	1,403	1.57	1.13	0.85	0.79
Long run							0.83

Note: The ratio of route trips after the service change compared to prior to the service change was 1.50

F5.5.4 Elasticity estimation – route extrapolation method

The extrapolation method could not be employed for analysis of route 190+191/196+199 because there was not enough patronage data (prior to the service change) that could be used to establish growth rates.

F5.5.5 Review and comments

Given the balance of evidence, we adopt the results of the control route analyses up to period six only as giving the most plausible saturation curve estimates. We ignored the elasticity estimates after this period as being unreliable (likely to be affected by other factors).

F5.5.6 Conclusions

This gives the following results based on the actual quarterly estimates:

Q1 0.51, Q2 0.73, Q3 0.63, Q4 0.69

Y2 0.86

The corresponding mean saturation estimates are:

Q1 0.49, Q2 0.70, Q3 0.75, Q4 0.77

Y2 0.79, Y3 0.81, Y4 0.82

F5.6 Route 200 analysis

F5.6.1 Service change

The service change occurred in April 2005, with service frequencies increasing on average by some 170%, from 1.5 trips per hour to four trips per hour (each direction).

Table F.60 Details of service change

Date of service change for route/s 200:	Sunday, 24 April 2005
Trips before	24
Trips afterwards	64
Ratio	2.67
Control route/s:	210+212

F5.6.2 Data availability and quantity

As with previous routes, there was a ‘gash’ in the data from Sat 29 September 2007 to Sat 23 February 2008.

Figure F.74 Patronage on service route and control routes

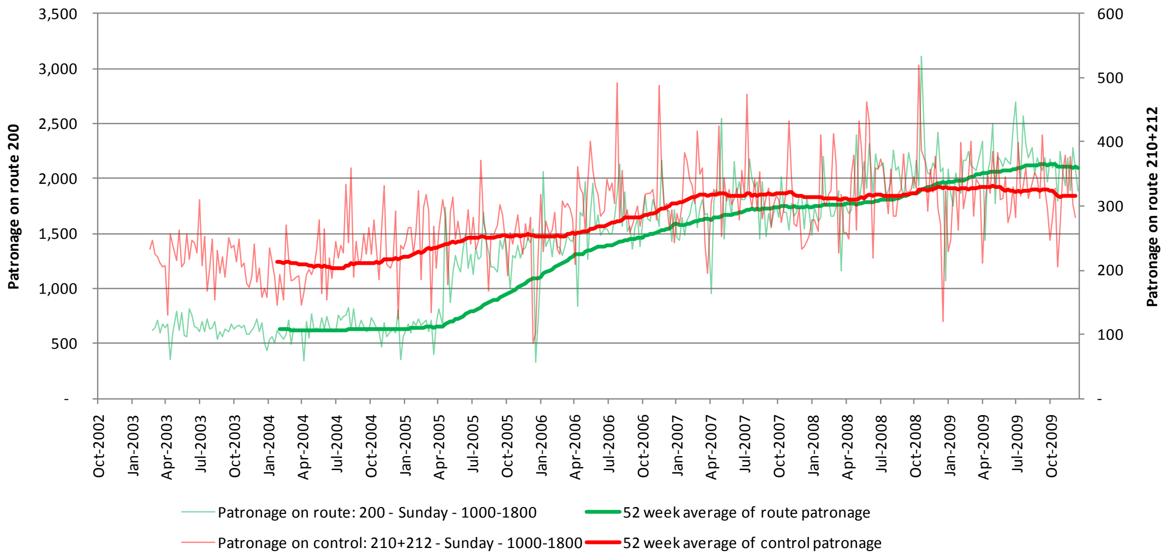
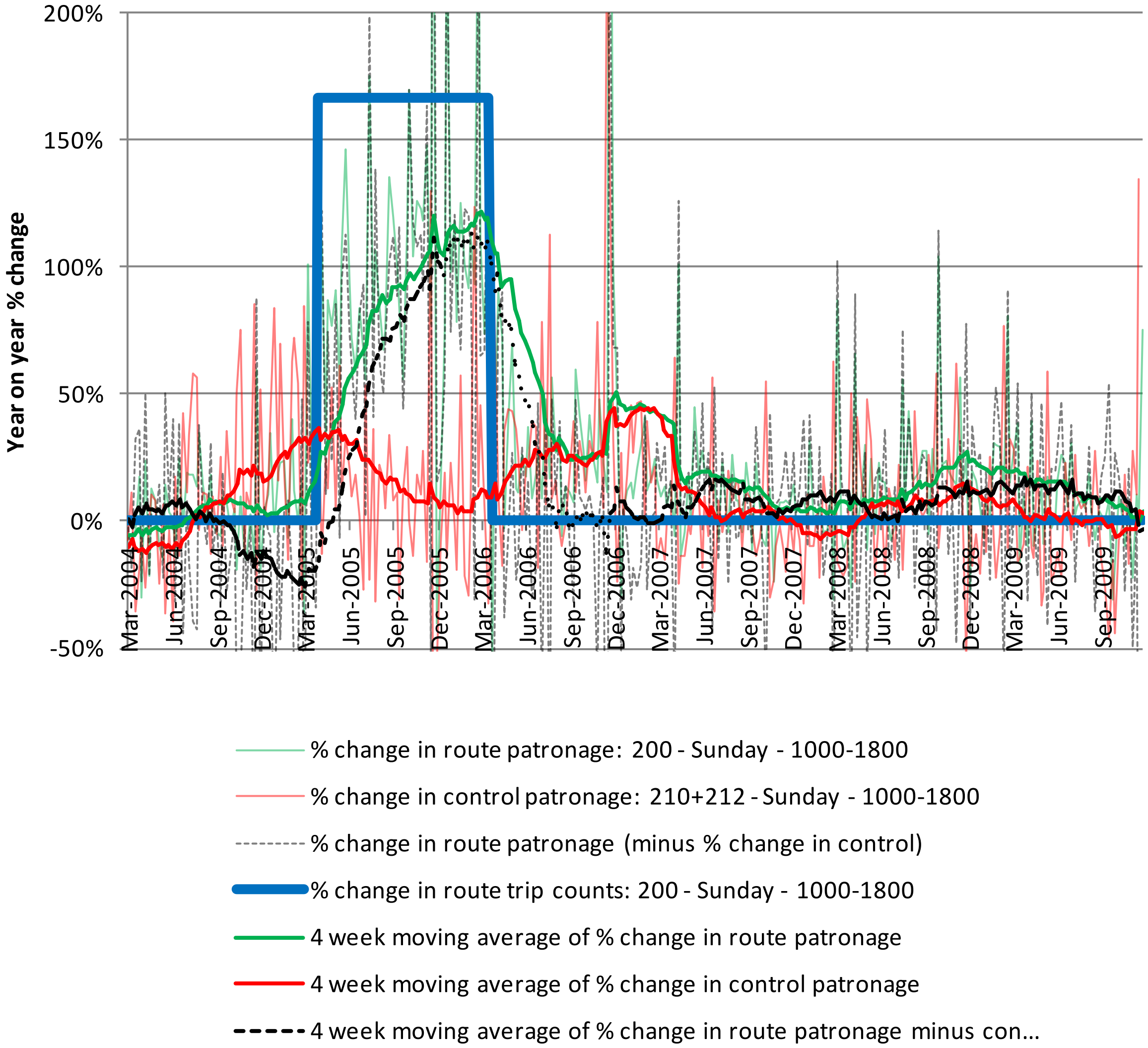


Figure F.75 Patronage growth rates on service route and control routes



F5.6.3 Elasticity estimation – control route method

The gap in the line in figure F.76 around Q11 is due to the 'gash' in the data from Sat 29 September 2007 to Sat 23 February 2008.

Figure F.76 Elasticity estimation using control route method

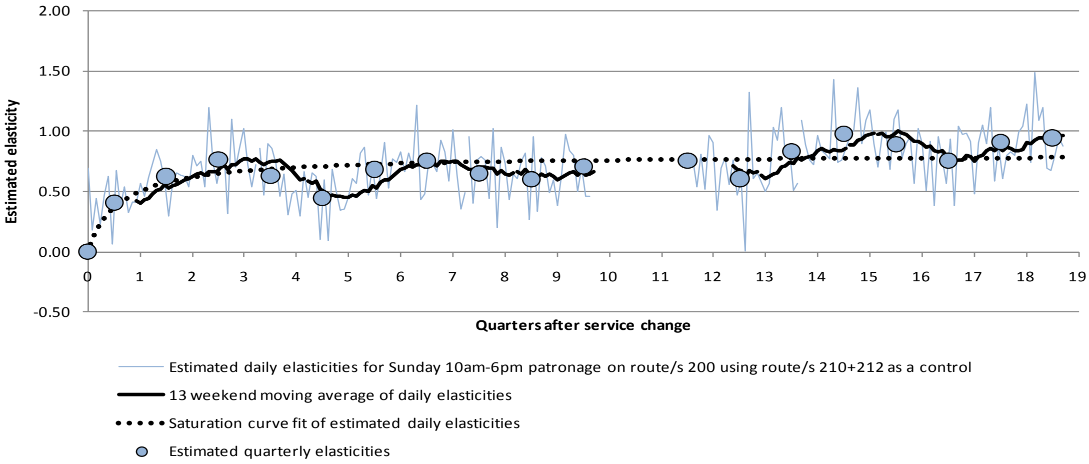


Table F.61 Elasticity estimation using control route method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Apr-05					0.00	0.00
Q1	Jul-05	1,236	260	1.83	1.24	0.41	0.35
Q2	Oct-05	1,320	261	1.93	1.05	0.62	0.57
Q3	Jan-06	1,291	232	2.13	1.01	0.77	0.65
Q4	Apr-06	1,393	277	2.17	1.19	0.63	0.69
Q5	Jul-06	1,611	325	2.39	1.54	0.45	0.71
Q6	Oct-06	1,653	307	2.40	1.23	0.69	0.73
Q7	Jan-07	1,671	312	2.89	1.41	0.75	0.74
Q8	Apr-07	1,652	325	2.59	1.39	0.65	0.75
Q9	Jul-07	1,906	334	2.83	1.59	0.60	0.75
Q10	Oct-07	1,745	310	2.53	1.29	0.71	0.76
Q11	Jan-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.76
Q12	Apr-08	1,671	302	2.64	1.26	0.76	0.77
Q13	Jul-08	2,053	360	3.05	1.72	0.61	0.77
Q14	Oct-08	2,034	324	2.99	1.33	0.84	0.77
Q15	Jan-09	2,074	316	3.60	1.44	0.98	0.77
Q16	Apr-09	2,060	319	3.20	1.34	0.89	0.78
Q17	Jul-09	2,216	332	3.28	1.58	0.76	0.78
Q18	Oct-09	2,181	325	3.18	1.33	0.91	0.78
Q19	#N/A	2,041	312	3.63	1.45	0.95	0.78
Long run							0.81

Note: The ratio of route trips after the service change compared to prior to the service change was 2.67

F5.6.4 Elasticity estimation – route extrapolation method

An alternative set of elasticity estimates was made, based on an extrapolation growth rate of 7.92% pa. This is the average growth rate of route 200 for the 52 weeks preceding the service change. The results are given in figure F.77 and table F.62.

Figure F.77 Elasticity estimation using extrapolation method

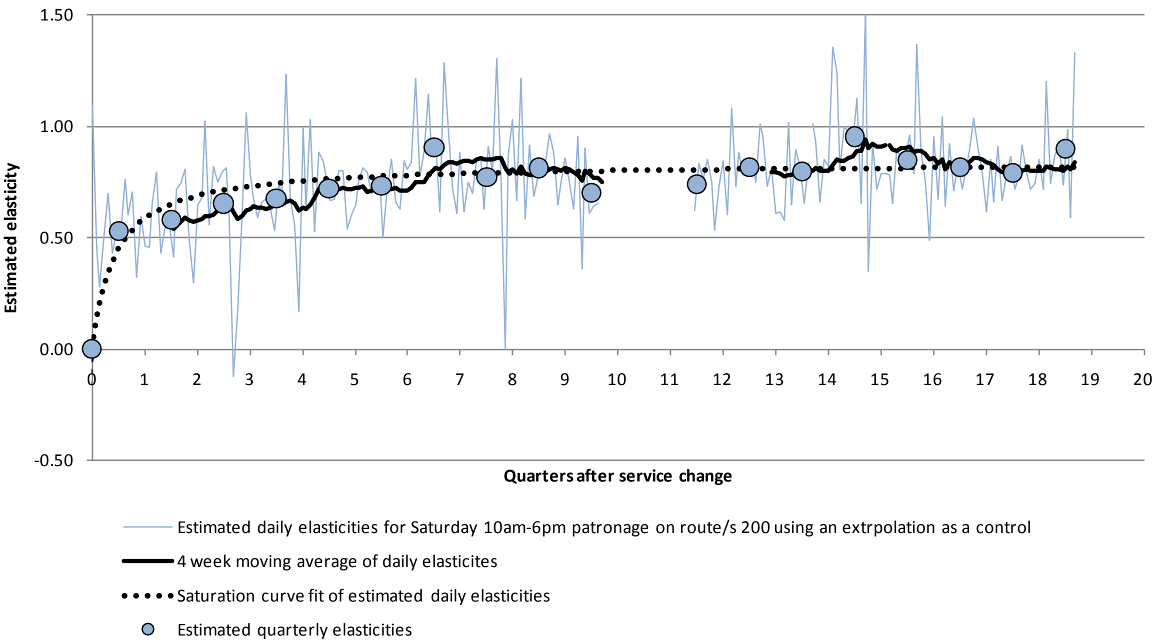


Table F.62 Elasticity estimation using extrapolation method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of extrapolated patronage this quarter to observed patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Apr-05					0.00	0.00
Q1	Jul-05	1,236	734	1.83	1.08	0.53	0.43
Q2	Oct-05	1,320	745	1.93	1.08	0.58	0.65
Q3	Jan-06	1,291	644	2.13	1.08	0.65	0.71
Q4	Apr-06	1,393	718	2.17	1.09	0.68	0.74
Q5	Jul-06	1,611	792	2.39	1.16	0.72	0.76
Q6	Oct-06	1,653	804	2.40	1.16	0.73	0.77
Q7	Jan-07	1,671	695	2.89	1.16	0.90	0.78
Q8	Apr-07	1,652	775	2.59	1.17	0.77	0.79
Q9	Jul-07	1,906	855	2.83	1.26	0.81	0.79
Q10	Oct-07	1,745	877	2.53	1.26	0.70	0.80
Q11	Jan-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.80
Q12	Apr-08	1,671	818	2.64	1.27	0.74	0.80
Q13	Jul-08	2,053	922	3.05	1.36	0.82	0.81
Q14	Oct-08	2,034	936	2.99	1.36	0.79	0.81
Q15	Jan-09	2,074	810	3.60	1.36	0.95	0.81
Q16	Apr-09	2,060	902	3.20	1.36	0.85	0.81
Q17	Jul-09	2,216	995	3.28	1.46	0.81	0.81
Q18	Oct-09	2,181	1,010	3.18	1.46	0.79	0.81
Q19	#N/A	2,041	863	3.63	1.46	0.90	0.82
Long run							0.83

Note: The ratio of route trips after the service change compared to prior to the service change was 2.67

F5.6.5 Review and comments

The 'control' elasticity estimates are reasonably well behaved, although with significant quarter-to-quarter variations around the best fit saturation curve. There are signs of effective saturation within the second year; but then a further patronage growth in the fourth year (we suspect this is due to influences other than the original service change).

The 'extrapolation' elasticity estimates are based on an extrapolated growth of 7.9% pa. The resultant elasticity values are little different from those for the 'control' estimates, and the extrapolated quarterly estimates show rather less variations than those of the control estimates.

F5.6.6 Conclusions

Given the small differences between the two sets of estimates, we take the mean of the two sets as the best estimate. These are as follows:

Estimates: Q1 0.47, Q2 0.60, Q3 0.71 Q4 0.66

Y2 0.71, Y3 0.72, Y4 0.84

Saturation curve: Q1 0.39, Q2 0.61, Q3 0.68, Q4 0.72

Y2 0.76, Y3 0.78, Y4 0.79.

F5.7 Route 345 analysis

F5.7.1 Service change

The service change occurred in February 2006, with services doubled from two trips per hour to four trips per hour (each direction).

Table F.63 Details of service change

Date of service change for route/s 345:	Sunday, 26 February 2006
Trips before	32
Trips afterwards	64
Ratio	2.00
Control route/s:	330

F5.7.2 Data availability and quantity

As with previous routes, there was a 'gash' in the data from Sat 29 September 2007 to Sat 23 February 2008.

Figure F.78 Patronage on service route and control routes

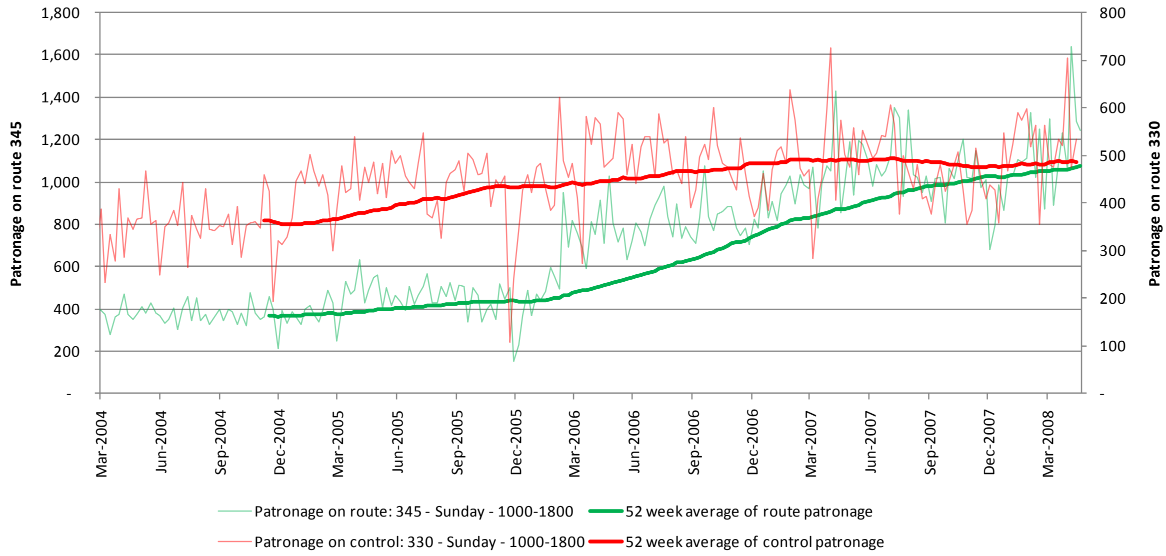
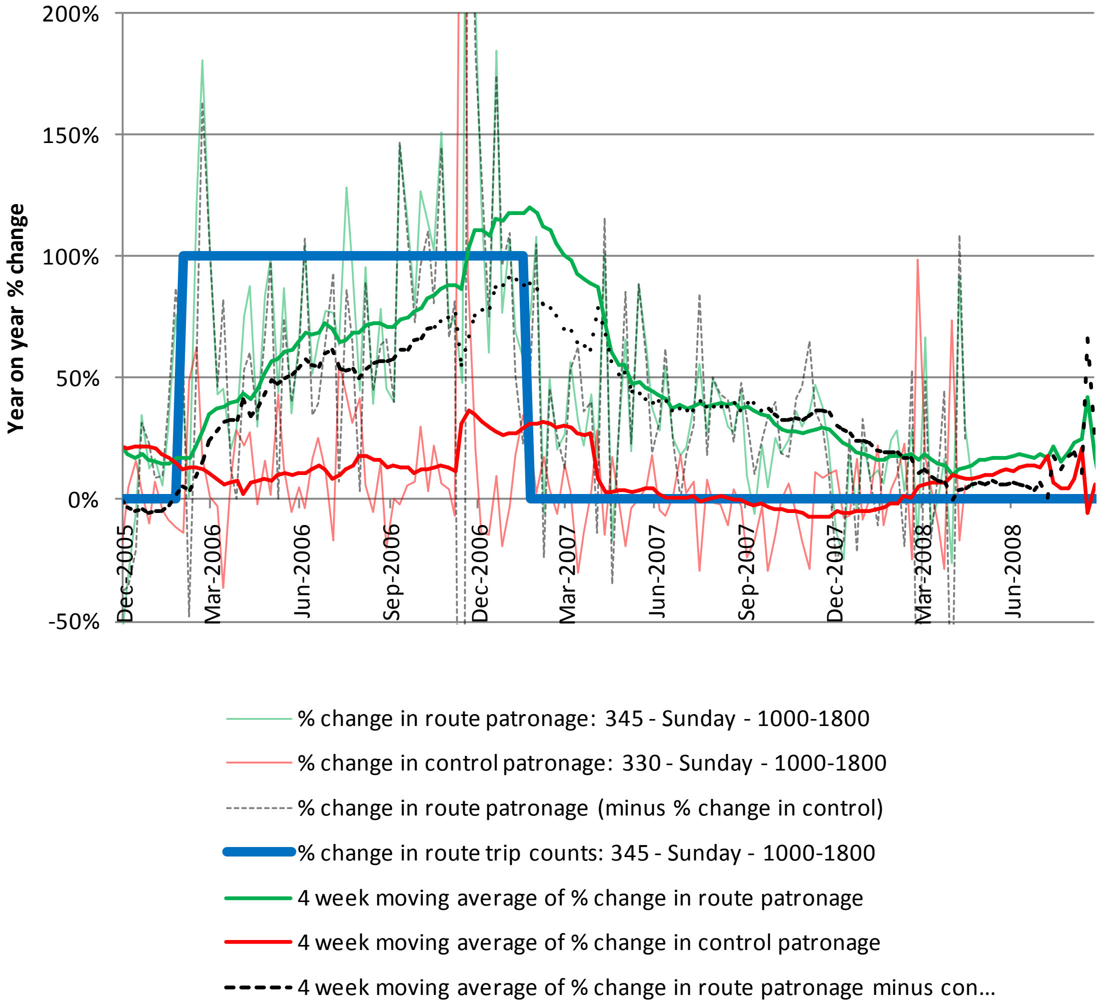


Figure F.79 Patronage growth rates on service route and control routes



F5.7.3 Elasticity estimation – control route method

Figure F.80 Elasticity estimation using control route method

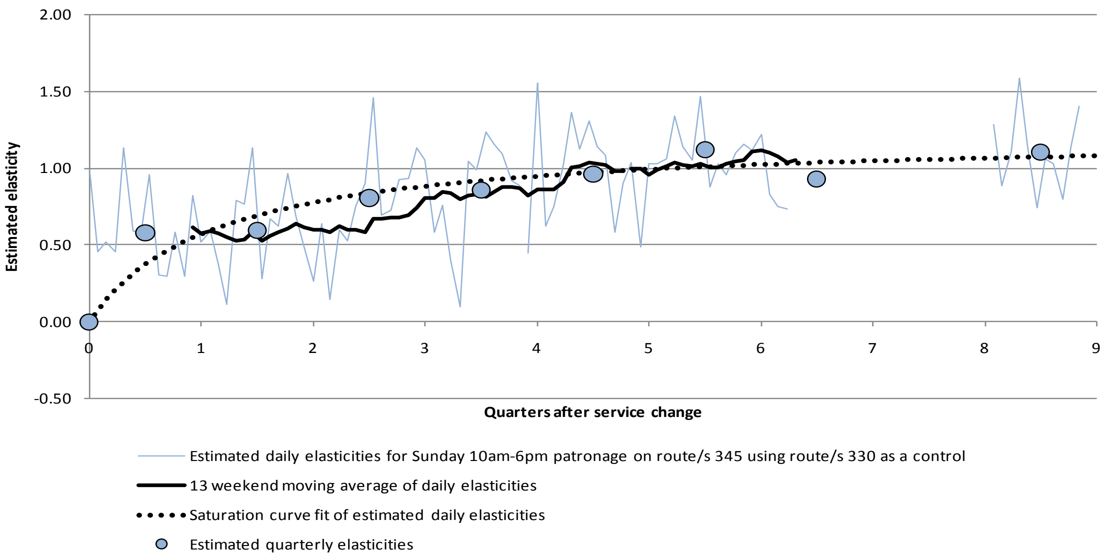


Table F.64 Elasticity estimation using control route method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-06					0.00	0.00
Q1	May-06	770	488	1.72	1.13	0.58	0.37
Q2	Aug-06	793	522	1.75	1.16	0.60	0.70
Q3	Nov-06	835	486	1.95	1.10	0.81	0.84
Q4	Feb-07	861	452	2.30	1.34	0.86	0.92
Q5	May-07	1,024	505	2.29	1.18	0.96	0.97
Q6	Aug-07	1,124	515	2.48	1.14	1.12	1.01
Q7	Nov-07	1,009	446	2.10	1.11	0.93	1.04
Q8	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	1.06
Q9	May-08	1,178	526	2.71	1.23	1.11	1.07
Long run							1.22

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

F5.7.4 Elasticity estimation – route extrapolation method

An alternative set of elasticity estimates was made, based on an extrapolation growth rate of 19.44% pa. This was the average growth rate of route 345 for the 52 weeks preceding the service change. The results are given in figure F.81 and table F.65.

Figure F.81 Elasticity estimation using extrapolation method

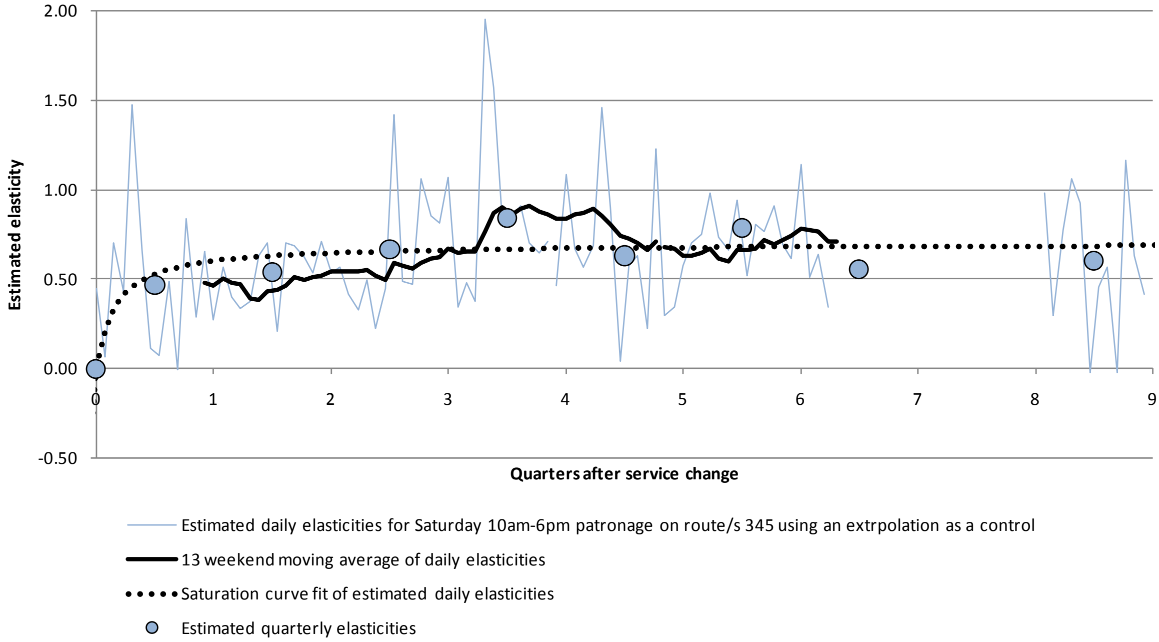


Table F.65 Elasticity estimation using extrapolation method

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of extrapolated patronage this quarter to observed patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-06					0.00	0.00
Q1	May-06	770	560	1.72	1.19	0.47	0.50
Q2	Aug-06	793	544	1.75	1.19	0.54	0.63
Q3	Nov-06	835	529	1.95	1.19	0.67	0.66
Q4	Feb-07	861	503	2.30	1.21	0.84	0.67
Q5	May-07	1,024	669	2.29	1.43	0.63	0.68
Q6	Aug-07	1,124	650	2.48	1.43	0.79	0.68
Q7	Nov-07	1,009	689	2.10	1.43	0.55	0.68
Q8	Feb-08	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#N/A	0.68
Q9	May-08	1,184	786	2.67	1.70	0.60	0.69
Long run							0.70

F5.7.5 Review and comments

The ‘control’ route elasticity estimates are reasonably well behaved, although apparently with a relatively slow build-up in patronage over the first two to three quarters, and a continuing gradual increase thereafter.

The ‘extrapolation’ elasticities are based on an extrapolated growth rate of 19.4% pa, which results in a tendency for the elasticity values to reduce after the first year, to relatively low values (around 0.5–0.6).

F5.7.6 Conclusions

In this case, we take the best estimates as a weighted combination of the ‘control’ estimates (2/3rds) and the extrapolation estimates (1/3rd). This gives the following results:

Estimates: Q1 0.54, Q2 0.58, Q3 0.76, Q4 0.85

Y2 0.89, Y3 0.94, Y4 N/A

Saturation curve: Q1 0.41, Q2 0.68, Q3 0.78, Q4 0.84

Y2 0.91, Y3 0.96, Y4 0.98.

F5.8 Summary of Sunday results

Section F5 has analysed the impacts of five sets of Sunday service changes. For two of these route groups (route 140 and routes 190/199), the elasticities are ‘abnormally’ high, suggesting significant abstraction of passengers from competing routes: our additional analyses, incorporating these competing routes, resulted in more ‘normal’ elasticities in both cases.

All the elasticity estimates derived are summarised in table F.66. This gives quarterly elasticity values for the first 12 months, then annual average values thereafter. Estimates derived from both the control route method and the extrapolation method are given, for both the actual best estimates and the saturation curve estimates.

Based on inspection of the data of the data for each route (as discussed earlier), the estimates judged to be the ‘best’ in each case are highlighted (in bold).

Further discussion of these findings is given in section F6 (following), and in the main report section 4.6 and chapter 5.

Table F.66 Results summary – Sunday (1000–1800) daytime

Route/s	Date of service change	Initial freq. per hr	% freq. increase	Control/s		Q1	Q2	Q3	Q4	Q5-Q8 (2nd yr)	Q9-Q12 (3rd yr)	Q13-Q16 (4th yr)	Long run	Comment
140	23 February 2009	1.44	178%	120+170+180	Estimated elasticities:	1.03	0.87	0.92	0.86!	#N/A	#N/A	#N/A	#N/A	High elasticities - do not allow for abstraction effects from route 130.
					Saturation curve fit:	0.93	0.94	0.94	0.94	#N/A	#N/A	#N/A	0.94	
				Extrapolation	Estimated elasticities:	1.02	0.89	0.91	0.79!	#N/A	#N/A	#N/A	#N/A	
					Saturation curve fit:	0.93	0.93	0.93	0.93	#N/A	#N/A	#N/A	0.93	
130+140 *	23 February 2009	5.44	47%	120+170+180	Estimated elasticities:	**0.75**	**0.45**	**0.61**	**0.87!**	#N/A	#DIV/0!	#DIV/0!	#N/A	More 'normal' elasticity values incorporating abstraction effects from route 130. Control results appear to be the best estimates, but some divergencies between quarterly estimates and saturation curve values.
					Saturation curve fit:	**0.57**	**0.64**	**0.65**	**0.65**	#N/A	#DIV/0!	#DIV/0!	**0.66**	
				Extrapolation	Estimated elasticities:	0.61	0.40	0.50	0.58!	#N/A	#N/A	#N/A	#N/A	
					Saturation curve fit:	0.51	0.51	0.51	0.51	#N/A	#N/A	#N/A	0.51	
150	8 November 2004	1.44	178%	140	Estimated elasticities:	**N/a**	**0.66**	**0.70**	**0.78**	**0.70**	**0.79**	**0.86**	**#N/A**	Control results are best estimate, with quarterly figures and saturation curve estimates very similar.
					Saturation curve fit:	**0.44**	**0.65**	**0.70**	**0.73**	**0.76**	**0.78**	**0.79**	**0.81**	
				Extrapolation	Estimated elasticities:	0.53	0.70	0.69	0.83	0.85	0.97	1.04	#N/A	
					Saturation curve fit:	0.39	0.68	0.78	0.84	0.90	0.94	0.96	1.01	
190/199	20 February	2.0	100%	375	Estimated elasticities:	#N/A	0.95	0.96	0.94	1.05	1.47	1.68	#N/A	Abnormally high elasticity values – do not allow for

Route/s	Date of service change	Initial freq. per hr	% freq. increase	Control/s		Q1	Q2	Q3	Q4	Q5-Q8 (2nd yr)	Q9-Q12 (3rd yr)	Q13-Q16 (4th yr)	Long run	Comment
(all data)	2006				Saturation curve fit:	0.26	0.62	0.86	1.03	1.28	1.51	1.63	2.04	abstraction effects from routes 191/196.
				Extrapolation	Estimated elasticities:	#N/A	0.98	1.01	1.16	1.02	1.27	1.38	#N/A	
					Saturation curve fit:	0.45	0.84	1.01	1.10	1.21	1.29	#N/A	1.43	
190/199 (excluding post-October 2008)	20 February 2006	2.0	100%	375	Estimated elasticities:	#N/A	0.95	0.96	0.94	1.05	1.37	#DIV/0!	#N/A	
					Saturation curve fit:	0.42	0.80	0.97	1.07	1.19	1.27	#N/A	1.43	
				Extrapolation	Estimated elasticities:	#N/A	0.98	1.01	1.16	1.02	1.15	#DIV/0!	#N/A	
					Saturation curve fit:	0.71	0.97	1.04	1.06	1.09	1.11	1.12	1.14	
190+191 / 196+199 * (all data)	20 February 2006	4.0	50%	375	Estimated elasticities:	0.51	0.73	0.63	0.69	0.86	1.52	1.81	#N/A	More 'normal' elasticity values, incorporating abstraction effects from routes 191/196. However, they show a continuing strong increase in patronage for at least 3-4 years after the service change, which is most likely attributable to other factors.
					Saturation curve fit:	0.14	0.37	0.57	0.75	1.11	1.54	1.84	3.66	
				Extrapolation	Estimated elasticities:	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
					Saturation curve fit:	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
190+191 / 196+199 *	20 February 2006	4.0	50%	375	Estimated elasticities:	0.51	0.73	0.63	0.69	0.86	#N/A	#N/A	#N/A	Modification of the above results to ignore any data after Q6 – considered to give more plausible results
					Saturation curve fit:	0.49	0.70	0.75	0.77	0.79	0.81	0.82	0.83	

Route/s	Date of service change	Initial freq. per hr	% freq. increase	Control/s		Q1	Q2	Q3	Q4	Q5-Q8 (2nd yr)	Q9-Q12 (3rd yr)	Q13-Q16 (4th yr)	Long run	Comment
(excluding data after Q6 ie 27 August 2007)				Extrapolation	Estimated elasticities:	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	for the saturation curve.
					Saturation curve fit:	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
200	18 April 2005	1.5	167%	210+212	Estimated elasticities:	0.41	0.62	0.77	0.63	0.64	0.69	0.83	#N/A	Both sets of estimates are sensibly consistent – use mean of these as best estimates.
					Saturation curve fit:	0.35	0.57	0.65	0.69	0.73	0.76	0.77	0.81	
				Extrapolation	Estimated elasticities:	0.53	0.58	0.65	0.68	0.78	0.75	0.85	#N/A	
					Saturation curve fit:	0.43	0.65	0.71	0.74	0.78	0.80	0.81	0.83	
345	20 February 2006	2.0	100%	330	Estimated elasticities:	**0.58**	**0.60**	**0.81**	**0.86**	**1.00**	**1.11**	#N/A	#N/A	Extrapolation estimates appear less plausible than control estimates beyond the first year. Take best estimates as weighting of control figures (2/3rds) and extrapolation figures (1/3rd).
					Saturation curve fit:	**0.37**	**0.70**	**0.84**	**0.92**	**1.02**	**1.09**	**1.12**	**1.22**	
				Extrapolation	Estimated elasticities:	0.47	0.54	0.67	0.84	0.66	0.60	#N/A	#N/A	
					Saturation curve fit:	0.50	0.63	0.66	0.67	0.68	0.69	0.69	0.70	

* Note – the route of interest was expanded to include routes where there were not service enhancements so we could explore ‘abstraction’ effects.

! Note – these quarters included only about a month of data, due to the data ending partway through the quarter. Hence, less weight should be given to these quarters.

F6 Summary of findings

F6.1 Overview of key outputs

Table F.67 provides a summary of the various elasticity analyses and results derived in this appendix, drawing on tables F.22, F.45 and F.66.

For each service change, the table shows the date of the change, the control routes used, the initial service frequency and the % frequency increase. It then provides our best estimate elasticity values for Q4 (ie the average for weeks 40–52 after the service change, relative to the corresponding period 52 weeks earlier).

In each case two elasticity values are given:

- the actual elasticity values calculated for the period in question
- the corresponding elasticity values taken from the saturation curve fitted to the series of (daily) elasticity values.

The latter (saturation curve) values are generally taken as the best estimates, as they effectively 'smooth out' the data series, minimising the effects of any 'noise' in the data.

For each case, the two elasticity values given are based on the results for:

- the control route analyses, or
- the route extrapolation analyses (where available), or
- some weighted combination of these two analyses, as described in the relevant sections of this appendix.

While results are given for routes 140, 190/199 and 199 (Saturdays) alone, in these cases the evidence indicates significant abstraction of passengers from competing routes. Therefore little comment is provided on these cases; instead the focus is on the results for combined routes 130 + 140, 190 + 191/196 + 199, and 196+199 (Saturday).

F6.2 Comments on the results

The following comments focus primarily on the table F.67 saturation curve (S) elasticity values for Q4, as described above.

Key (tentative) findings are as follows:

- The unweighted average elasticity values for the three time periods are: weekday evening 0.59 (range 0.47 to 0.70), Saturday 0.73 (range 0.49 to 0.83), Sunday 0.74 (range 0.65 to 0.84).
- Prima facie (in the absence of statistical testing) these results suggest that:
  - Saturday and Sunday elasticities are not significantly different from each other
  - weekday evening elasticities are significantly lower than weekend elasticity, (for example, four of the five Saturday estimates are higher than all the evening estimates).
- From this limited sample, there is no evidence of systematic variations in elasticity values with:
  - initial service frequencies
  - extent of service increases.

- There is also no evidence that would suggest significant differences in elasticity values between routes (ie the differences in the best estimate values between routes, after allowing for other factors, may well be the result of data or analysis issues).

Further analyses of these results and testing of hypotheses on elasticity relationships will be undertaken subsequently, using the results drawn from all the centres covered in the project.

For the service changes on route 140 and routes 190/199 that have been examined on both a ‘stand alone’ basis and a ‘combined’ basis, in all six cases the ‘combined’ elasticity estimates are considerably lower than the ‘stand alone’ elasticities. The ratios of combined values to stand alone values (for the saturation curves) are between 56% and 78%, averaging 68%. This implies that, on average about one-third of the additional patronage on the routes as a result of the service improvements is ‘abstracted’ from competing routes, while the other two-thirds represents additional bus passenger trips.

Table F.67 BNE off-peak service improvements – patronage impacts (service elasticities) summary

Route No	Service Change Date	Control Routes	Weekday Evening (1900-2300)				Saturday (1000-1800)				Sunday (1000-1800)			
			Initial Freq (1-way trips/ hr)	Initial Headway (mins)	Frequency Increase (%)	Q4 Elast (E=Est S=Sat Curve)	Initial Freq (1-way trips/ hr)	Initial Headway (mins)	Frequency Increase (%)	Q4 Elast (E=Est S=Sat Curve)	Initial Freq (1-way trips/ hr)	Initial Headway (mins)	Frequency Increase (%)	Q4 Elast (E=Est S=Sat Curve)
140	Feb-09	120+170+180	1.125	53.3	256%	(E 0.92) (S 1.05)	2.0	30	100%	(E 0.87) (S 1.04)	1.44	42	178%	(E 0.83) (S 0.94)
130+140 (1)	Feb-09	120+170+180	5.75	10.4	50%	E 0.55 **S 0.59**	6.0	10	33%	E 0.35 **S 0.81**	5.44	11	47%	E 0.87 **S 0.65**
150	Nov-04	140	1.125	53.3	278%	E 0.51 **S 0.47**	2.0	30	100%	E 0.83 **S 0.80**	1.44	41.7	178%	E 0.78 **S 0.73**
190/199	Feb-06	375	1.0	60	300%	(E 0.82) **(S 0.88)**	2.0	30	100%	(E 0.78) **(S 0.76)**	2.0	30	100%	(E 1.05) **(S 1.07)**
190+191/ 196+199 (1)	Feb-06	375	2.0	30	194%	E 0.58 **S 0.62**	4.0	15	50%	E 0.51 **S 0.49**	4.0	15	50%	E 0.69 **S 0.77**
199	Nov-08	375					4.0	15	50%	(???) (???)				
196+199 (1)	Nov-08	375					6.0	10	33%	??? S 0.80??				
200	Apr-05	210+212	1.25	48	220%	E 0.67 **S 0.70**	2.0	30	100%	E 0.84 **S 0.72**	1.5	40	167%	E 0.66 **S 0.72**
345	Feb-06	330	1.0	60	313%	E 0.64 **S 0.59**	2.0	30	100%	E 0.98 **S 0.83**	2.0	30	100%	E 0.85 **S 0.84**

Notes:

(1). These wider analyses (including additional routes) were undertaken to test the effects of any passenger abstraction from competing routes.

(2). Two elasticity estimates are given in each case:

E = direct estimate of elasticity for 4th quarter (weeks 40-52) after the service change

S = corresponding estimate taken from the saturation curve fitted to the quarterly elasticity estimates.

In both cases, these elasticities are derived from the 'control' analysis or the 'extrapolation' analysis or some combination of the two sets of analyses, as described in the text.

(3). Abnormal result, based on limited data.

Appendix G: Service elasticity assessments – Adelaide

G1 Introduction

This appendix covers the project analyses of Adelaide's experience with changes in bus service levels, principally in off-peak periods, initiated over the period 2003–2008. It provides full details of the various analyses undertaken, the results of which were summarised in the main report (section 4.7).

The analyses covered 20 service frequency improvements and two cases of service reductions. In most cases, the improvements involved a doubling of frequencies, typically from one service to two services per hour. The service changes were considered in four groups for analysis purposes: weekday inter-peak, weekday evening, Saturday and Sunday.

The focus of the work was on estimating service frequency elasticities for the day types/time periods on which the services were improved. In particular, the analyses examined how these elasticity values varied by day/time period and over time following the service improvements.

G1.1 Acknowledgements

We would like to express our great thanks for the support received in this project from Tom Wilson and Andrew Every, staff of the Public Transport Services Division of the (then) SA Department for Transport, Energy and Infrastructure (now the Department of Planning, Transport and Infrastructure). Their support in terms of data provision, advice and review of draft outputs has been a major contributor to the quality of the research and its findings.

G2 Methodology and data

G2.1 Service changes analysed

The focus of the project was to analyse the effects of changes in bus service frequencies at off-peak periods on patronage, and in particular to estimate demand elasticities with respect to service frequency.

Services in four time periods were nominated for examination of off-peak frequency effects:

- weekday interpeak – timetabled trips starting between 0900 and 1500 hours
- weekday evening – timetabled trips starting between 1900 and 2359 hours
- Saturday
- Sunday.

Based on discussions with PTD staff, 22 candidate off-peak service changes implemented over the period January 2003 to January 2008 were identified as appropriate for analysis, as listed in table G.1. These candidates were chosen on the basis that:

- they involved a change in service frequencies at one or more of the relevant off-peak periods
- the effects of the service change on patronage were judged as likely to be largely unaffected by other service changes (to service frequencies, route structure etc) at about the same period.

Table G.1 Adelaide off-peak service improvements – service changes and patronage data summary

Route No	Service Change Date	Period of Pax Data		Weekday Interpeak (0900-1500)			Weekday Evening (1900-2400)			Saturday			Sunday		
		Start Period	End Period	Initial Freq (1-way trips/ hr)	Initial Headway (mins)	Frequency Increase (%)	Initial Freq (1-way trips/ hr)	Initial Headway (mins)	Frequency Increase (%)	Initial Freq (1-way trips/ hr)	Initial Headway (mins)	Frequency Increase (%)	Initial Freq (1-way trips/ hr)	Initial Headway (mins)	Frequency Increase (%)
113	Jan-04	Jan-03	Dec-07	1	60	100%									
122-125	Jan-03	Jul-02 (1)	Jul-05	4	15	50%									
125	Aug-05	Aug-04	Jan-08	1	60	100%									
140-142	Jan-03	Jul-02 (1)	Jan-10	2	30	100%									
142	Jan-03	Jul-02 (1)	Jan-10	1	60	100%									
143	Jan-03	Jul-02 (1)	Jan-10	1	60	100%									
155	Feb-03	Jul-02 (1)	Jul-05							1	60	100%			
	Aug-05	Aug-04	Dec-07							2	30	-50%			
167-168	Aug-05	Aug-04	May-09										1	60	100%
	Jan-08	Jan-07	Jan-10	2	30	100%									
171	Jan-08	Jan-07	Jan-10										1	60	100%
172	Oct-06	Oct-05	Jan-10				1	60	100%						
178	Jan-08	Jan-07	Jan-10	2	30	100%									
203 (200)	Oct-06	Oct-05	Aug-09	3	20	33%	1	60	100%				1	60	100%
263	Oct-06	Oct-05	Jan-10	1.33	45	50%									
291	Jan-08	Jan-07	Aug-09							1	60	100%	1	60	100%
541	Aug-05	Aug-04	Dec-07	2	30	100%									
682	Aug-05	Aug-04	Aug-09				2	30	-50%						
864	Feb-07	Feb-06	Jan-10	1	60	100%									

Notes: (1). In these cases a back-casting process was applied to derive patronage estimates from Jan to June 02, so as to provide a full 12 months data set before the service change

Table G.1 provides further details on each of the service changes assessed, including information on initial service frequencies and the proportionate frequency change. It is seen that 2 of the 22 service changes involved reductions in service frequency, the remaining 20 increases in frequency. It also notes whether other frequency changes on the route (at other time periods) were introduced at the same time as the change being assessed.

G2.2 Patronage data

The basic unit of patronage used in our analyses was monthly average passenger boardings per day (both directions combined) for the route (or control route) during the time period of interest. PTD provided us with data on this basis.

For each route of interest (and the corresponding control route), we requested patronage data starting 24 months prior to the service change and continuing as long as possible (usually up to January 2010 in practice), except in cases where other events sometime after the service change meant that the analysis of data after these events would not be useful. For each route, the data obtained covered part or all of the period July 2002–January 2010: table G.1 provides details of the data used in the analyses for each route.

G2.3 'Control' routes

For all analyses undertaken, we applied a 'control' route approach, involving analysis of the change in patronage on the route in question relative to a 'control' route. The intention was that the 'control' route would allow for any factors, other than the service change under examination that might have affected patronage on the route in question over the analysis period.

Based on discussions with PTD, the control chosen in every case was the patronage for the time period in question on all bus routes expected to be unaffected by service changes over the analysis period (ie for each time period, the total bus system patronage less patronage on the routes listed in table G.1). Inspection of the 'control' patronage showed that it varied only slightly over most of the analysis period, although it did increase by around 5%–8% in the last 18 months of the period (ie from mid-2008 onwards)[63].

G2.4 Scope of analyses

In general, the analyses for each route/time period compared the change in patronage on that route/period following the service frequency increase with the extent of the service increase. This enabled derivation of a route/time period service elasticity.

However, potentially, a change in service on a single route/time period may have wider impacts on patronage, ie:

A on other (competing or complementary) routes at the same time period

B on the same routes at other time periods

C on other (competing or complementary) routes at other time periods.

These 'secondary' impacts are often ignored in studies that derive route-based elasticity estimates, but they may be very significant: ignoring them may underestimate or overestimate the true market response to service changes.

In regard to these three potential responses, we comment as follows:

A **Effects on other routes.** Generally the service changes selected for analysis were such that the changes were expected to have only small, if any, impacts on other (competing or complementary) routes. In some cases where such effects might be expected, a group of potentially competing routes were considered together (eg 122–125). Despite these efforts, it might be expected that our assessments would tend to overestimate the net patronage effects on the bus system overall: generally we would expect any overestimate of elasticity values due to this effect would be less than 10%.

B **Effects in other time periods.** Prima facie, if a service is improved in one time period (eg weekday evenings), the improvement would also be expected to influence patronage in other time periods in which people are travelling on the same round trip or trip chain (eg weekday interpeak or PM peak). In the case of weekend travel, it would be expected that the great majority of people would complete their round trip on the same day, so that the Saturday and Sunday service changes assessed would be expected to have very limited effects beyond the day in question.

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[63] It is understood that some increases were made to the control route services in July 2008 and July 2009; these are likely to explain the increase in control patronage from mid-2008 onwards. Hence we have generally not used control route data beyond mid-2008.

Our Adelaide analyses did not investigate any effects of the service changes in question on patronage at other time periods. We would not expect these to be substantial for the weekend service changes, but they may be so for the weekday changes. For both interpeak and evening periods, it would be expected that a substantial proportion of people making one trip 'leg' in either of these periods would make the other trip leg (assuming an out-and-back return trip) in another period of the day. Hence our elasticity estimates based just on the patronage effects in a single time period may significantly underestimate the full market response[64][65].

Given these patronage interactions between (weekday) time periods, it would be expected that market responses (and hence elasticity estimates) for a given period would be greater if services were simultaneously increased at other periods of the day than if they were increased only in the period in question. In interpreting the elasticity estimates derived for weekday changes, we have therefore taken into account whether services were also increased at other weekday time periods.

We consider that the effects on elasticity values of which time periods are included in the analyses, and of any service changes in other time periods, should be a priority aspect for attention in any further research.

C **Effects on other routes at other time periods**. Given the above discussion, this effect might be expected to be somewhat secondary to effects A and B, but maybe still of significance. In practical terms, we suggest that if the extent of effects A and B can be identified in any specific case, then it should be possible to make a good estimate of the likely extent of effect C without having to undertake wider data analyses. If further work is to be undertaken on effect B, we suggest the effect C impacts also be investigated along with this.

G2.5 Elasticity formulation

We adopted a commonly-used elasticity formulation as the basis for our estimation of service frequency elasticities. This was:

$$\text{Elasticity} = \frac{\ln(\text{patronage increase factor})}{\ln(\text{service increase factor})}$$

This (natural) logarithmic function has a number of advantages over alternative elasticity functions in terms of the project requirements, including that it provides consistent elasticity results in cases where:

- Two sets of service changes are made on a route: the total patronage effects calculated for the two separate changes will be the same as if the patronage effect was calculated for both changes together.
- A service increase is followed by a service decrease (or vice versa), resulting in no net service change: this method will calculate no net patronage change, while other methods generally do not.

In our estimation of elasticities using the above function:

- We compared patronage in each 'after' monthly period with that for the corresponding month in the 12 months immediately before the service change (thus overcoming any seasonality effects).

[64] If it is assumed that all passengers affected make a simple (out-and-back) return trip, and 50% of them make one of their two trips outside the analysis period, then the estimated elasticities would need to be increased by 33% to allow for the full market response.

[65] This is consistent with the project finding that weekday interpeak and evening service elasticity estimates are significantly lower than the weekend estimates (refer section G.6).

- We compared these patronage changes on the route under examination with patronage changes on the specified 'control' (unaffected) route, and calculated elasticities on the net change ratio (thus allowing for any other 'external' factors that might have affected patronage over the relevant period).

On this basis, the above elasticity function was expressed as follows:

Estimated elasticity $$E_e = \frac{\ln [\,(P_R^{Ta} / P_R^{Tb}) / (P_C^{Ta} / P_C^{Tb})\,]}{\ln (S_R^{Ta} / S_R^{Tb})}$$

where: E_e = service frequency elasticity estimate (for time period T_a)

P = patronage in specified period

S = number of service trips over time period

R = route experiencing service change

C = control route

Ta = time period (month) after the service change

Tb = corresponding time period (month) in the year immediately before the service change.

G2.6 Estimation of elasticity values

Patronage data was provided by PTD on a monthly (average day) basis for each of the day types/time periods of interest, for both the routes of interest and the control route(s).

We used this data to calculate, on a daily basis:

- for the route of interest: ratio of monthly average 'after' patronage to patronage in the same month in the 12 months before the service change
- for the 'control' route: similar ratio of monthly 'after' patronage to 'before' patronage
- the ratio A/B.

The formulation above was then used to derive estimated elasticity values on a monthly (average day) basis.

Similarly, averaged elasticities were calculated for longer periods using average patronage data. In particular, we calculated average elasticities over three-monthly (quarterly) periods.

For most of the project work in assessing patterns of elasticity results, we focused on average values for each quarterly period after the service change. The result was elasticity estimates for Q1, Q2, Q3, Q4 etc following the service change. In practice, the continuing rate of growth in market response (and hence elasticity estimates) is much reduced beyond the first 12 months, and hence we derived annual average elasticities beyond the first year. This resulted in a set of elasticity estimates for the following periods: Q1, Q2, Q3, Q4, Y2, Y3, Y4 etc.

We chose the Q4 elasticity estimate (ie relating to the period 10–12 months after the service change) as our single primary indicator of market response: one reason for this choice is that it is largely consistent with the definition of short-run elasticities generally found in the literature. When examining elasticity trends over time we then related these back to the Q4 elasticity value as the base.

G2.7 Saturation curve assessment

As noted above, we estimated elasticity values initially on a monthly (average day) basis; and then derived from these three-monthly average values. The graphical results presented in this appendix include monthly average values, 12 months moving average values and average values for each quarterly period. As expected, the monthly values show generally considerable month-to-month variations; while the 12-month period averages show a reasonably smooth curve, generally increasing over time since the service change but at a decreasing rate.

In order to be able to generalise from the various results, it is useful to fit a smooth curve to the results, indicating the 'underlying' trends over time. In this case, a 'saturation'-type curve is most appropriate, reflecting an expectation that in the long run the elasticity would be expected to approach a fixed value (rather than continue to increase indefinitely).

In developing our saturation curves we adopted a popular equation for curve fitting – the 'two-parameter saturation growth' function:

$$E_S = A.T/(B+T)$$

where T is time (following the introduction of the service change), and A and B are two parameters.

An alternative popular equation used for curve fitting is the 'two parameter exponential' function:

$$Y = A\ (1\text{-}exp(\text{-}B^*T))$$

where T is time, and A and B are two parameters (Kirk 2005).

Both of these equations were initially tested and compared (in our analysis of the Hamilton data). We found that both equations provided a similar fit to the set of elasticity estimates. However, the 'two-parameter saturation growth' method generally provided a better fit for off-peak data. Therefore, that method was employed for analysis of the remaining centres (including Adelaide).

Hence the saturation curve formula adopted was:

Curve fitted elasticity $E_S = A.T_a/(B + T_a)$

where: A is a parameter representing the long-run elasticity

B is a parameter representing the speed of convergence to the long-run elasticity

T_a is time since introduction of service change.

Analysis of the dataset of actual elasticity estimates enables A and B to be estimated so as to minimise the following:

Sum of squared error $\sum_{t=0}^{t=n}$ (derived elasticity–curve-fitted elasticity)^2

$$= \sum_{Ta=0}^{Ta=n} [E_e - A.T_a/(B + T_a)]^2$$

In much of the work in the project to examine the patterns of elasticity results (eg in examining elasticity changes over time), the saturation curve estimates were used in place of (or in addition to) the actual results to minimise the effects of random fluctuations in the data.

G3 Weekday interpeak analyses

G3.1 Route 113

G3.1.1 Service change

The service change occurred on 26 January 2004, with services increasing from one per hour to two per hour (each direction).

Table G.2 Details of service change

Date of service change for route group 113	Monday, 26 January 2004
Trips before	1
Trips afterwards	2
Ratio	2.00
Control route/s:	Total system minus routes of interest

G3.1.2 Notes re data

The route patronage appeared to decline for around 12 months from early 2008. PTD advised that: 'There were substantial changes around West Lakes (the terminus of route 113) and suburbs north of this point on 13 January 2008. A new route 117 was introduced that travelled from north of West Lakes, through West Lakes and onto the city, removing the need for passengers to transfer at West Lakes. Perhaps passengers were transferring onto route 113. This new route 117 also travels partly along the same road as route 113 (for a few km). Route 113 itself was not changed but services in the area were, perhaps this affected the route more than we thought'.

Therefore, data from January 2008 onwards has been excluded from our estimation of elasticities.

Figure G.1 Patronage on service route and control route

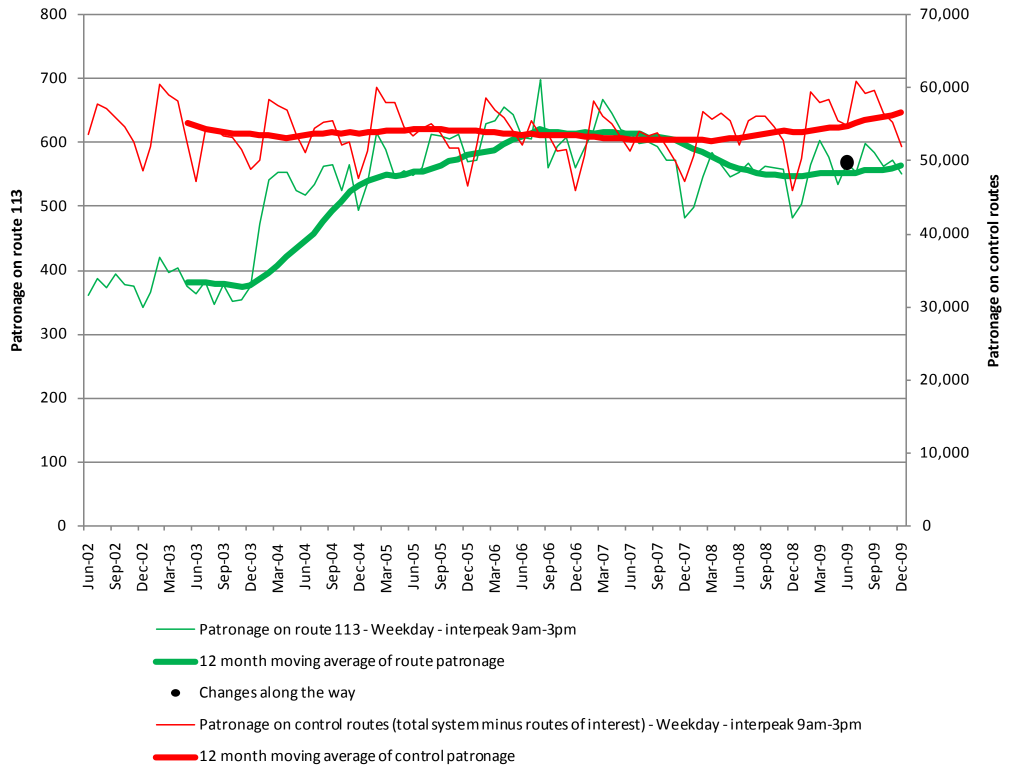
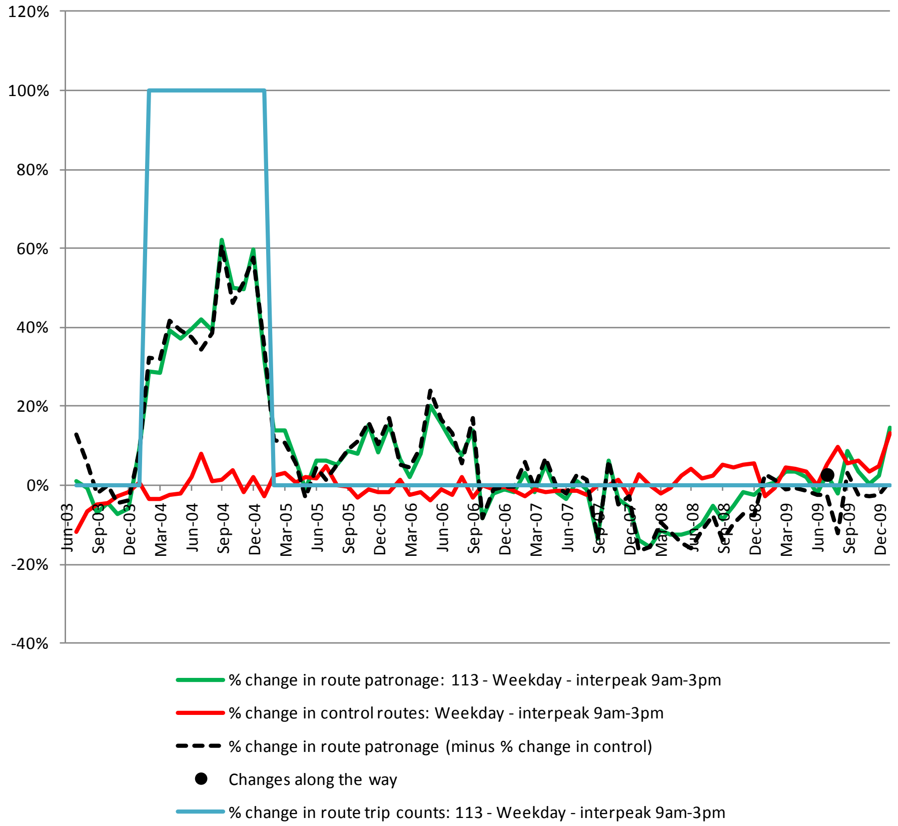


Figure G.2 Patronage changes (year-on-year) on service route and control routes



G3.1.3 Review and conclusions

Figure G.3 indicates elasticity values increasing to around 0.5–0.6 over the first 12 months, with continuing increases through the second year and into the third year after the service change. The data is generally a reasonably good fit to the saturation curve, with elasticities of around 0.7 in the third and fourth years, and a long-run (saturation) elasticity of 0.75.

Figure G.3 Monthly/quarterly elasticity estimates and saturation curve

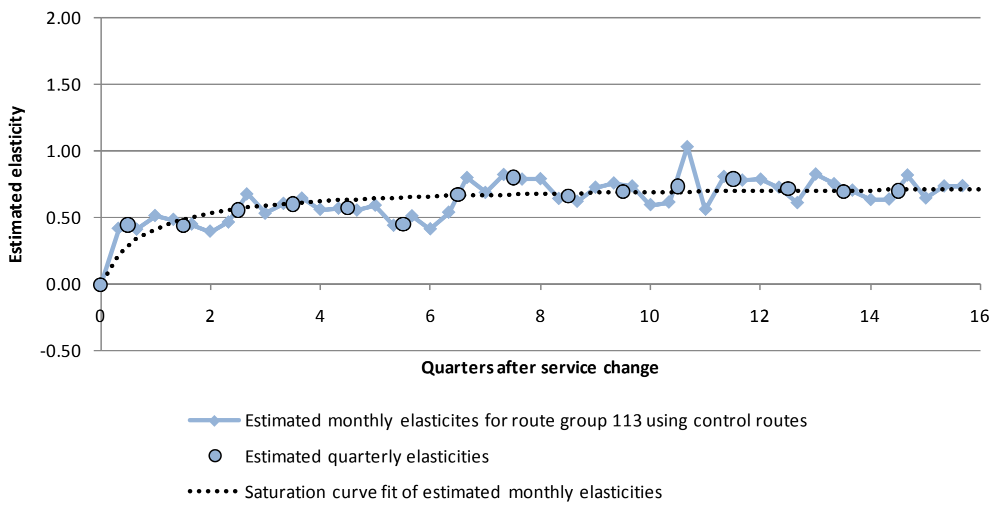


Table G.3 Quarterly elasticity estimates

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Jan-04					0.00	0.00
Q1	Apr-04	522	55,368	1.32	0.97	0.45	0.33
Q2	Jul-04	532	53,898	1.40	1.03	0.44	0.50
Q3	Oct-04	554	55,016	1.50	1.02	0.56	0.58
Q4	Jan-05	528	50,788	1.51	0.99	0.60	0.61
Q5	Apr-05	580	56,491	1.47	0.99	0.57	0.64
Q6	Jul-05	551	55,377	1.45	1.06	0.46	0.66
Q7	Oct-05	595	54,383	1.62	1.01	0.68	0.67
Q8	Jan-06	596	50,012	1.71	0.98	0.80	0.68
Q9	Apr-06	612	55,916	1.55	0.98	0.66	0.69
Q10	Jul-06	636	54,036	1.67	1.03	0.70	0.69
Q11	Oct-06	621	54,206	1.69	1.01	0.74	0.70
Q12	Jan-07	586	49,532	1.68	0.97	0.79	0.70
Q13	Apr-07	626	54,951	1.59	0.96	0.72	0.70
Q14	Jul-07	627	53,260	1.65	1.02	0.70	0.71
Q15	Oct-07	598	53,770	1.62	1.00	0.70	0.71
Long Run							0.75

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

G3.2 Route 122–125

G3.2.1 Service change

The service change on these combined routes occurred in January 2003, with services increasing from four per hour to six per hour (each direction).

Table G.4 Details of service change

Date of service change for route group 122-125 (and 126 from Jan 08)	Monday, 27 January 2003
Trips before	4
Trips afterwards	6
Ratio	1.50
Control route/s:	Total system minus routes of interest

G3.2.2 Notes re data

In August 2005, route 125 was shortened in length, along with a frequency upgrade from 60 to 30 minutes in the weekday interpeak. Therefore, data from August 2005 onwards has been excluded from the following estimation of elasticities (but refer to section G3.3 for analyses for route 125)..

In addition, the data series started in July 2002 while the first service change was in January 2003. Therefore, patronage on the route of interest (and the control routes) had to be back-casted so that a suitable 'before' and 'after' comparison could be made. This back-cast was derived from a regression model that looked at seasonal dummies and time trends from June 2004 to July 2005.

Figure G.4 Patronage on service route and control route

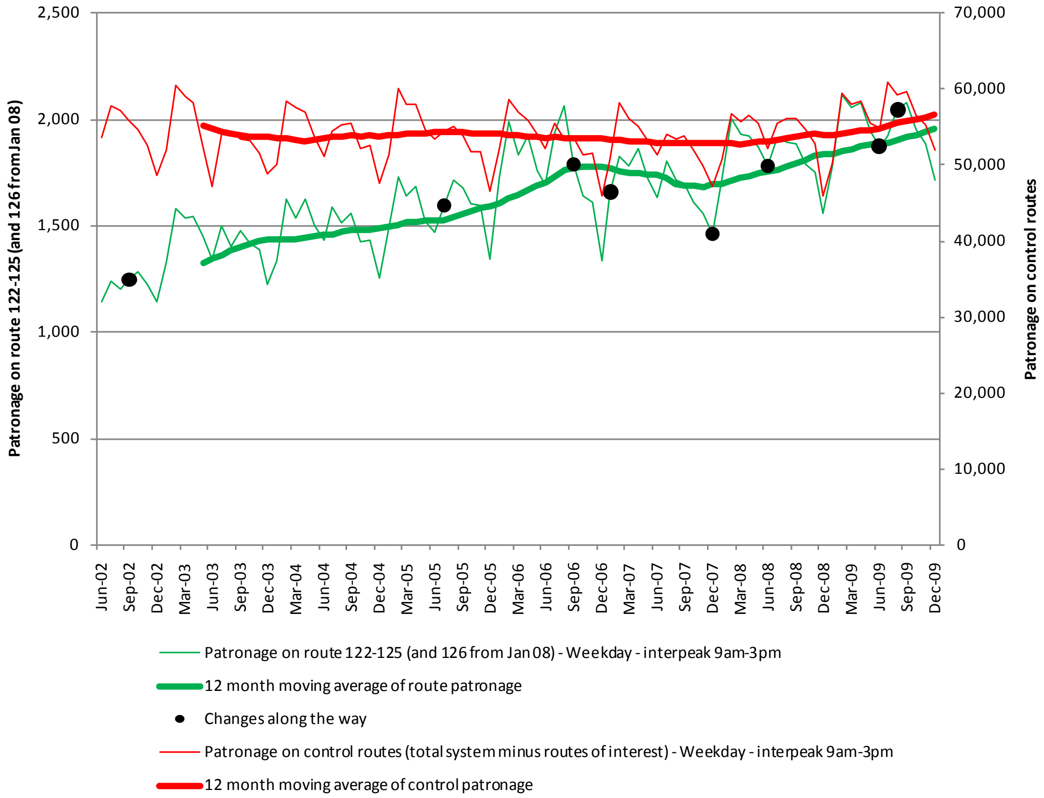
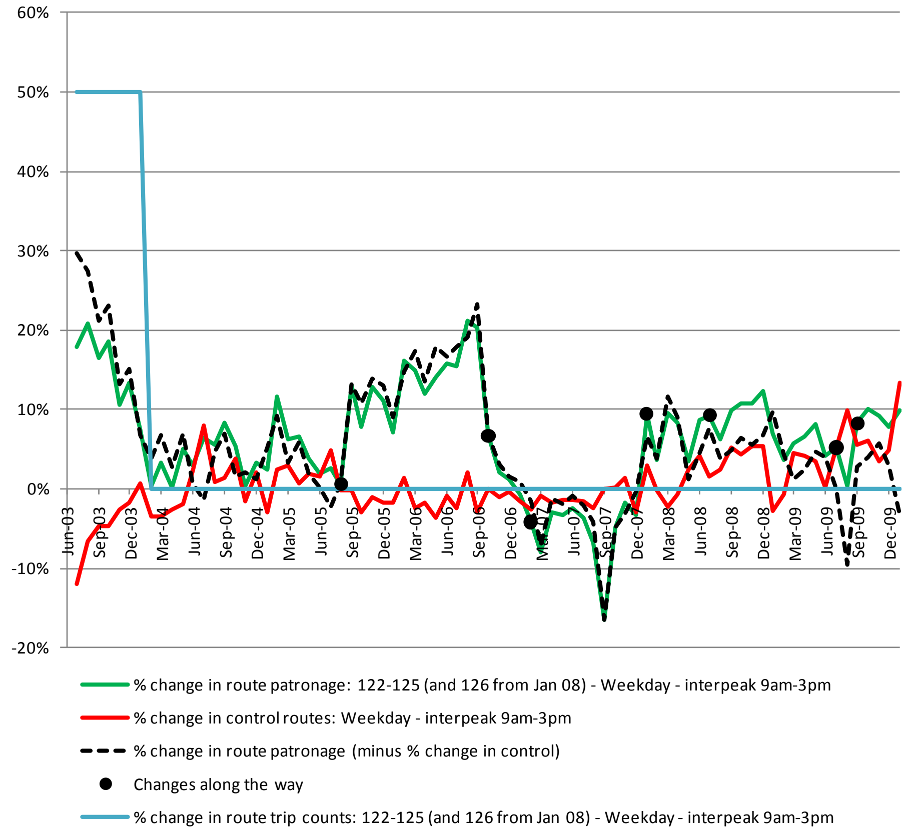


Figure G.5 Patronage changes (year-on-year) on service route and control routes



G3.2.3 Review and conclusions

Figure G.6 indicates elasticity values increasing to up to abour 0.6 within the first 12 months, with signs of some further increases for the following 18 months (the extent of the valid data series). The Q4 estimate of 0.42 is well below the saturation curve figure of 0.58, which is judged to be a more representative value. The medium/long-run elasticities appear to converge on around 0.6 to 0.65.

Figure G.6 Monthly/quarterly elasticity estimates and saturation curve

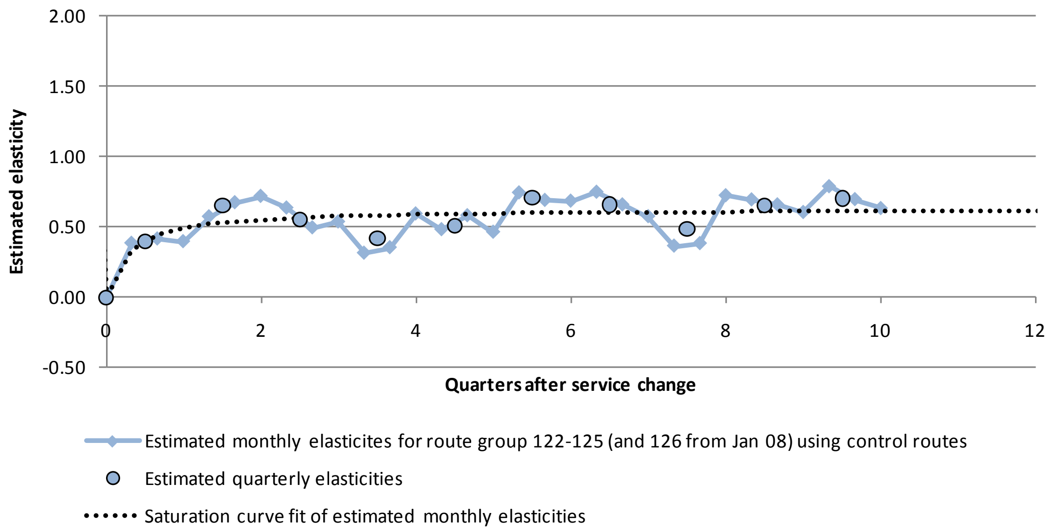


Table G.5 Quarterly elasticity estimates

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Jan-03					0.00	0.00
Q1	Apr-03	1,481	57,174	1.17	1.00	0.40	0.42
Q2	Jul-03	1,447	52,650	1.26	0.97	0.65	0.54
Q3	Oct-03	1,459	53,930	1.19	0.95	0.55	0.57
Q4	Jan-04	1,345	51,202	1.17	0.98	0.42	0.58
Q5	Apr-04	1,500	55,368	1.19	0.96	0.51	0.59
Q6	Jul-04	1,516	53,898	1.32	0.99	0.71	0.60
Q7	Oct-04	1,552	55,016	1.26	0.97	0.66	0.60
Q8	Jan-05	1,371	50,788	1.19	0.97	0.49	0.61
Q9	Apr-05	1,620	56,491	1.28	0.98	0.65	0.61
Q10	Jul-05	1,558	55,377	1.35	1.02	0.70	0.61
Long Run							0.63

Note: The ratio of route trips after the service change compared to prior to the service change was 1.50

G3.3 Routes 140–142

G3.3.1 Service change

The service change in January 2003 involved services increasing from two trips per hour to four trips per hour (each direction.

Table G.6 Details of service change

Date of service change for route group 140-142	Monday, 27 January 2003
Trips before	2
Trips afterwards	4
Ratio	2.00
Control route/s:	Total system minus routes of interest

G3.3.2 Notes re data

As the available patronage data series only started in July 2002, a back-casting process was used to provide a full 12 months 'before' data (refer section G3.2.2).

Figure G.7 Patronage on service route and control route

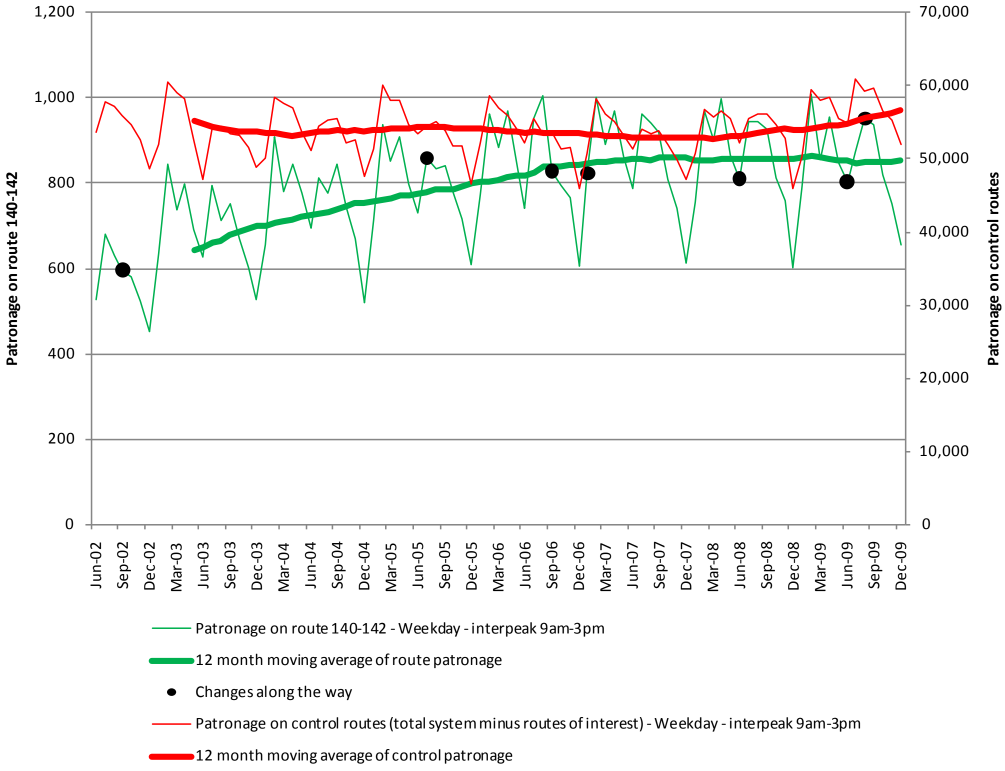
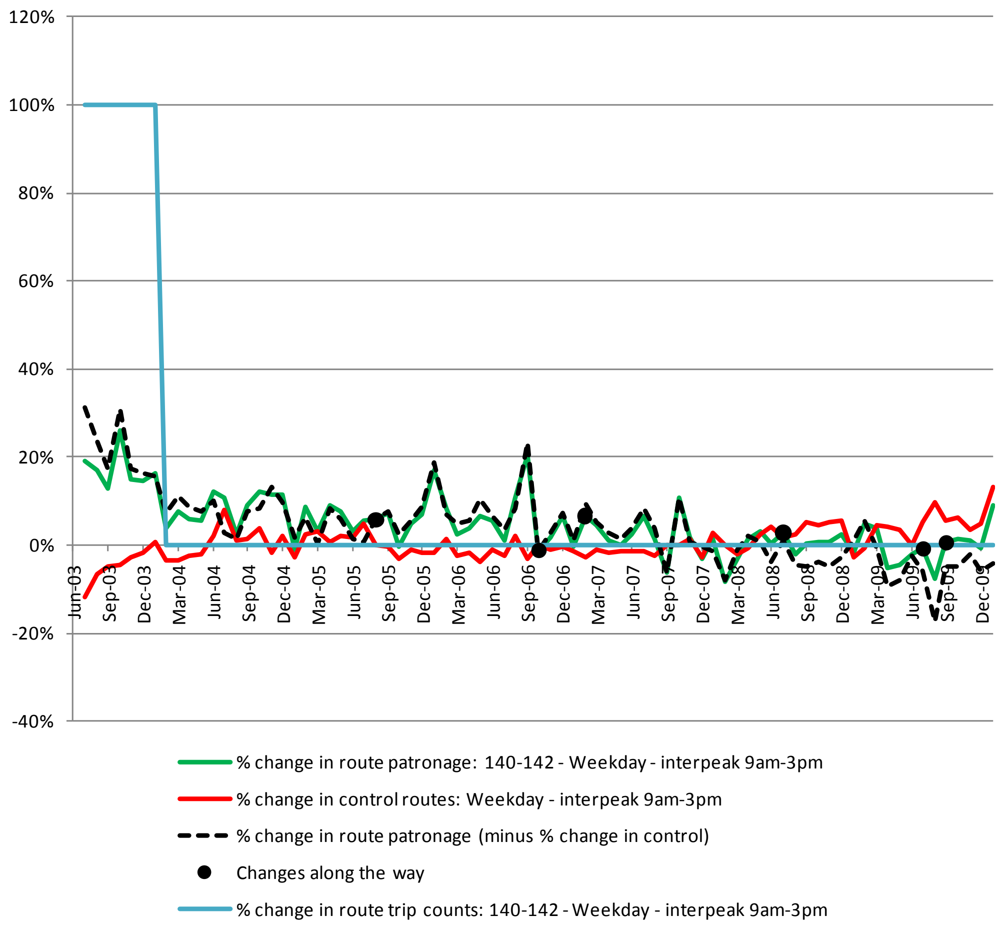


Figure G.8 Patronage changes (year-on-year) on service route and control routes



G3.3.3 Review and conclusions

Figure G.9 indicates elasticities of 0.3–0.4 within the first 12 months, with an ongoing slow increase for the first four to five years. The elasticity values reach around 0.65–0.70 by the fifth year, with signs of some decline thereafter (table G.7): this decline most likely reflects the apparent increase in the control route patronage from about mid-2008.

Figure G.9 Monthly/quarterly elasticity estimates and saturation curve

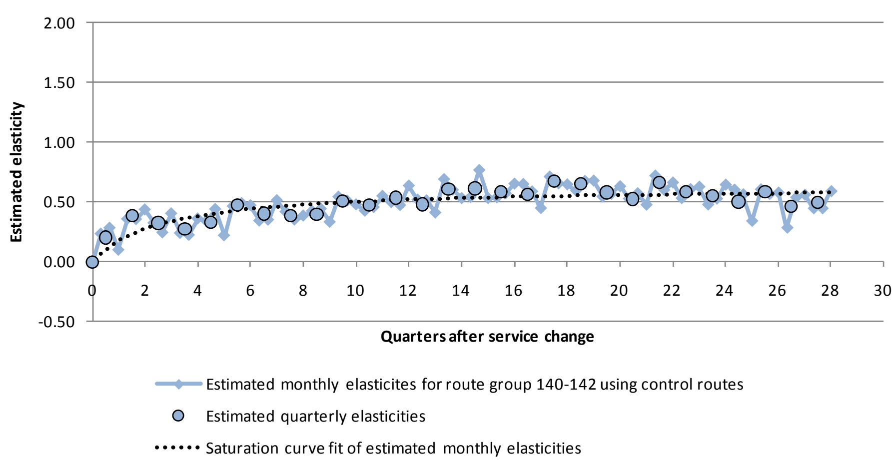


Table G.7 Quarterly elasticity estimates

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Jan-03					0.00	0.00
Q1	Apr-03	738	57,174	1.15	1.00	0.20	0.13
Q2	Jul-03	706	52,650	1.26	0.97	0.38	0.25
Q3	Oct-03	753	53,930	1.19	0.95	0.32	0.32
Q4	Jan-04	599	51,202	1.19	0.98	0.27	0.37
Q5	Apr-04	783	55,368	1.22	0.96	0.33	0.41
Q6	Jul-04	771	53,898	1.38	0.99	0.48	0.43
Q7	Oct-04	811	55,016	1.28	0.97	0.40	0.46
Q8	Jan-05	645	50,788	1.27	0.97	0.38	0.47
Q9	Apr-05	834	56,491	1.30	0.98	0.40	0.49
Q10	Jul-05	813	55,377	1.45	1.02	0.51	0.50
Q11	Oct-05	844	54,383	1.33	0.95	0.48	0.51
Q12	Jan-06	701	50,012	1.39	0.96	0.54	0.52
Q13	Apr-06	872	55,916	1.36	0.98	0.48	0.52
Q14	Jul-06	851	54,036	1.52	0.99	0.61	0.53
Q15	Oct-06	927	54,206	1.46	0.95	0.61	0.54
Q16	Jan-07	721	49,532	1.43	0.95	0.59	0.54
Q17	Apr-07	906	54,951	1.42	0.96	0.56	0.55
Q18	Jul-07	874	53,260	1.56	0.98	0.67	0.55
Q19	Oct-07	941	53,770	1.48	0.94	0.65	0.55
Q20	Jan-08	720	49,702	1.43	0.95	0.58	0.56
Q21	Apr-08	876	54,369	1.37	0.95	0.53	0.56
Q22	Jul-08	892	54,705	1.59	1.01	0.66	0.56
Q23	Oct-08	938	55,918	1.48	0.98	0.59	0.57
Q24	Jan-09	724	51,081	1.43	0.98	0.55	0.57
Q25	Apr-09	885	55,874	1.38	0.97	0.50	0.57
Q26	Jul-09	868	56,260	1.55	1.03	0.58	0.57
Q27	Oct-09	920	59,916	1.45	1.05	0.46	0.58
Q28	Jan-10	743	54,594	1.48	1.05	0.49	0.58
Long Run							0.63

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

G3.4 Route 143

G3.4.1 Service change

The service change in January 2003 involved a doubling of service frequencies, from one trip per hour to two trips per hour (each direction).

Table G.8 Details of service change

Date of service change for route group 143	Monday, 27 January 2003
Trips before	1
Trips afterwards	2
Ratio	2.00
Control route/s:	Total system minus routes of interest

G3.4.2 Notes re data

As the available patronage data series only started in July 2002, a back-casting process was used to provide a full 12 months 'before' data.

Figure G.10 Patronage on service route and control route

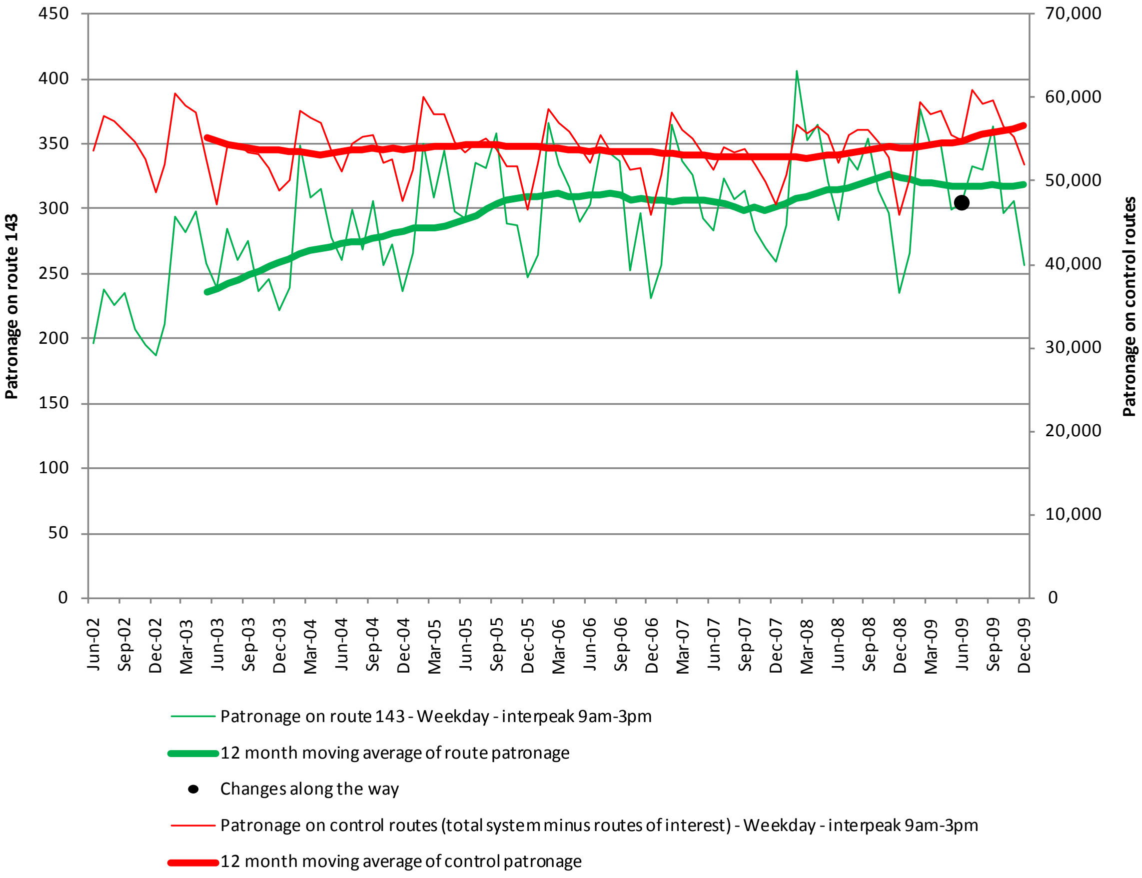
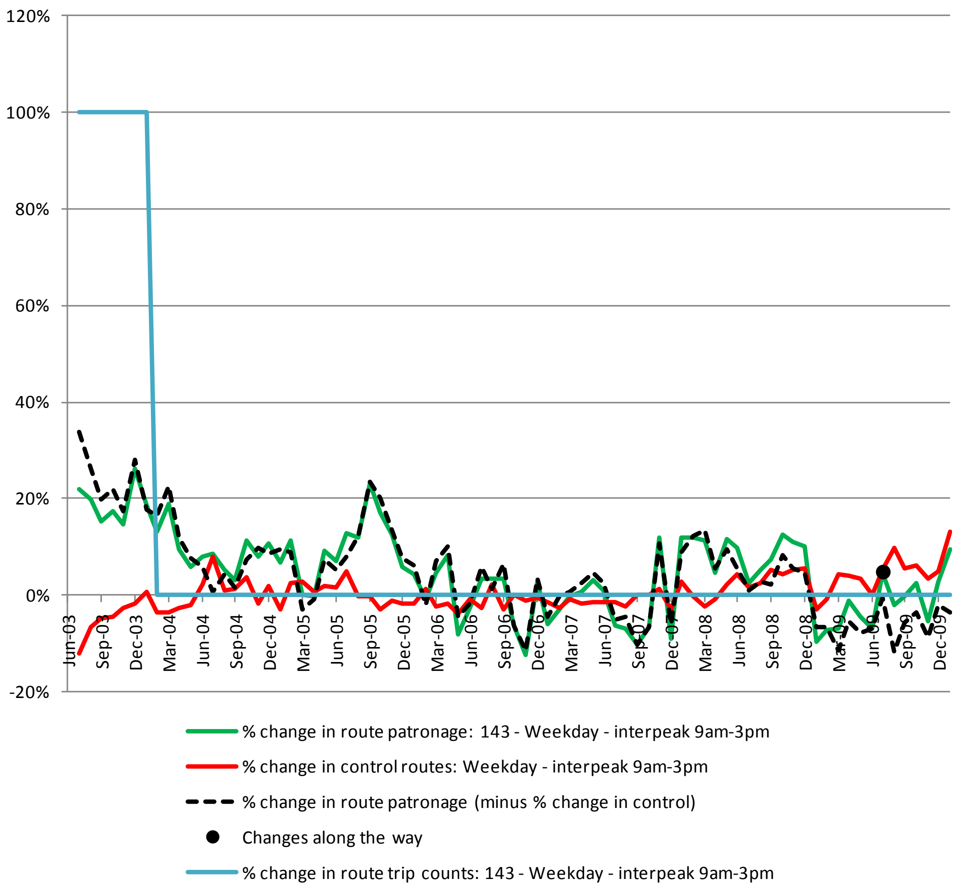


Figure G.11 Patronage changes (year-on-year) on service route and control routes



G3.4.3 Review and conclusions

Figure G.12 and table G.9 indicate that elasticities of around 0.4 were achieved within the first 12 months, with further increases to around 0.6 within the first three years. As for other services examined, there is some tendency for the elasticity values to reduce from about mid-2008 onwards, reflecting the increase in the control route patronage.

Figure G.12 Monthly/quarterly elasticity estimates and saturation curve

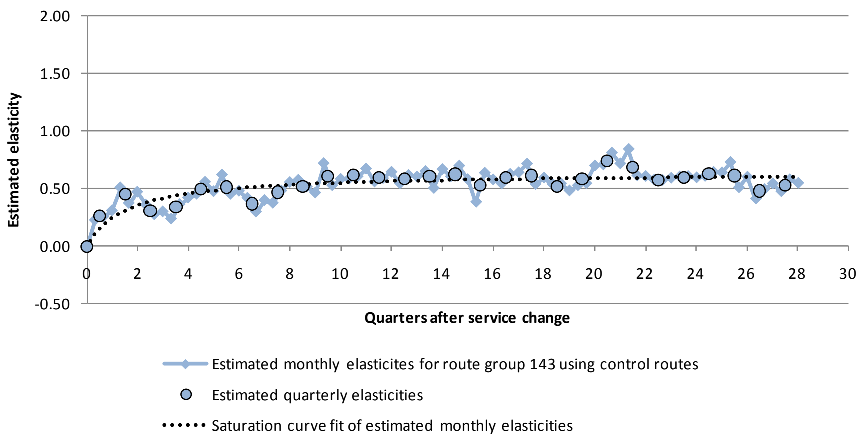


Table G.9 Quarterly elasticity estimates

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Jan-03					0.00	0.00
Q1	Apr-03	262	57,174	1.19	1.00	0.26	0.18
Q2	Jul-03	265	52,650	1.32	0.97	0.45	0.33
Q3	Oct-03	273	53,930	1.17	0.95	0.31	0.40
Q4	Jan-04	235	51,202	1.25	0.98	0.34	0.45
Q5	Apr-04	299	55,368	1.36	0.96	0.49	0.48
Q6	Jul-04	285	53,898	1.42	0.99	0.52	0.50
Q7	Oct-04	291	55,016	1.25	0.97	0.37	0.52
Q8	Jan-05	255	50,788	1.35	0.97	0.47	0.53
Q9	Apr-05	308	56,491	1.41	0.98	0.52	0.54
Q10	Jul-05	312	55,377	1.55	1.02	0.61	0.55
Q11	Oct-05	341	54,383	1.47	0.95	0.62	0.56
Q12	Jan-06	274	50,012	1.45	0.96	0.60	0.56
Q13	Apr-06	321	55,916	1.46	0.98	0.59	0.57
Q14	Jul-06	303	54,036	1.51	0.99	0.61	0.57
Q15	Oct-06	342	54,206	1.47	0.95	0.63	0.58
Q16	Jan-07	260	49,532	1.38	0.95	0.53	0.58
Q17	Apr-07	319	54,951	1.45	0.96	0.60	0.58
Q18	Jul-07	301	53,260	1.50	0.98	0.61	0.59
Q19	Oct-07	315	53,770	1.35	0.94	0.52	0.59
Q20	Jan-08	271	49,702	1.44	0.95	0.59	0.59
Q21	Apr-08	349	54,369	1.59	0.95	0.74	0.59
Q22	Jul-08	326	54,705	1.62	1.01	0.69	0.60
Q23	Oct-08	341	55,918	1.47	0.98	0.58	0.60
Q24	Jan-09	282	51,081	1.48	0.98	0.60	0.60
Q25	Apr-09	331	55,874	1.51	0.97	0.63	0.60
Q26	Jul-09	318	56,260	1.58	1.03	0.61	0.60
Q27	Oct-09	342	59,916	1.47	1.05	0.48	0.60
Q28	Jan-10	287	54,594	1.52	1.05	0.53	0.60
Long Run							0.64

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

G3.5 Route 178

G3.5.1 Service change

The service change in January 2008 involved a doubling of service frequencies, from two trips per hour to four trips per hour (each direction).

Table G.10 Details of service change

Date of service change for route group 178	Monday, 14 January 2008
Trips before	2
Trips afterwards	4
Ratio	2.00
Control route/s:	Total system minus routes of interest

G3.5.2 Notes re data

Figures G.13 and G.14 indicate a sharp increase in patronage, relative to the control routes, following the service change.

Figure G.13 Patronage on service route and control route

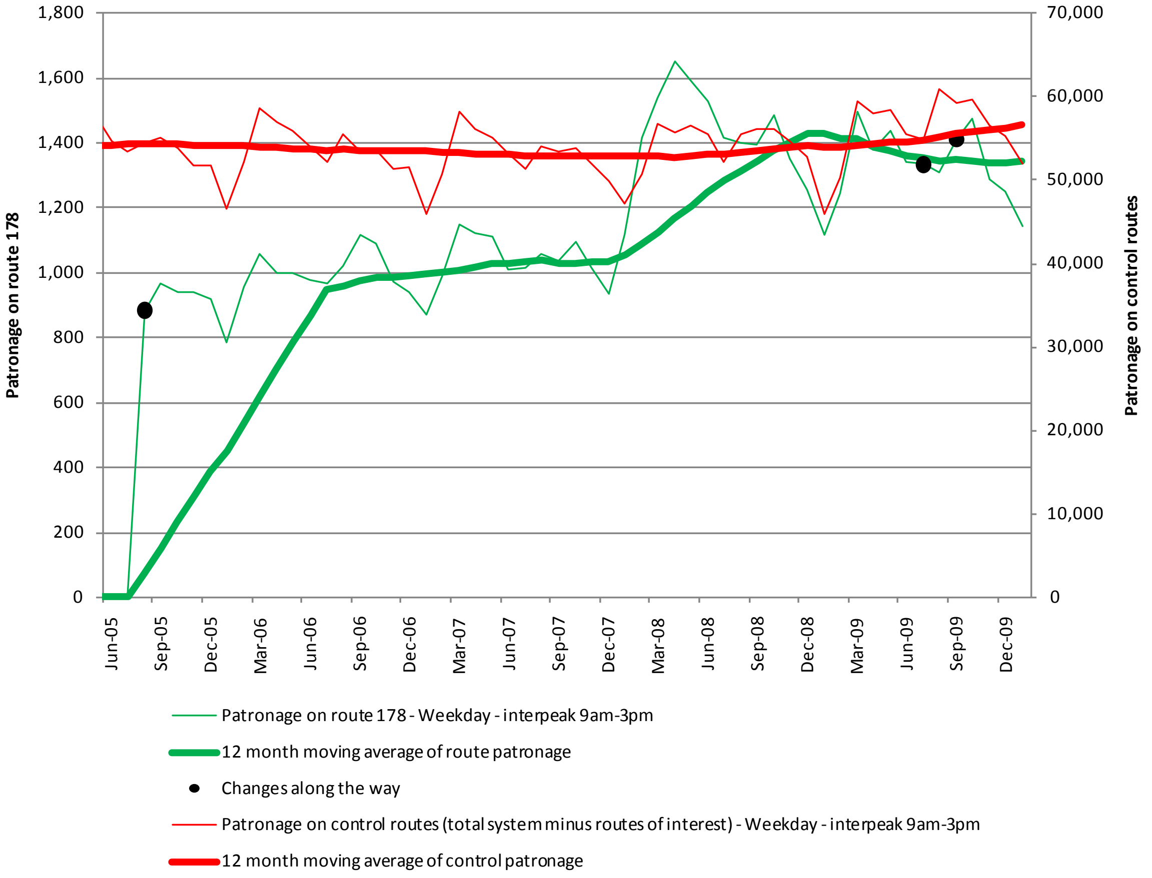
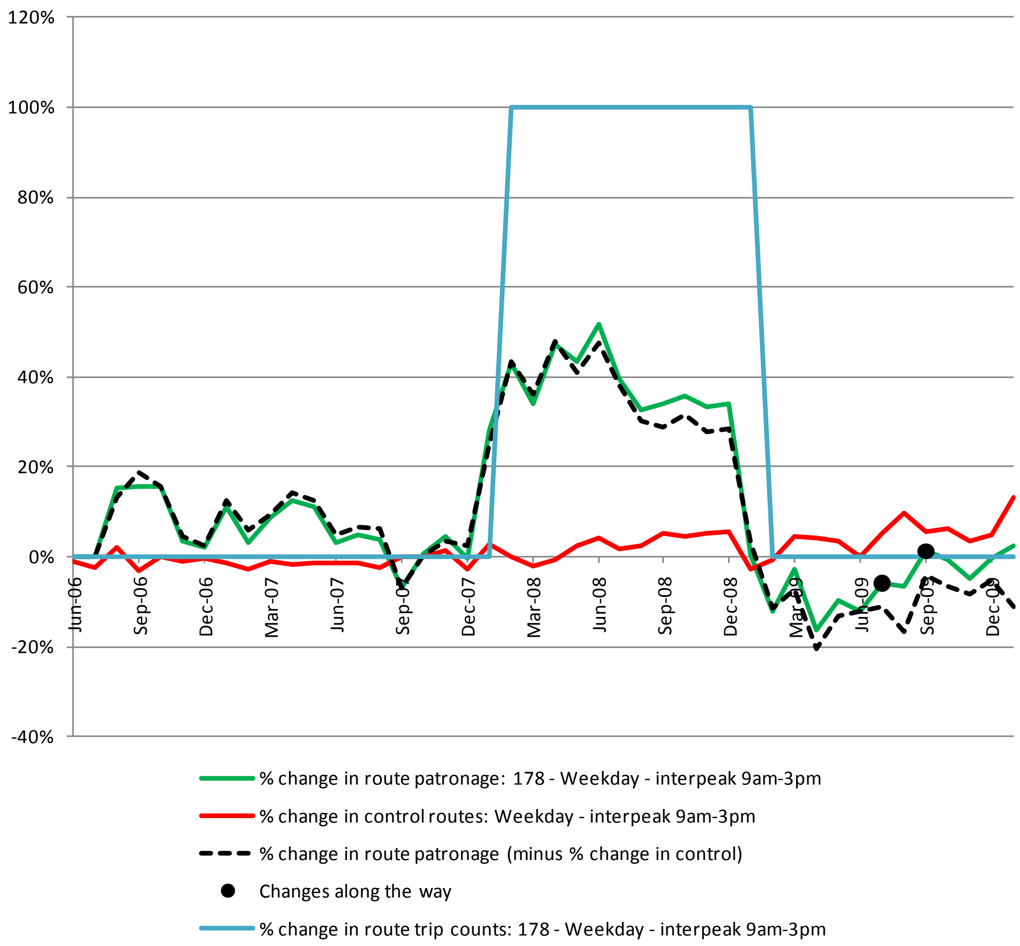


Figure G.14 Patronage changes (year-on-year) on service route and control routes



G3.5.3 Review and conclusions

Figure G.15 and table G.11 indicate that elasticities of around 0.5 were achieved within the first six months, but followed by an apparent gradual decline thereafter (figure G.15). As before, it seems likely that this decline reflects the increase in the control route patronage from around mid-2008 onwards. Our inference would be that the 'true' elasticity, achieved within the first 12 months, is likely to be around 0.55, rather than the calculated saturation level of about 0.35.

Figure G.15 Monthly/quarterly elasticity estimates and saturation curve

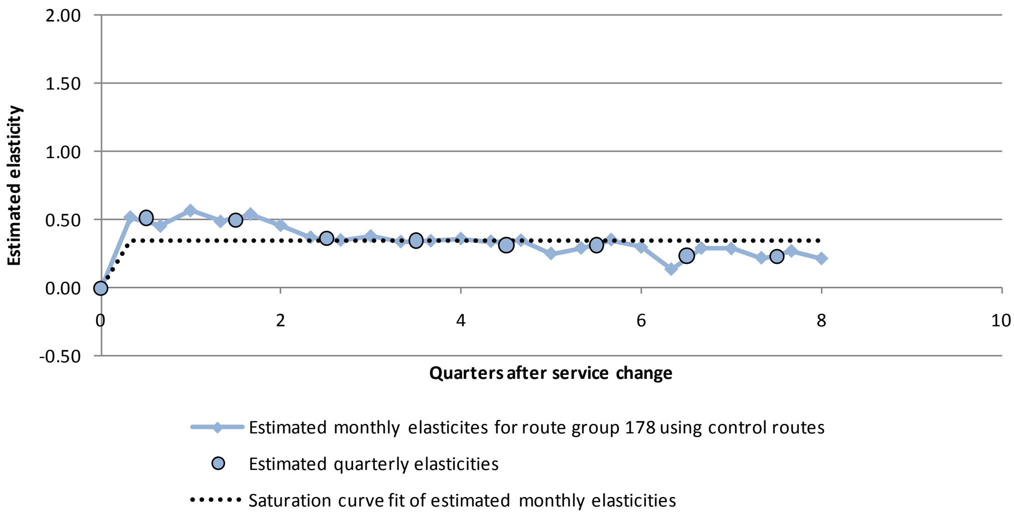


Table G.11 Quarterly elasticity estimates

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Jan-08					0.00	0.00
Q1	Apr-08	1,535	54,369	1.41	0.99	0.51	0.35
Q2	Jul-08	1,513	54,705	1.45	1.03	0.50	0.35
Q3	Oct-08	1,427	55,918	1.34	1.04	0.37	0.35
Q4	Jan-09	1,243	51,081	1.32	1.04	0.35	0.35
Q5	Apr-09	1,372	55,874	1.26	1.02	0.31	0.35
Q6	Jul-09	1,371	56,260	1.31	1.06	0.31	0.35
Q7	Oct-09	1,398	59,916	1.31	1.11	0.24	0.35
Q8	Jan-10	1,228	54,594	1.30	1.11	0.23	0.35
Long Run							0.35

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

G3.6 Route 203 (200)

G3.6.1 Service change

The service change in October 2006 involved an increase in frequency from three trips per hour to four trips per hour (each direction).

Table G.12 Details of service change

Date of service change for route group 203 (200)	Monday, 16 October 2006
Trips before	3
Trips afterwards	4
Ratio	1.33
Control route/s:	Total system minus routes of interest

G3.6.2 Notes re data

In January 2008, route 203 was re-numbered to 200. This change could be associated with negative patronage trends from that point onwards but does not seem to explain that fall in patronage.

On 27 September 2009, route 200 was split into routes 200 and 202, with route 202 taking around one-third of the interpeak passengers previously on route 200. Therefore data from September 2009 onwards has been excluded from the estimation of elasticities below.

Figure G.16 Patronage on service route and control route

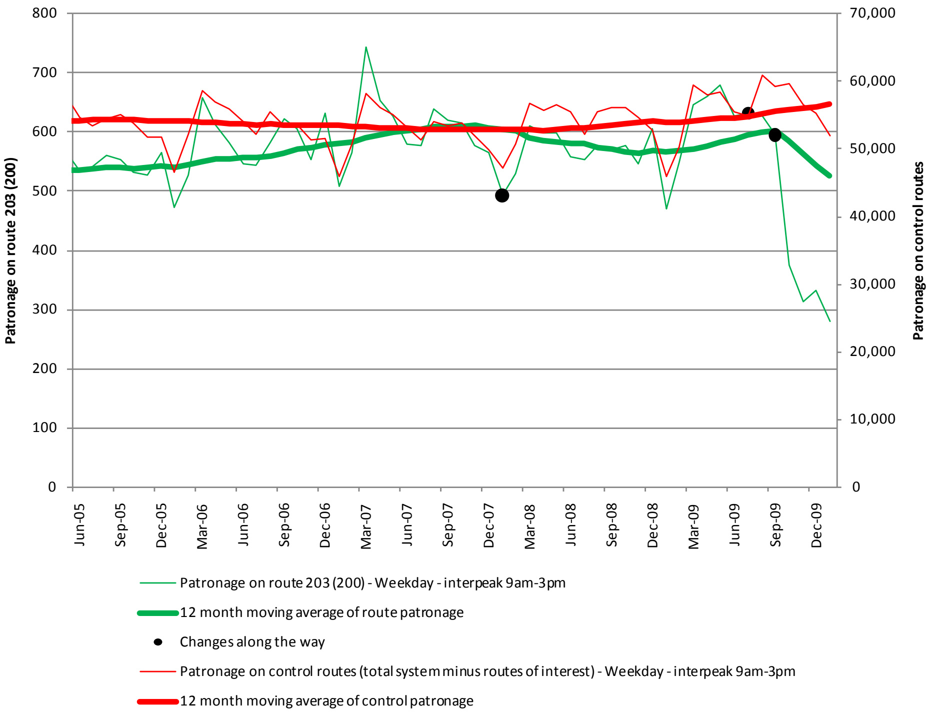
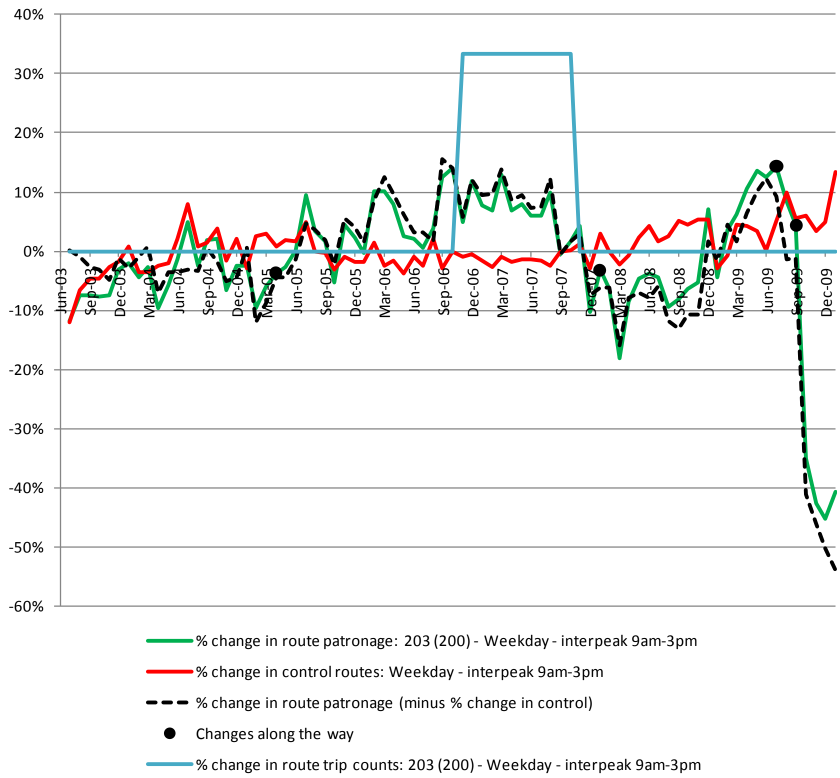


Figure G.17 Patronage changes (year-on-year) on service route and control routes



G3.6.3 Review and conclusions

Figure G.18 and table G.13 indicate that the elasticity increased to around 0.3–0.35 within the first six months, then apparently fell to around zero in the second year. This strange result appears again to reflect the apparent increase in the control route patronage from early/mid 2008 onwards. Our inference would be that the 'true' elasticity, achieved within the first 12 months, is probably around 0.35–0.40 and that the 'saturation' estimate of 0.16 is not realistic.

We also note the apparent route patronage increases in the first year prior to the service change (figure G.17). These cast some doubt on the accuracy and robustness of the elasticity estimates.

Figure G.18 Monthly/quarterly elasticity estimates and saturation curve

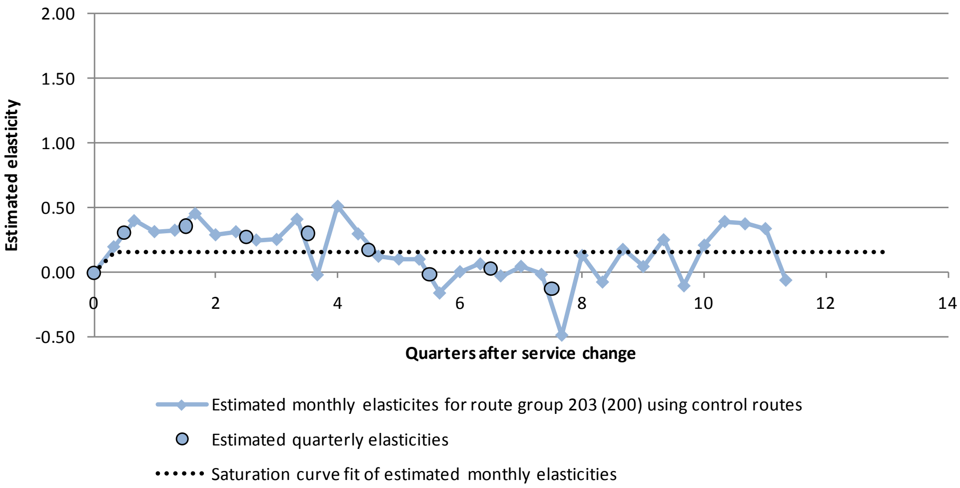


Table G.13 Quarterly elasticity estimates

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Oct-06					0.00	0.00
Q1	Jan-07	565	49,532	1.08	0.99	0.31	0.16
Q2	Apr-07	654	54,951	1.09	0.98	0.36	0.16
Q3	Jul-07	595	53,260	1.07	0.99	0.27	0.16
Q4	Oct-07	625	53,770	1.08	0.99	0.30	0.16
Q5	Jan-08	545	49,702	1.05	0.99	0.18	0.16
Q6	Apr-08	579	54,369	0.97	0.97	-0.02	0.16
Q7	Jul-08	569	54,705	1.02	1.01	0.03	0.16
Q8	Oct-08	575	55,918	1.00	1.03	-0.12	0.16
Q9	Jan-09	541	51,081	1.04	1.02	0.05	0.16
Q10	Apr-09	619	55,874	1.03	1.00	0.12	0.16
Q11	Jul-09	646	56,260	1.16	1.04	0.37	0.16
Long Run							0.16

Note: The ratio of route trips after the service change compared to prior to the service change was 1.33

G3.7 Route 263

G3.7.1 Service change

The service change in October 2006 involved a 50% increase in service frequency, from 1.33 trips per hour to two trips per hour (each direction).

Table G.14 Details of service change

Date of service change for route group 263	Monday, 16 October 2006
Trips before	1.33
Trips afterwards	2
Ratio	1.50
Control route/s:	Total system minus routes of interest

G3.7.2 Notes re data

Patronage trends on the route in the year prior to the service change appear to be very volatile (figures G.19 and G.20), including an apparent dramatic fall in June/July 2006 (relative to the same months in the previous two years). This will cast some doubt on the robustness of the elasticity estimates.

Figure G.19 Patronage on service route and control route

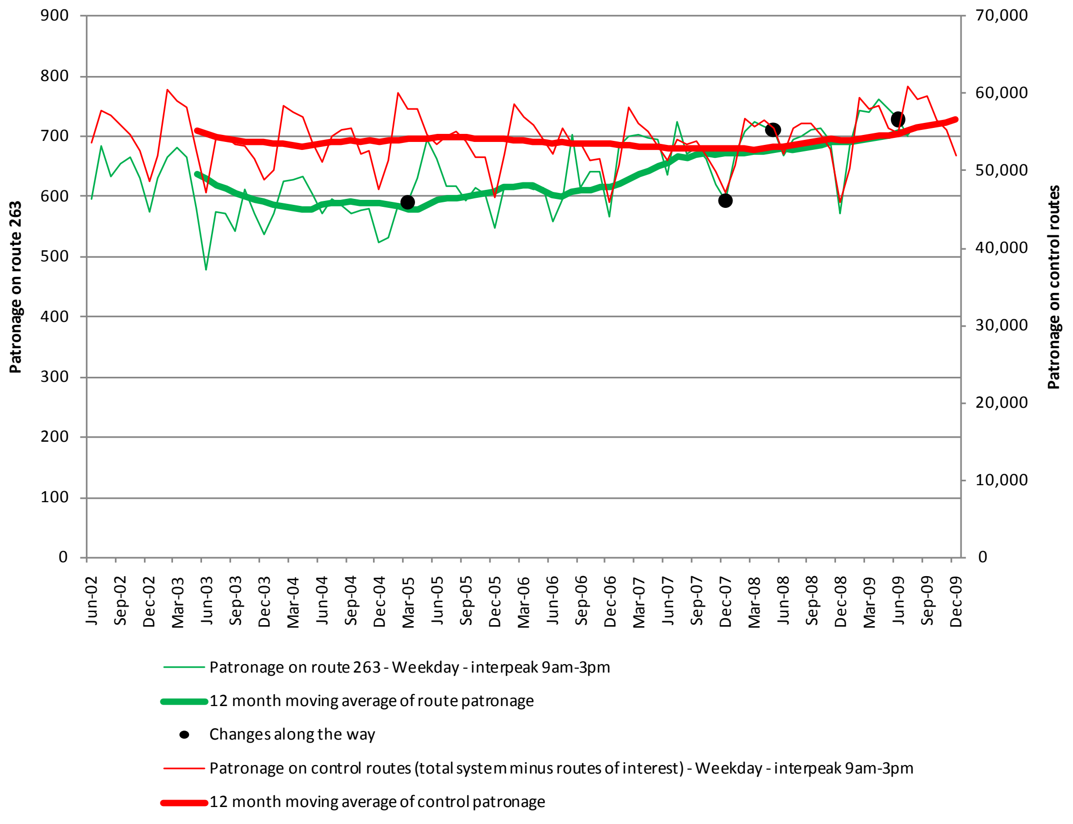
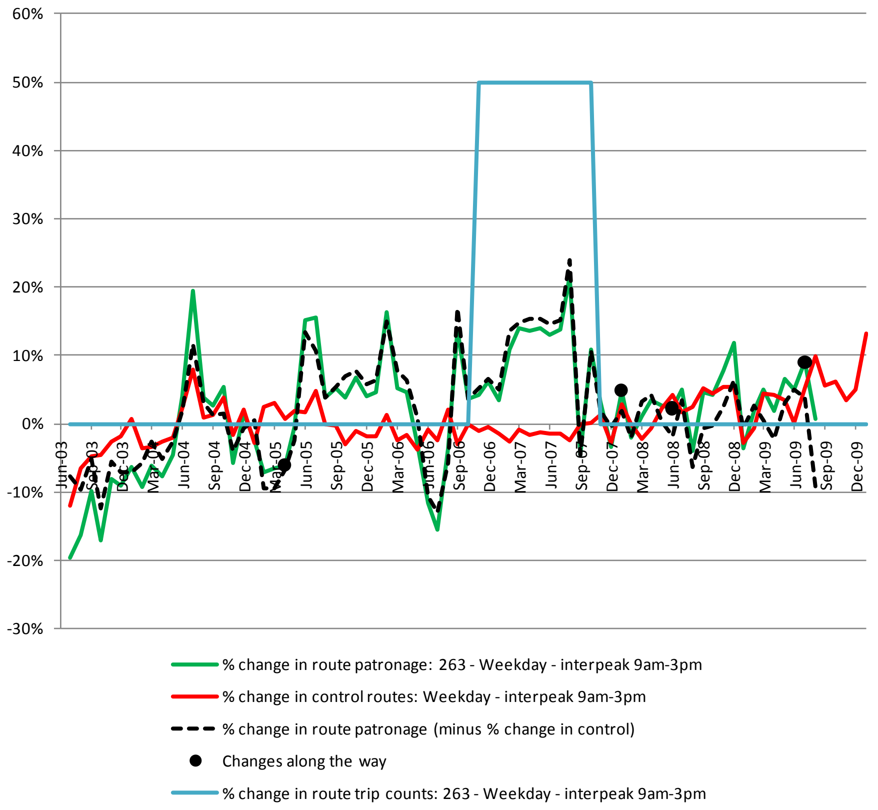


Figure G.20 Patronage changes (year-on-year) on service route and control routes



G3.7.3 Review and conclusions

Figure G.21 and table G.15 indicate that the elasticity increased to around 0.35 within the first 12 months, with a modest further increase (to around 0.4) in the second and third years. The volatility in the 'before' data has resulted in an uneven pattern of quarterly elasticities (figure G.21). It also seems likely that the saturation elasticity estimate of 0.30 underestimates the 'true' elasticity value, which would appear to be closer to 0.4 over the medium term.

Figure G.21 Monthly/quarterly elasticity estimates and saturation curve

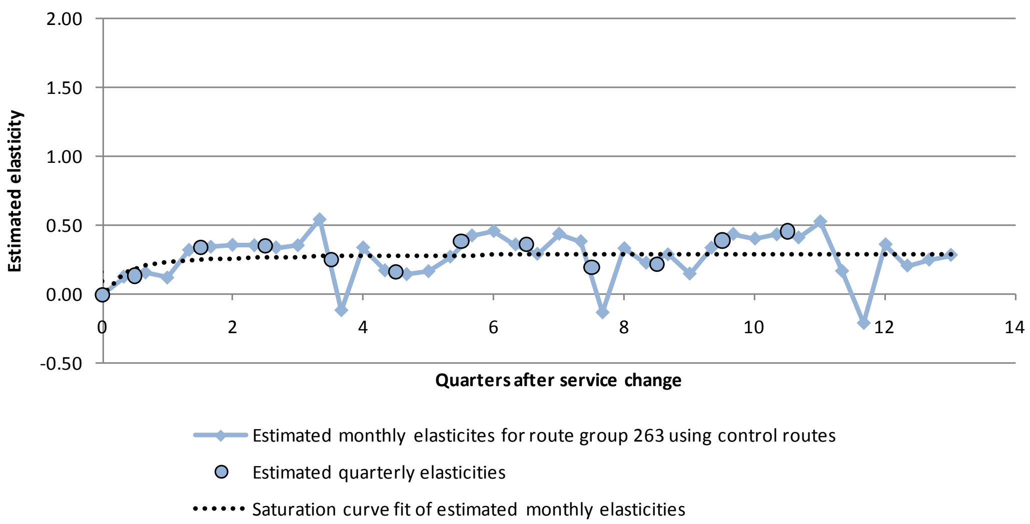


Table G.15 Quarterly elasticity estimates

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Oct-06					0.00	0.00
Q1	Jan-07	616	49,532	1.05	0.99	0.13	0.20
Q2	Apr-07	696	54,951	1.13	0.98	0.34	0.26
Q3	Jul-07	676	53,260	1.14	0.99	0.35	0.27
Q4	Oct-07	691	53,770	1.11	0.99	0.26	0.28
Q5	Jan-08	625	49,702	1.06	0.99	0.16	0.28
Q6	Apr-08	702	54,369	1.14	0.97	0.39	0.29
Q7	Jul-08	698	54,705	1.17	1.01	0.36	0.29
Q8	Oct-08	701	55,918	1.12	1.03	0.20	0.29
Q9	Jan-09	660	51,081	1.12	1.02	0.22	0.29
Q10	Apr-09	722	55,874	1.17	1.00	0.39	0.29
Q11	Jul-09	745	56,260	1.25	1.04	0.46	0.29
Q12	Oct-09	726	59,916	1.16	1.11	0.11	0.29
Q13	Jan-10	711	54,594	1.21	1.09	0.25	0.29
Long Run							0.30

Note: The ratio of route trips after the service change compared to prior to the service change was 1.50

G3.8 Route 864

G3.8.1 Service change

The service change in February 2007 involved an increase in services from one trip per hour to two trips per hour (each direction).

Table G.16 Details of service change

Date of service change for route group 864	Monday, 26 February 2007
Trips before	1
Trips afterwards	2
Ratio	2.00
Control route/s:	Total system minus routes of interest

G3.8.2 Notes re data

The patronage data for the route in the year or so prior to the service change appears very volatile (figures G.22 and G.23), and this would be expected to result in less robust elasticity estimates.

G3.8.3 Review and conclusions

Figure G.23 and table G.17 indicate that elasticities of around 0.5 were achieved within the first 12 months, with some small increases thereafter. The pattern of elasticities (figure G.24) is adversely affected by i) the anomalous values each June, which result from the voltatile June result in the year prior to the service change; and ii) the lower values in 2009, which most likely reflect the increase in control route patronage from mid-2008 onwards.

We believe that the 'true' medium-run elasticity would be around 0.55, compared with the long-run saturation value of 0.44.

Figure G.22 Patronage on service route and control route

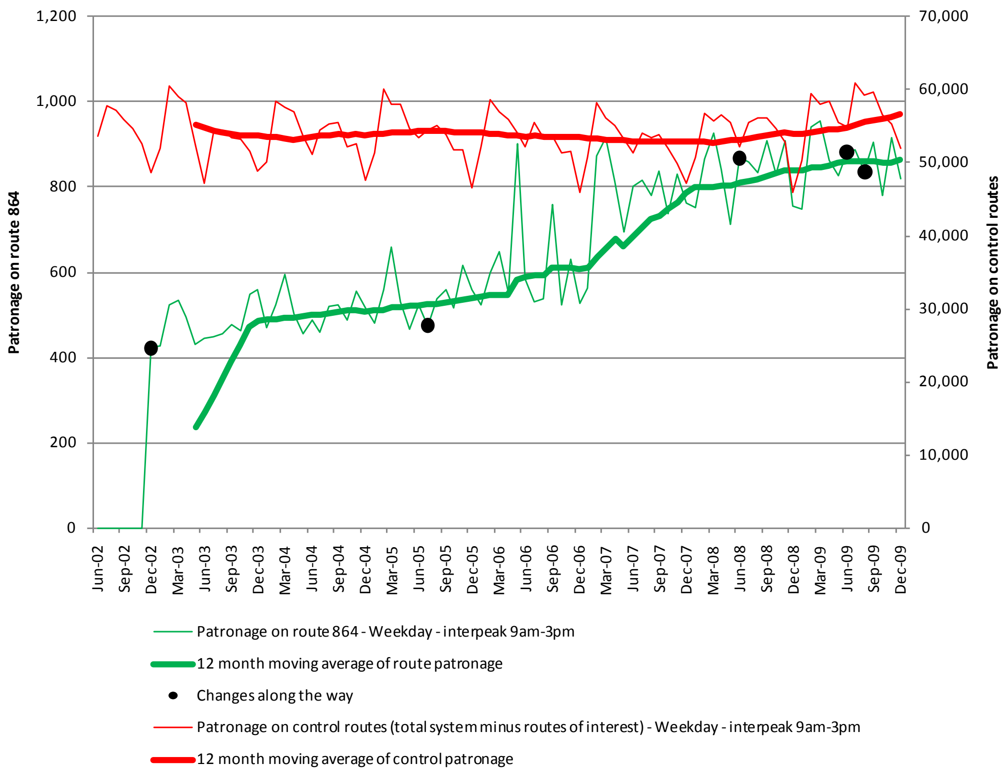


Figure G.23 Patronage changes (year-on-year) on service route and control routes

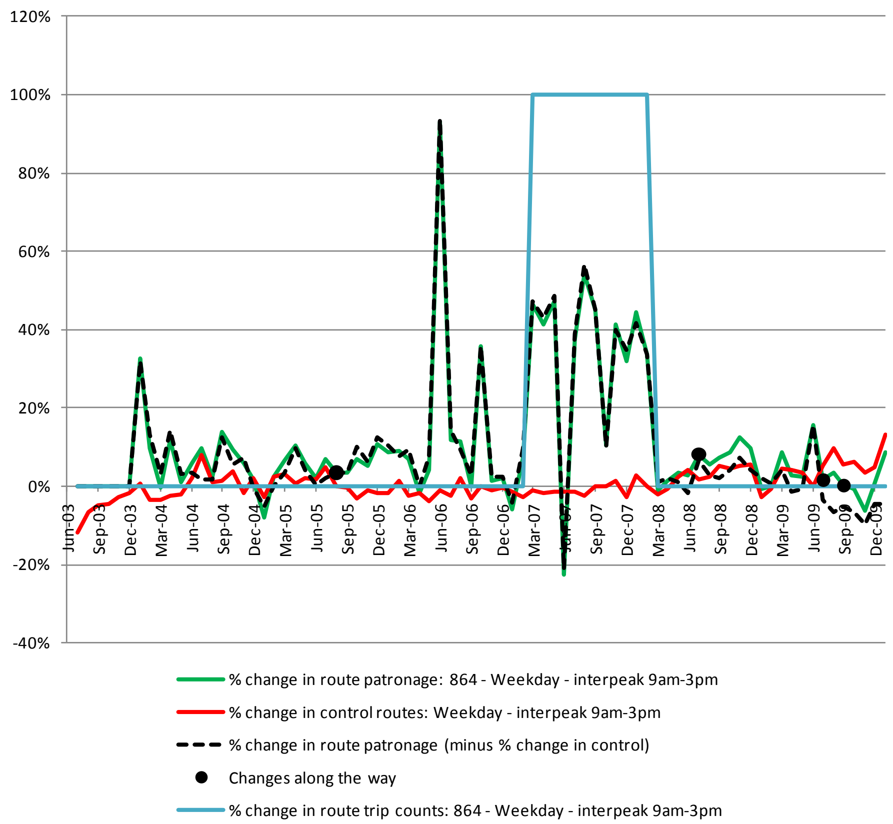


Figure G.24 Monthly/quarterly elasticity estimates and saturation curve

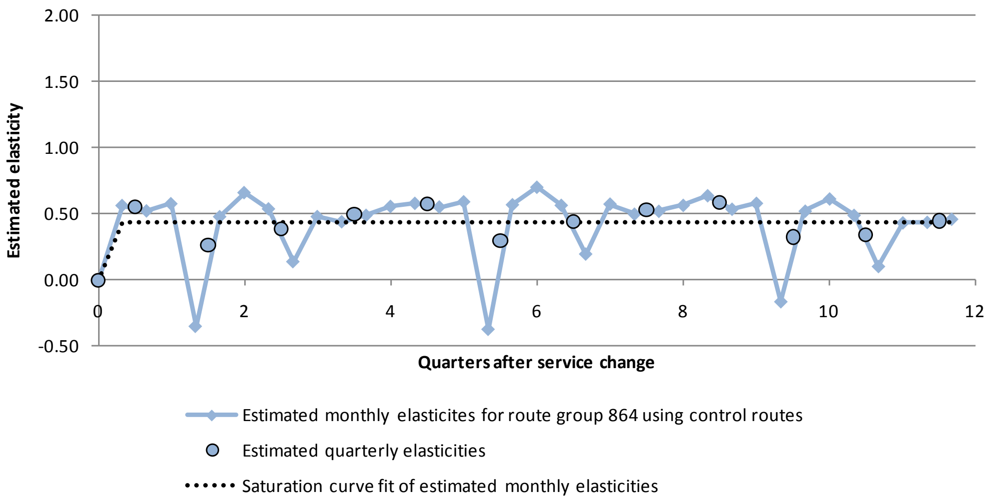


Table G.17 Quarterly elasticity estimates

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Feb-07					0.00	0.00
Q1	May-07	867	56,436	1.45	0.99	0.55	0.44
Q2	Aug-07	772	52,920	1.23	0.98	0.26	0.44
Q3	Nov-07	785	53,027	1.32	1.00	0.39	0.44
Q4	Feb-08	780	49,283	1.40	0.99	0.50	0.44
Q5	May-08	877	56,301	1.47	0.98	0.57	0.44
Q6	Aug-08	814	54,375	1.30	1.01	0.30	0.44
Q7	Nov-08	858	55,655	1.45	1.05	0.45	0.44
Q8	Feb-09	805	49,626	1.44	1.00	0.53	0.44
Q9	May-09	918	58,563	1.54	1.02	0.58	0.44
Q10	Aug-09	866	57,110	1.37	1.06	0.32	0.44
Q11	Nov-09	839	58,449	1.41	1.11	0.34	0.44
Q12	#DIV/0!	868	53,636	1.51	1.10	0.45	0.44
Long Run							0.44

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

G3.9 Summary of weekday interpeak results

The weekday interpeak analyses reported in this section cover the impacts of eight sets of service changes. The elasticity estimates derived are summarised in table G.18. This gives quarterly elasticity values for the first 12 months, then annual average values thereafter. Values are given for both the actual best estimates and the saturation curve estimates.

The Q4 mean elasticity values for the eight service changes are:

- actual Q4 elasticity estimates: average 0.38, range 0.26 to 0.60
- Q4 saturation curve estimates: average 0.47, range 0.35 to 0.61 (however, the table G.18 comments note that the saturation curve elasticity estimates are considered not reliable in some cases.)

Further discussion of the findings is given in section 6 and in the main report, section 4.7 and chapter 5.

Table G.18 Results summary – weekday interpeak (0900–1500) period

Route/s	Date of service change	Initial freq. per hr	% freq. incr		Q1	Q2	Q3	Q4	Q5-Q8 (2nd yr)	Q9-Q12 (3rd yr)	Q13-Q16 (4th yr)	Long run	Comment
113	26 January 2004	1	100%	Estimated elasticities:	0.45	0.44	0.56	0.60	0.63	0.72	#N/A		OK.
				Saturation curve fit:	0.33	0.50	0.58	0.61	0.66	0.69	0.71	0.75	
122–125	27 January 2003	4	50%	Estimated elasticities:	0.40	0.65	0.55	0.42	0.59	#N/A	#N/A		OK. The saturation curve value (0.58) gives the best representation of Q4 elasticity.
				Saturation curve fit:	0.42	0.54	0.57	0.58	0.60	0.61	0.62	0.63	
140-142	27 January 2003	2	100%	Estimated elasticities:	0.20	0.38	0.32	0.27	0.40	0.48	0.57		OK. The saturation curve value (0.37) gives the best representation of Q4 elasticity
				Saturation curve fit:	0.13	0.25	0.32	0.37	0.44	0.50	0.53	0.63	
143	27 January 2003	1	100%	Estimated elasticities:	0.26	0.45	0.31	0.34	0.46	0.58	0.59		OK. The saturation curve value (0.45) gives the best representation of Q4 elasticity
				Saturation curve fit:	0.18	0.33	0.40	0.45	0.51	0.55	0.57	0.64	
178	14 January 2008	2	100%	Estimated elasticities:	0.51	0.50	0.37	0.35	0.27	#DIV/0!	#DIV/0!		Results beyond Q2 not reliable because of increased service levels (July 2008) on control routes. 'True' elasticity by Q4 looks to be around 0.55. Not used for RU profile.
				Saturation curve fit:	0.35	0.35	0.35	0.35	0.35	#DIV/0!	#DIV/0!	0.35	
203 (200)	16 October 2006	3	33%	Estimated elasticities:	0.31	0.36	0.27	0.30	0.02	#N/A	#N/A		Saturation curve unreliable. 'True' elasticity by Q4 looks to be around 0.35.
				Saturation curve fit:	0.16	0.16	0.16	0.16	0.16	0.16	#DIV/0!	0.16	Not used for RU profile.

Route/s	Date of service change	Initial freq. per hr	% freq. incr		Q1	Q2	Q3	Q4	Q5-Q8 (2nd yr)	Q9-Q12 (3rd yr)	Q13-Q16 (4th yr)	Long run	Comment
263	16 October 2006	1.33	50%	Estimated elasticities:	0.13	0.34	0.35	0.26	0.28	0.29	#DIV/0!		'True' elasticity by Q4 looks to be around 0.35, rising to around 0.4 in Y2. Saturation curve unreliable: saturation value unrealistically low – appears should be around 0.45 - 0.50. Not used for RU profile.
				Saturation curve fit:	0.20	0.26	0.27	0.28	0.29	0.29	#DIV/0!	0.30	
864	26 February 2007	1	100%	Estimated elasticities:	0.55	0.26	0.39	0.50	0.46	0.42	#DIV/0!		Volatile data in before period. Saturation curve unreliable – 'true' value appears to be around 0.6. Elasticity levels for Q6 onwards affected by increased service levels on control routes. Not used for RU profile.
				Saturation curve fit:	0.44	0.44	0.44	0.44	0.44	0.44	#DIV/0!	0.44	

G4 Weekday evening analyses

G4.1 Route 172

G4.1.1 Service change

The service change in October 2006 resulted in a doubling of service frequency on this route, from one trip per hour to two trips per hour (each direction).

Table G.19 Details of service change

Date of service change for route group 172 - Weekday - evenings 7pm-12am	Monday, 16 October 2006
Trips (per hour) before	1
Trips (per hour) afterwards	2
Ratio	2.00
Control route/s:	Total system minus routes of interest

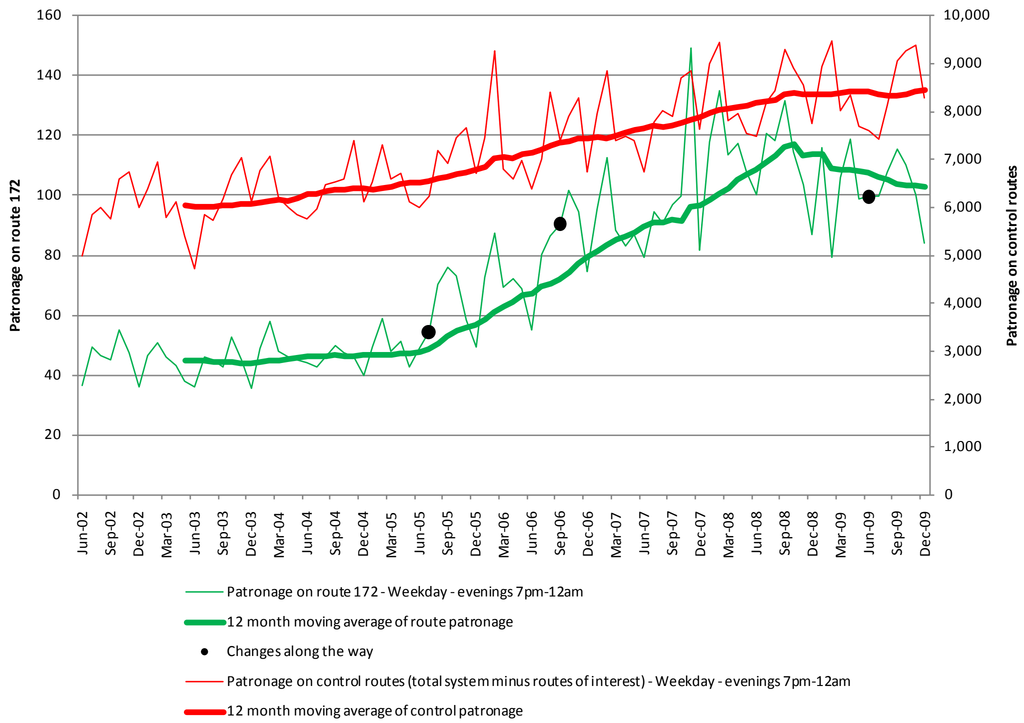
G4.1.2 Notes re data

In August 2005 additional peak period services were introduced. It appears from the patronage data that this peak service change had a strongly positive impact on evening (non-peak) patronage. This makes it difficult to assess the impact of the evening service change (October 2006) because some of the growth in the year following this change may well be due to the earlier peak period service change (August 2005). Therefore, any elasticities derived for the evening service change may well be overestimated.

In October 2006, PTD noted that the 'Sunday detour to Carrick Hill [was] introduced on route 172 instead of 171'. This seems unlikely to have had any significant impact on the evening service patronage.

In July 2009, free travel was introduced (on all services) for seniors during interpeak and weekend periods. This may have had significant (but probably minor) effects on evening patronage, although it is unclear whether these would be positive or negative.

Figure G.25 Patronage on service route and control route



G4.1.3 Review and conclusions

Figure G.26 indicates a rather confused pattern of patronage changes from August 2005 onwards. As noted above, the route patronage appears to have grown strongly from that time, first apparently due to the increased peak period services (August 2005), and then for two years apparently due to the evening service increase (October 2006). From late 2008, the route patronage appears to go into decline, both in absolute terms and relative to the control routes.

Our best estimate quarterly elasticities resulting from the evening service increases (table G.20) average 0.30 for the first four quarters, 0.52 for the second year and then fall to 0.37 for the third year. The saturation curve with its long-run elasticity estimate of 0.40 appears to be unreliable, as it is affected by the anomalous pattern of quarterly elasticity values.

Our judgement would be that the average elasticity values for the first year (0.30) and second year (0.52) are reasonably realistic; on this basis, the appropriate Q4 estimate would be around 0.40. The appropriate long-run elasticity would be around 0.6. However, we note that these estimates are not very robust, given the data issues.

Figure G.26 Patronage changes (year-on-year) on service route and control routes

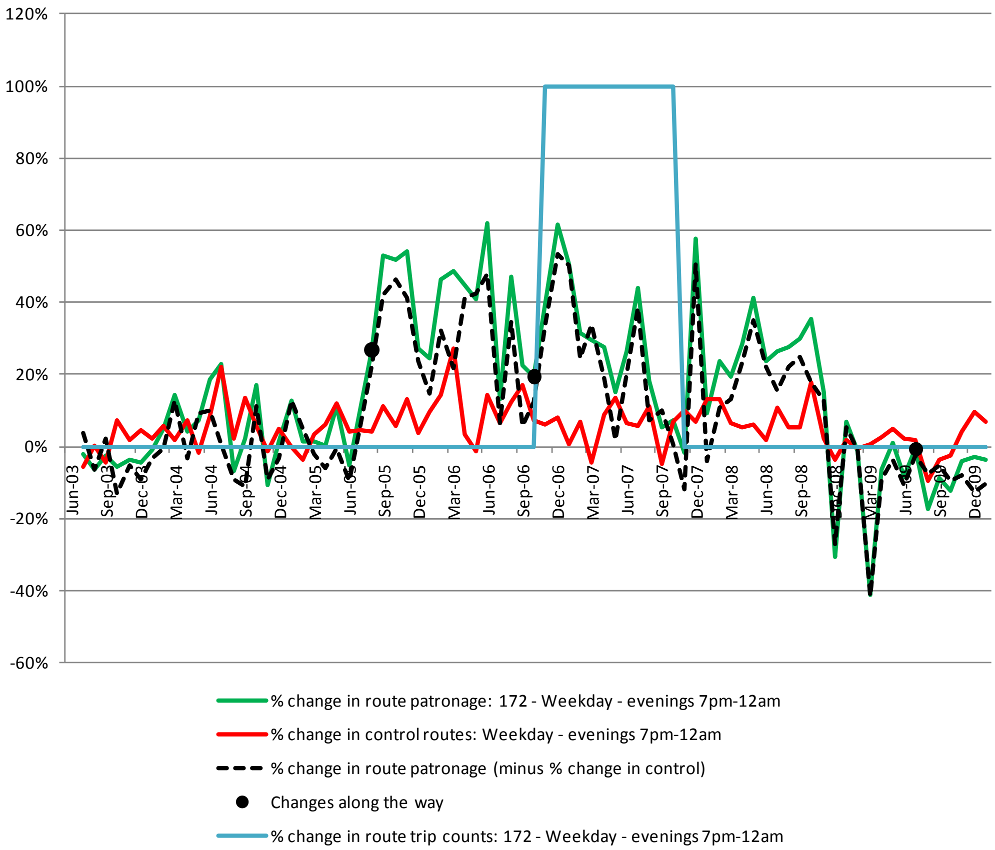


Figure G.27 Monthly/quarterly elasticity estimates and saturation curve

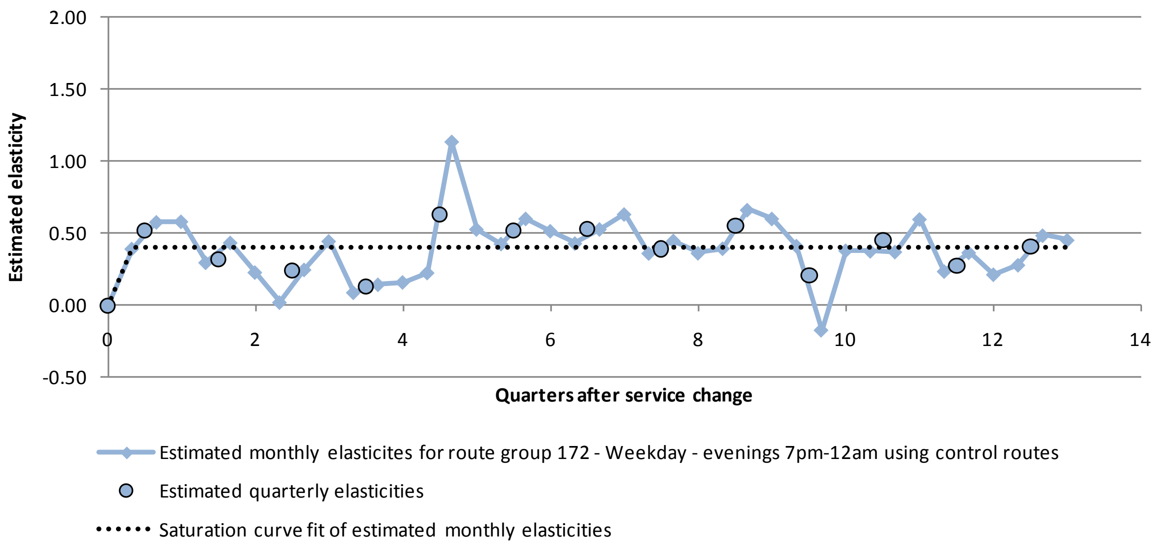


Table G.20 Quarterly elasticity estimates

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Oct-06					0.00	0.00
Q1	Jan-07	90	7,642	1.51	1.05	0.52	0.40
Q2	Apr-07	99	8,073	1.29	1.04	0.32	0.40
Q3	Jul-07	83	7,209	1.28	1.08	0.24	0.40
Q4	Oct-07	94	7,900	1.17	1.07	0.13	0.40
Q5	Jan-08	110	8,393	1.85	1.15	0.63	0.40
Q6	Apr-08	122	8,737	1.60	1.12	0.52	0.40
Q7	Jul-08	108	7,647	1.67	1.15	0.53	0.40
Q8	Oct-08	123	8,647	1.54	1.17	0.39	0.40
Q9	Jan-09	102	8,398	1.70	1.16	0.55	0.40
Q10	Apr-09	100	8,806	1.35	1.13	0.21	0.40
Q11	Jul-09	106	7,873	1.62	1.19	0.45	0.40
Q12	Oct-09	108	8,197	1.34	1.11	0.27	0.40
Q13	Jan-10	98	8,968	1.64	1.23	0.41	0.40
Long Run							0.40

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

G4.2 Route 203 (200)

G4.2.1 Service change

The service change in October 2006 resulted in a doubling of evening service frequencies, from one trip per hour to two trips per hour (each direction).

Table G.21 Details of service change

Date of service change for route group 203 (200) - Weekday - evenings 7pm-12am	Monday, 16 October 2006
Trips (per hour) before	1
Trips (per hour) afterwards	2
Ratio	2.00
Control route/s:	Total system minus routes of interest

G4.2.2 Notes re data

In July 2009, one additional service in the PM peak and free travel for seniors during interpeak and weekends were introduced.

In September 2009, approximately one-third of trips during the day, on weekdays, were replaced by route 202. Therefore, data from September 2009 onwards has been excluded from the elasticity estimates below.

Figure G.28 Patronage on service route and control route

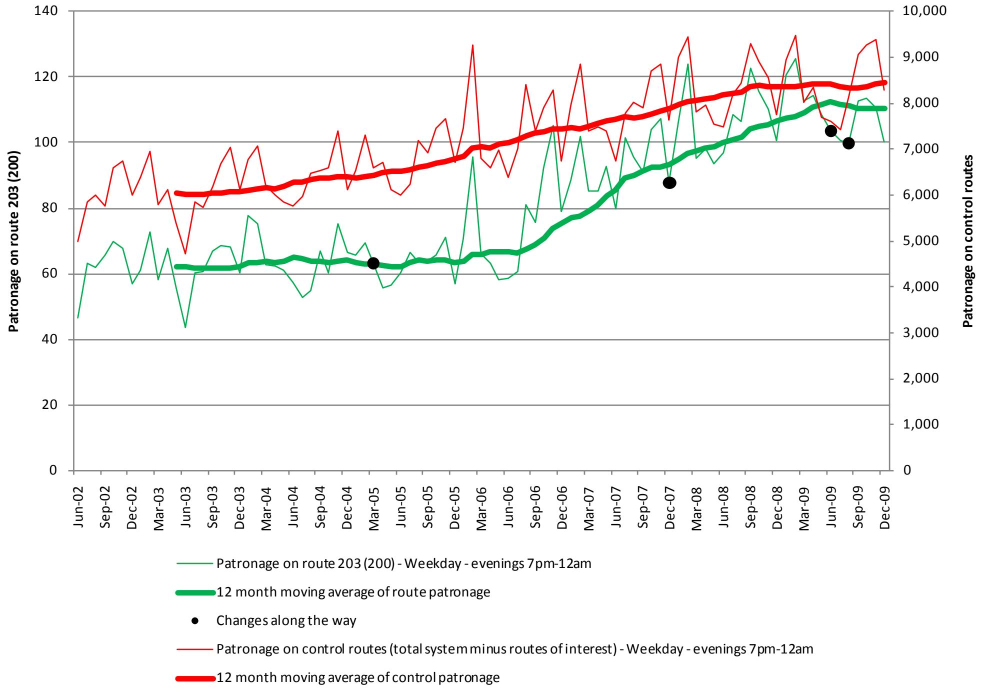
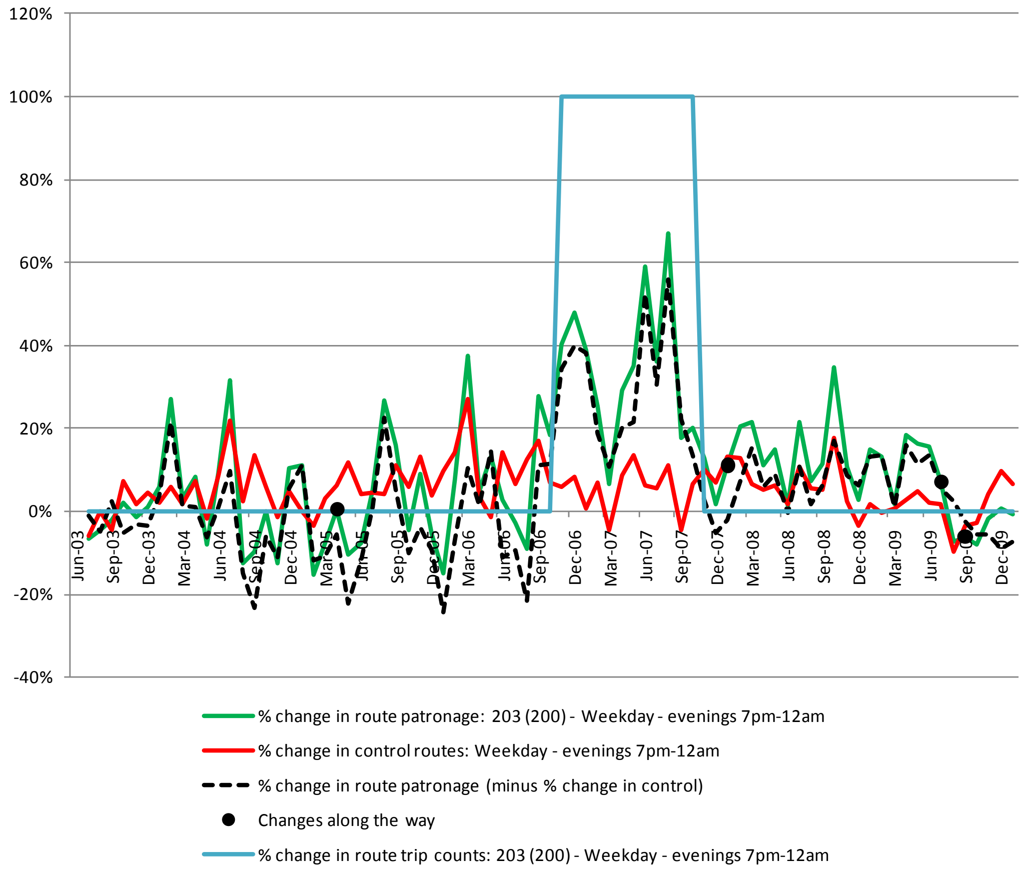


Figure G.29 Patronage changes (year-on-year) on service route and control routes



G4.2.3 Review and conclusions

Figure G.29 indicates considerable volatility in monthly patronage changes prior to the service change, and then continuing after the change. The quarterly elasticity estimates (figure G.30 and table G.22) are therefore somewhat erratic, although a reasonable time series and saturation curve results.

Our best estimate quarterly elasticities average 0.36 for the first four quarters, 0.43 for the second year and 0.55 for the third year. Given the pattern of the results, we would accept the Q4 actual elasticity of 0.40 and the saturation elasticity of 0.51 as reasonable best estimates.

Figure G.30 Monthly/quarterly elasticity estimates and saturation curve

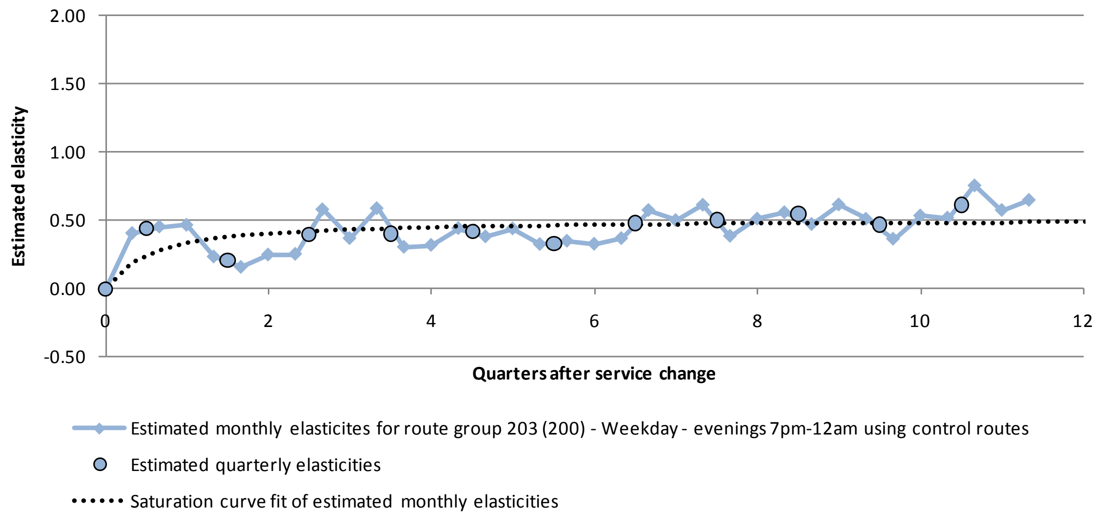


Table G.22 Quarterly elasticity estimates

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Oct-06					0.00	0.00
Q1	Jan-07	92	7,642	1.42	1.05	0.44	0.27
Q2	Apr-07	92	8,073	1.20	1.04	0.21	0.38
Q3	Jul-07	86	7,209	1.43	1.08	0.40	0.42
Q4	Oct-07	96	7,900	1.42	1.07	0.40	0.45
Q5	Jan-08	100	8,393	1.54	1.15	0.42	0.46
Q6	Apr-08	108	8,737	1.41	1.12	0.33	0.47
Q7	Jul-08	96	7,647	1.61	1.15	0.48	0.47
Q8	Oct-08	112	8,647	1.67	1.17	0.50	0.48
Q9	Jan-09	109	8,398	1.69	1.16	0.55	0.48
Q10	Apr-09	120	8,806	1.57	1.13	0.47	0.48
Q11	Jul-09	109	7,873	1.81	1.19	0.62	0.49
Long Run							0.51

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

G4.3 Route 682

G4.3.1 Service change

The service change in August 2005 involved a **reduction** in service levels, from two trips per hour to one trip per hour (each direction).

Table G.23 Details of service change

Date of service change for route group 682 - Weekday - evenings 7pm-12am	Monday, 22 August 2005
Trips (per hour) before	2
Trips (per hour) afterwards	1
Ratio	0.50
Control route/s:	Total system minus routes of interest

G4.3.2 Notes re data

In September 2009, the route changed around Hallet Cove Shopping Centre and frequency improved during the day. Major changes were made to other services in the area. Therefore, we have excluded data from September 2009 onwards from the estimation of elasticities.

G4.3.3 Review and conclusions

Figures G.31 and G.32 indicate considerable volatility in the route patronage both before and after the service change. Patronage on the route appears to have continued to decline throughout the four years after the service change, while patronage on the control routes continued to increase. The result was that the elasticity estimates continued to increase throughout this four-year period, although with considerable quarterly variability.

Our best estimate quarterly elasticities resulting from the service reduction (table G.24) average 0.61 for the first four quarters, 0.77 for the second year, 0.98 for the third year and 1.04 for the fourth year. This suggests that the best estimate Q4 (smoothed) elasticity should be around 0.70 (rather than the estimate of 0.48), and that the saturation elasticity should be around 1.10 (rather than 1.00).

Figure G.31 Patronage on service route and control route

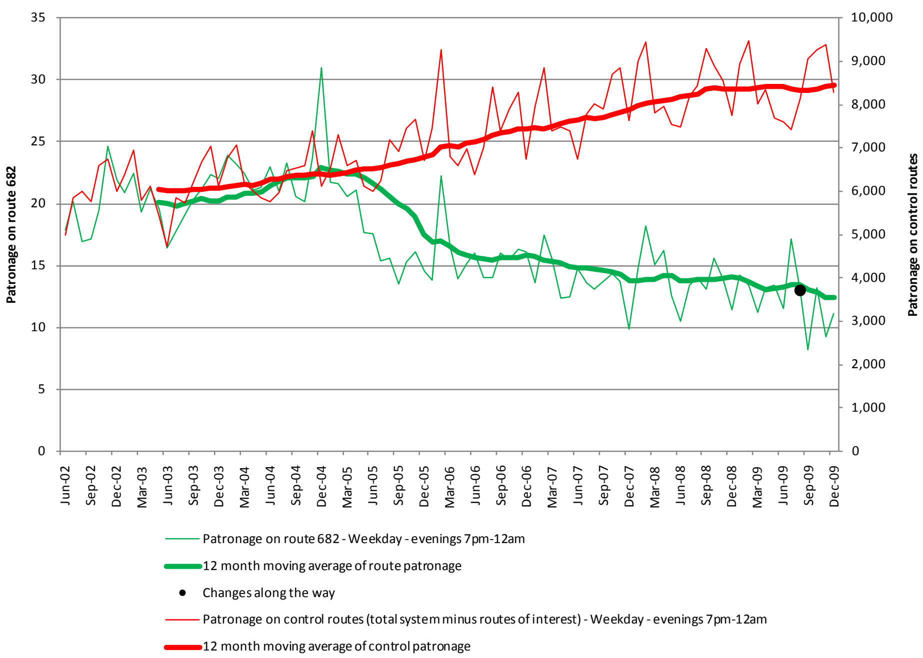


Figure G.32 Patronage changes (year-on-year) on service route and control routes

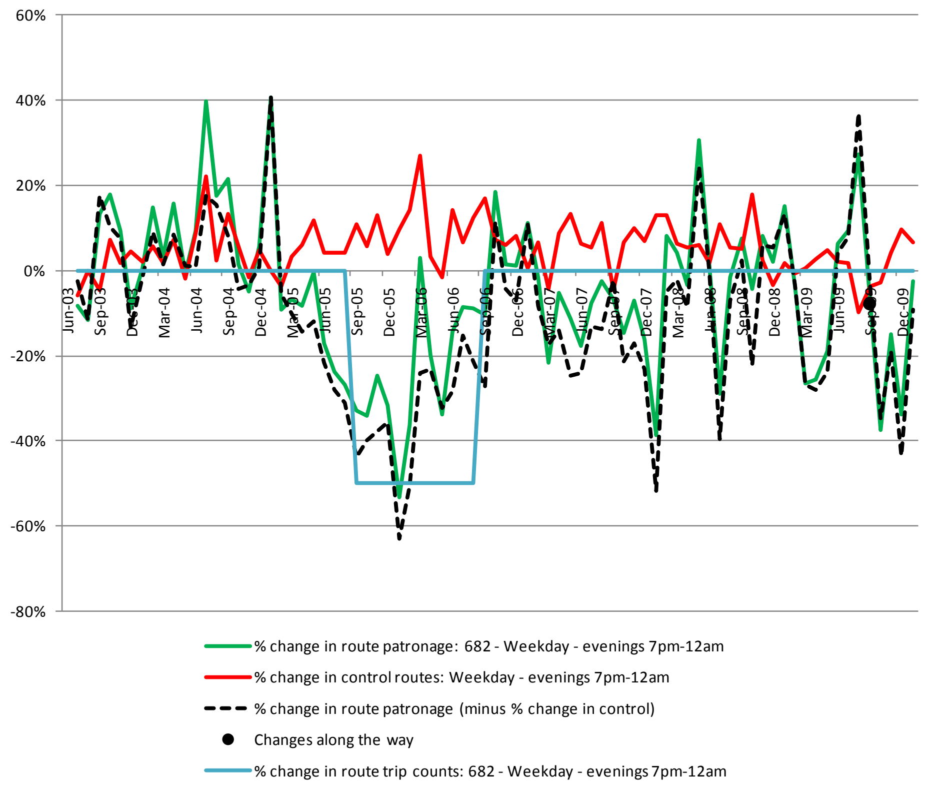


Figure G.33 Monthly/quarterly elasticity estimates and saturation curve

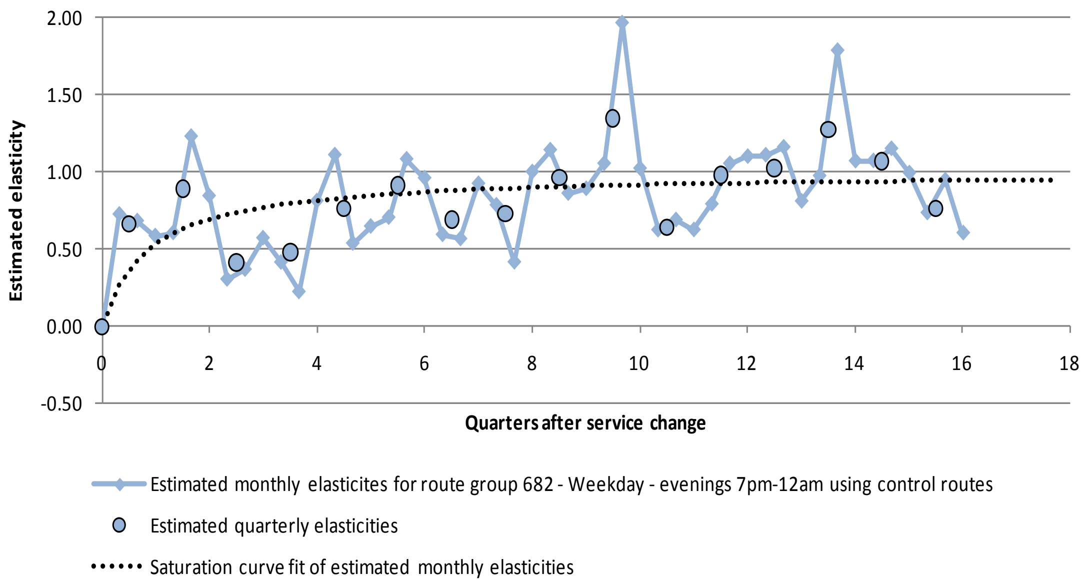


Table G.24 Quarterly elasticity estimates

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Aug-05					0.00	0.00
Q1	Nov-05	15	7,187	0.70	1.10	0.66	0.41
Q2	Feb-06	15	7,271	0.60	1.09	0.89	0.65
Q3	May-06	18	7,560	0.83	1.10	0.41	0.75
Q4	Aug-06	15	6,786	0.81	1.13	0.48	0.80
Q5	Nov-06	15	7,903	0.72	1.21	0.76	0.84
Q6	Feb-07	15	7,660	0.61	1.15	0.91	0.86
Q7	May-07	15	7,918	0.72	1.15	0.69	0.88
Q8	Aug-07	14	7,309	0.73	1.21	0.73	0.90
Q9	Nov-07	14	8,202	0.65	1.25	0.96	0.91
Q10	Feb-08	13	8,489	0.53	1.27	1.35	0.91
Q11	May-08	16	8,392	0.78	1.22	0.64	0.92
Q12	Aug-08	12	7,735	0.65	1.28	0.98	0.93
Q13	Nov-08	14	8,876	0.67	1.36	1.03	0.93
Q14	Feb-09	13	8,411	0.54	1.27	1.28	0.94
Q15	May-09	13	8,606	0.60	1.25	1.07	0.94
Q16	Aug-09	14	7,566	0.74	1.26	0.76	0.95
Long Run							1.00

Note: The ratio of route trips after the service change compared to prior to the service change was 0.50

G4.4 Summary of weekday evening results

The results for the weekday evening elasticity analyses are summarised in table G.25. Of the three service changes analysed, two involved a doubling of frequencies (from one to two trips per hour), the other a halving of frequencies (from two to one trip per hour).

The robustness and interpretation of the results is affected in at least two of these three cases by data volatility problems. The Q4 actual elasticity estimates for the three cases are 0.13, 0.40 and 0.48 (average 0.34). However, 'smoothing' two of the three cases to compensate for data volatility, we get Q4 estimates of 0.45, 0.40 and 0.70 (average 0.52).

Similarly, the long-run saturation estimates from the analyses are 0.40, 0.51 and 1.00 (average 0.64). 'Smoothing' two of the three cases, we get estimates of 0.60, 0.51 and 1.10 (average 0.74).

Further discussion of the findings is given in section G.6 and the main report, section 4.7 and chapter 5.

Table G.25 Results summary – weekday evenings (1900–2400)

Route/s	Date of service change	Initial freq. per hr	% freq. increase		Q1	Q2	Q3	Q4	Q5-Q8 (2nd yr)	Q9-Q12 (3rd yr)	Q13-Q16 (4th yr)	Long run	Comment
172	16 October 2006	1	100%	Estimated elasticities:	0.52	0.32	0.24	0.13	0.52	0.37	#DIV/0!		Quarterly elasticity estimates unreliable, because of data volatility: more appropriate Q4 estimate is around 0.40. Saturation curve unreliable – 'true' long-run elasticity appears to be around 0.6.
				Saturation curve fit:	0.40	0.40	0.40	0.40	0.40	0.40	#DIV/0!	0.40	
203 (200)	16 October 2006	1	100%	Estimated elasticities:	0.44	0.21	0.40	0.40	0.43	#N/A	#N/A		OK
				Saturation curve fit:	0.27	0.38	0.42	0.45	0.47	0.48	#DIV/0!	0.51	
682	22 August 2005	2	-50%	Estimated elasticities:	0.66	0.89	0.41	0.48	0.78	0.98	1.03		Quarterly elasticity estimates unreliable, because of data volatility: more appropriate Q4 estimate is around 0.70. Saturation curve also somewhat unreliable – 'true' long-run elasticity appears to be around 1.10.
				Saturation curve fit:	0.41	0.65	0.75	0.80	0.87	0.92	0.94	1.00	

G5 Saturday and Sunday analyses

G5.1 Route 155 (Saturday)

G5.1.1 Service change

Two Saturday service changes were analysed for this route – an increase from one to two trips per hour (each direction) in February 2003, and a reduction back to one trip per hour in August 2005.

Table G.26 Details of service change

Date of service change for route group 155 - Saturday	Saturday, 1 February 2003	Saturday, 27 August 2005
Trips (per hour) before	1	2
Trips (per hour) afterwards	2	1
Ratio	2.00	0.50
Control route/s:	Total system minus routes of interest	Total system minus routes of interest

G5.1.2 Notes re data

In January 2008, this route changed: the service was replaced by route 157 through the day, with the first and last services operated as route 155. Therefore data from January 2008 onwards was excluded.

We note that patronage on route 155 fell a lot in December 2004, and spiked in August 2006. However, similar patterns were also observed on the control routes so we attributed this to seasonal and/or other factors that affected both the route of interest and the control routes in a similar manner.

Patronage data was only available from July 2002 onwards, while the service increase was in February 2003. Therefore, patronage (on both the route of interest and the control routes) had to be back-casted to create a series from January 2002 onwards. To do this we used a regression model to estimate the seasonal patterns and time trends observed from February 2004 to July 2005 and used these to generate back-casts prior to July 2002.

Figure G.34 Patronage on service route and control route

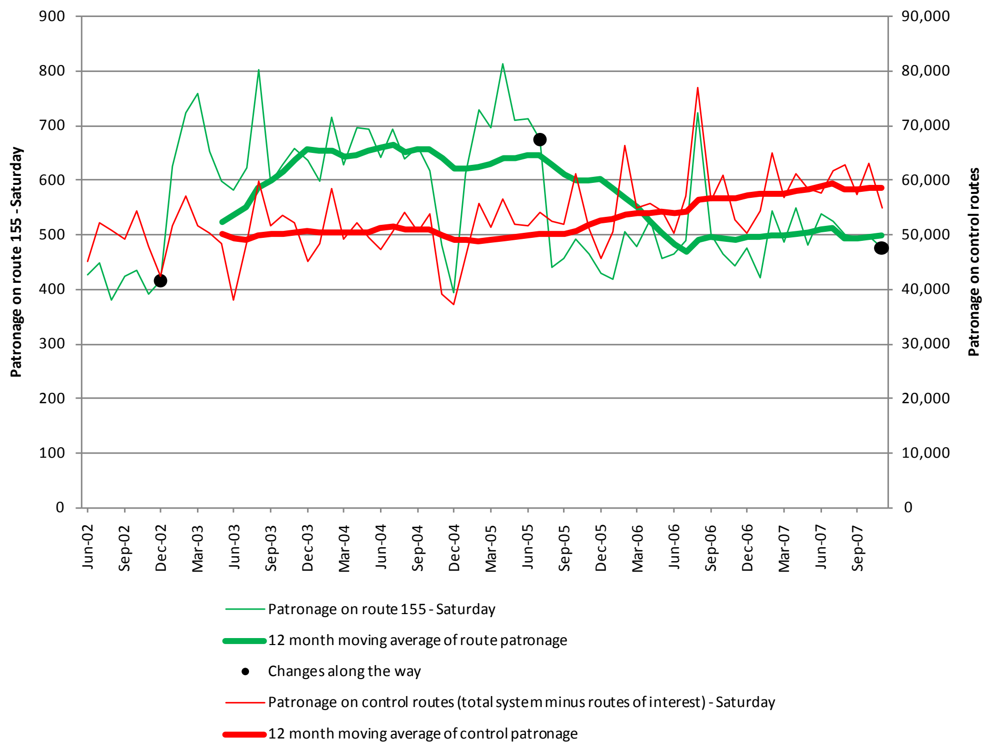
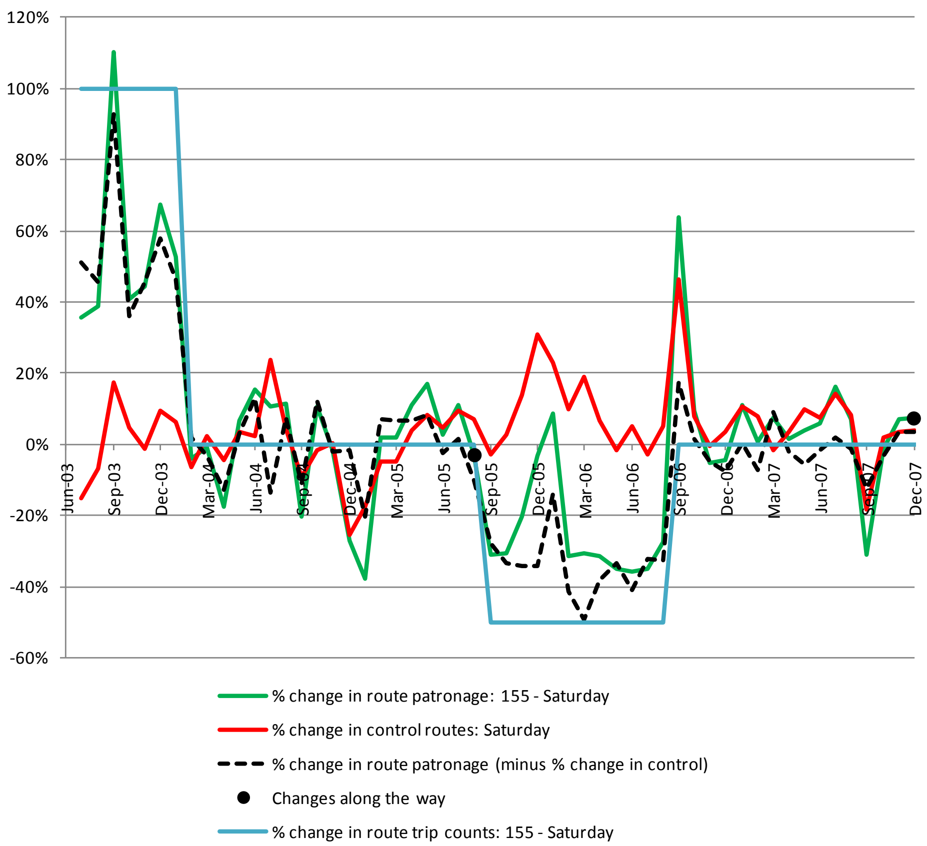


Figure G.35 Patronage changes (year-on-year) on service route and control routes



G5.1.3 Review and conclusions – service increase

Figure G.36/table G.27 indicates a substantial patronage response in the first 12 months after the service increase, with little further response in the 18 months thereafter. The average elasticity calculated for the first four quarters is 0.67, with that for the following four quarters being 0.63. This indicates that the actual Q4 estimate of 0.82 is on the high side: a more representative estimate would be 0.65.

The saturation curve indicates a horizontal line throughout, with a value of 0.65 (figure G.36). This appears improbable.

Figure G.36 Monthly/quarterly elasticity estimates and saturation curve – first service change (increase)

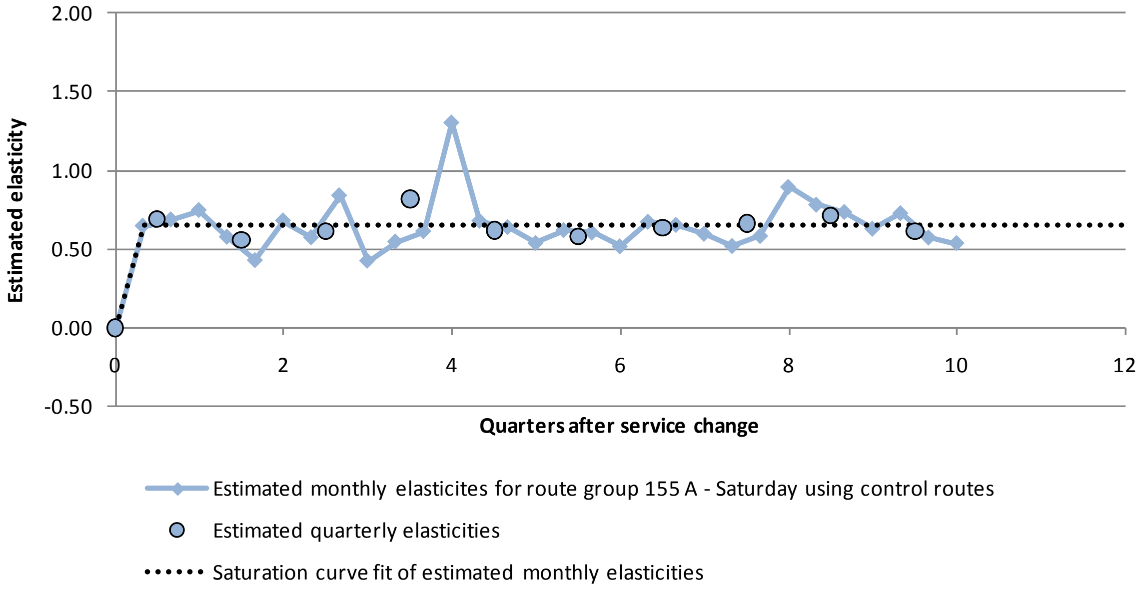


Table G.27 Quarterly elasticity estimates – first service change (increase)

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Jan-03					0.00	0.00
Q1	Apr-03	703	53,437	1.67	1.03	0.69	0.65
Q2	Jul-03	611	45,671	1.45	0.99	0.56	0.65
Q3	Oct-03	674	53,312	1.63	1.05	0.61	0.65
Q4	Jan-04	641	50,332	1.95	1.06	0.82	0.65
Q5	Apr-04	648	52,065	1.54	1.00	0.62	0.65
Q6	Jul-04	677	49,658	1.61	1.07	0.58	0.65
Q7	Oct-04	665	51,873	1.59	1.02	0.64	0.65
Q8	Jan-05	498	43,324	1.45	0.91	0.66	0.65
Q9	Apr-05	679	51,019	1.61	0.98	0.71	0.65
Q10	Jul-05	745	53,392	1.77	1.15	0.61	0.65
Long Run							0.65

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

G5.1.4 Review and conclusions – service decrease

As for the service increase, figure G.37/table G.28 indicates a substantial patronage decrease in the first 12 months after the service decrease, with little further response in the following year. The average elasticity calculated for the first four quarters is 0.57, with that for the following four quarters being 0.58. The long-run saturation elasticity estimate is 0.59, consistent with there being minimal further patronage impacts beyond the first year.

These figures suggest that the actual Q4 elasticity estimate of 0.65 is on the high side, and that a more representative estimate would be about 0.58.

Figure G.37 Monthly/quarterly elasticity estimates and saturation curve – second service change (decrease)

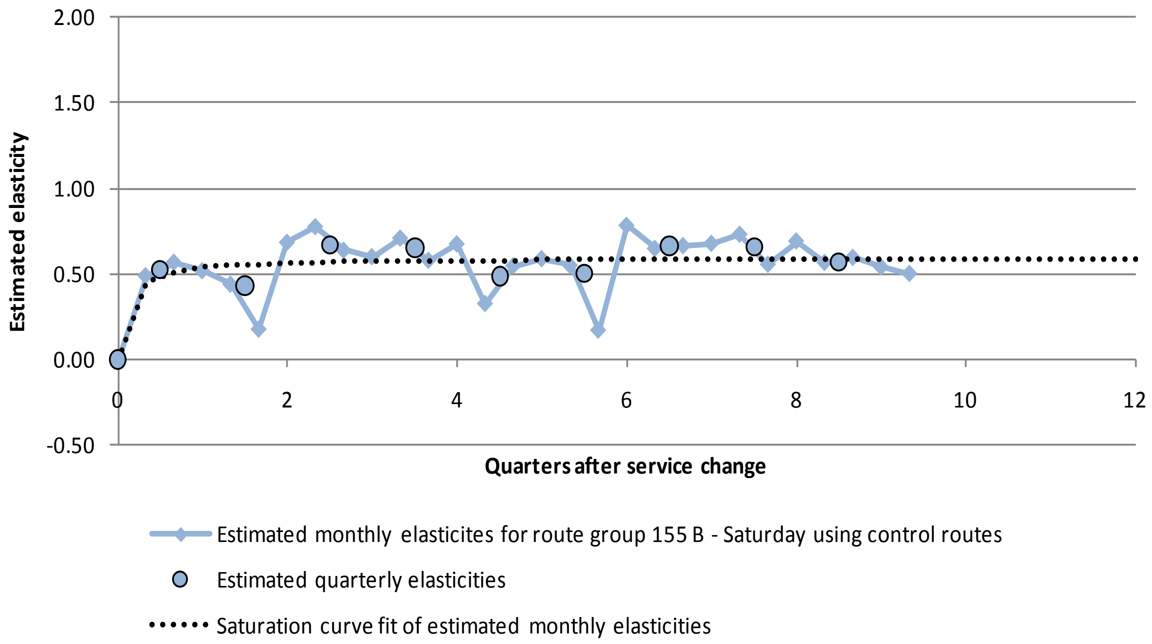


Table G.28 Quarterly elasticity estimates – second service change (decrease)

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Aug-05					0.00	0.00
Q1	Nov-05	463	55,287	0.73	1.04	0.52	0.50
Q2	Feb-06	438	49,107	0.91	1.21	0.43	0.56
Q3	May-06	504	58,924	0.68	1.08	0.67	0.57
Q4	Aug-06	470	53,940	0.67	1.05	0.65	0.58
Q5	Nov-06	564	64,757	0.88	1.22	0.49	0.58
Q6	Feb-07	447	52,600	0.94	1.30	0.50	0.58
Q7	May-07	526	61,016	0.71	1.12	0.66	0.59
Q8	Aug-07	515	59,258	0.73	1.15	0.66	0.59
Q9	Nov-07	498	61,111	0.78	1.15	0.57	0.59
Long Run							0.59

Note: The ratio of route trips after the service change compared to prior to the service change was 0.50

G5.2 Route 291 (Saturday)

G5.2.1 Service change

This service change in January 2009 involved a doubling of service frequencies, from one trip per hour to two trips per hour (each direction).

Table G.29 Details of service change

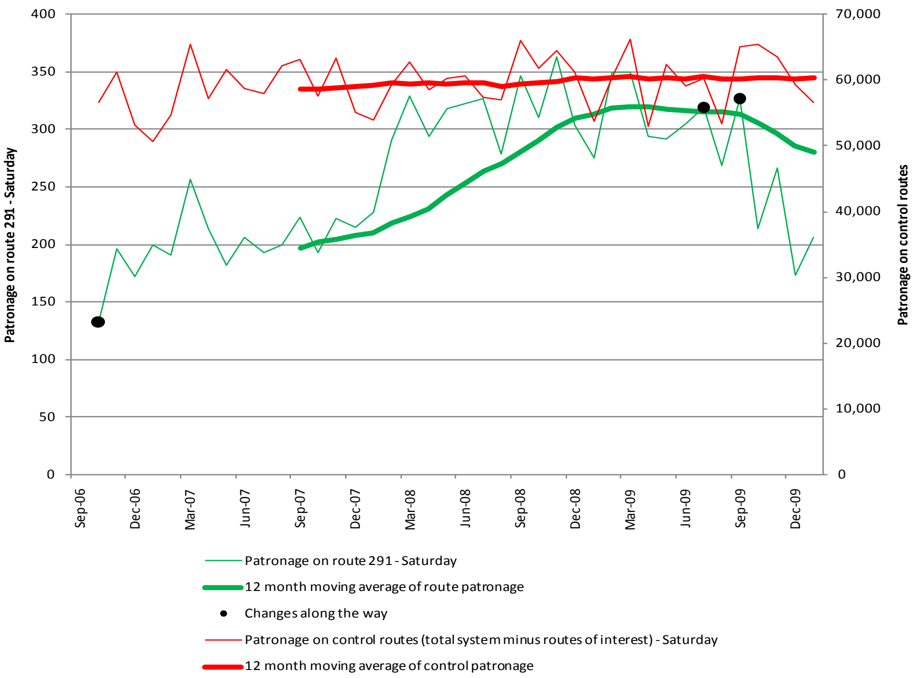
Date of service change for route group 291 - Saturday	Saturday, 19 January 2008
Trips (per hour) before	1
Trips (per hour) afterwards	2
Ratio	2.00
Control route/s:	Total system minus routes of interest

G5.2.2 Notes re data

This route was introduced in October 2006.

In September -2009, PTD advised that 'Route number changed to W90 or W91. Previously changed numbers upon reaching city and continued outwards, marketed now as one continuous route (with above number change)'. This may explain the fall in patronage from September 2009 onwards. On this basis, data from September 2009 onwards has been excluded from the estimation of elasticities below.

Figure G.38 Patronage on service route and control route



G5.2.3 Review and conclusions

Figure G.39 indicates a substantial patronage response in the first 12 months after the service increase, with little further response in the six to nine months thereafter (as noted above, no suitable data was available after September 2009).

The average elasticity calculated for the first four quarters was 0.56. This indicates that the actual Q4 estimate of 0.47 is on the low side: a more representative estimate would be about 0.59 (consistent with the Q4 saturation curve estimate). The saturation curve appears to be plausible (figure G.40).

Figure G.39 Patronage changes (year-on-year) on service route and control routes

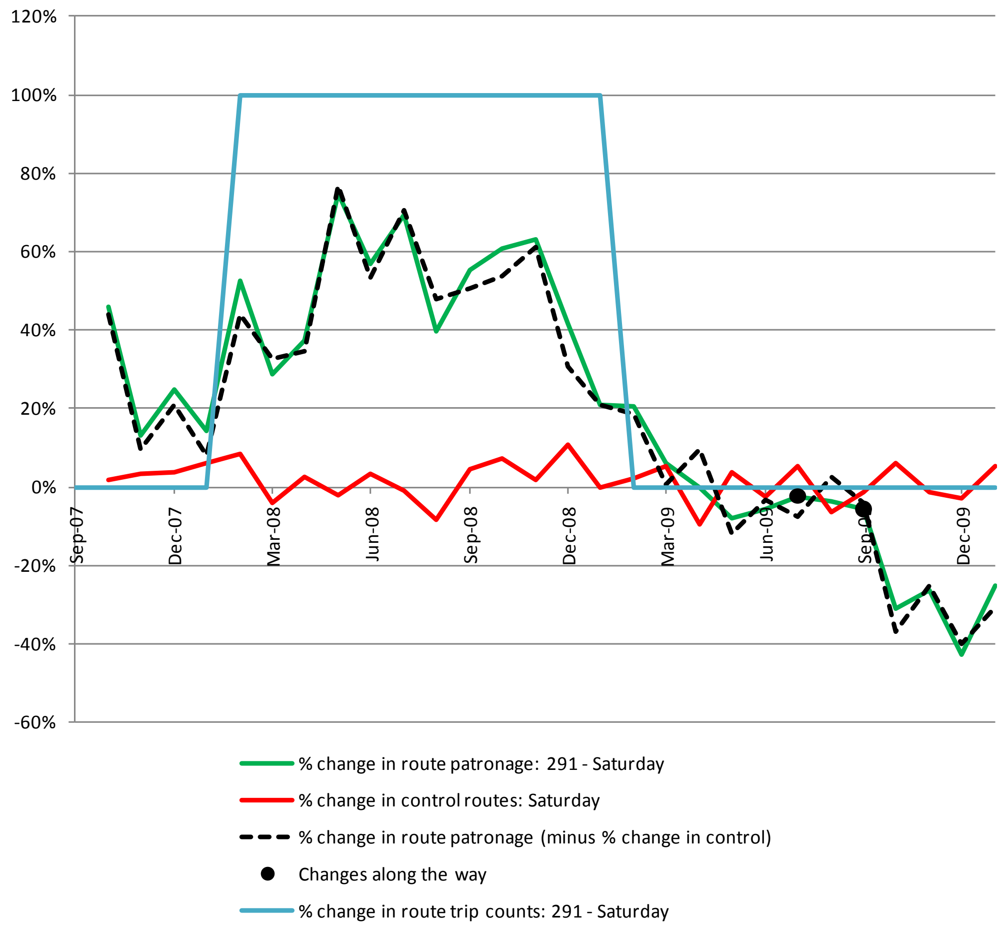


Figure G.40 Monthly/quarterly elasticity estimates and saturation curve

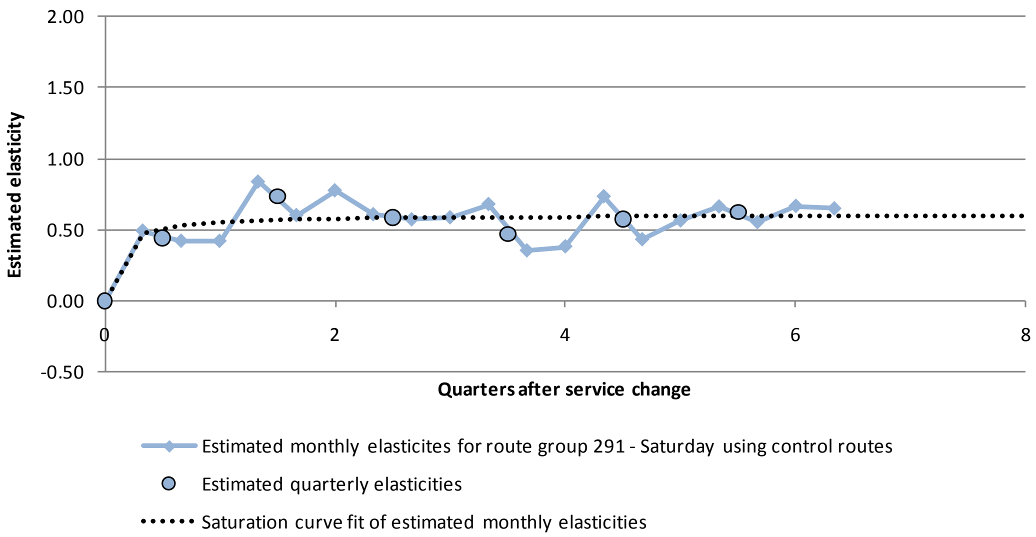


Table G.30 Quarterly elasticity estimates

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Jan-08					0.00	0.00
Q1	Apr-08	304	60,198	1.39	1.02	0.44	0.52
Q2	Jul-08	322	59,396	1.67	1.00	0.74	0.57
Q3	Oct-08	312	61,561	1.52	1.01	0.59	0.59
Q4	Jan-09	314	59,803	1.48	1.06	0.47	0.59
Q5	Apr-09	331	59,891	1.53	1.02	0.58	0.59
Q6	Jul-09	305	60,633	1.58	1.02	0.63	0.60
Long Run							0.61

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

G5.3 Route 167/168 (Sunday)

G5.3.1 Service change

This service change in August 2005 involved a doubling of service frequencies from one trip per hour to two trips per hour (each direction).

Table G.31 Details of service change

Date of service change for route group 167/168 - Sunday	Sunday, 21 August 2005
Trips (per hour) before	1
Trips (per hour) afterwards	2
Ratio	2.00
Control route/s:	Total system minus routes of interest

G5.3.2 Notes re data

We note that there is unusual behaviour in patronage on route 167/168 from about June 2009 onwards, with apparent patronage increases of around 20% (relative to the control routes). We could not identify the explanation for this behaviour but judged that it would be best to exclude data from June 2009 onwards.

Figure G.42 shows considerable volatility in monthly patronage changes on the route, both before and after the service change.

Figure G.41 Patronage on service route and control route

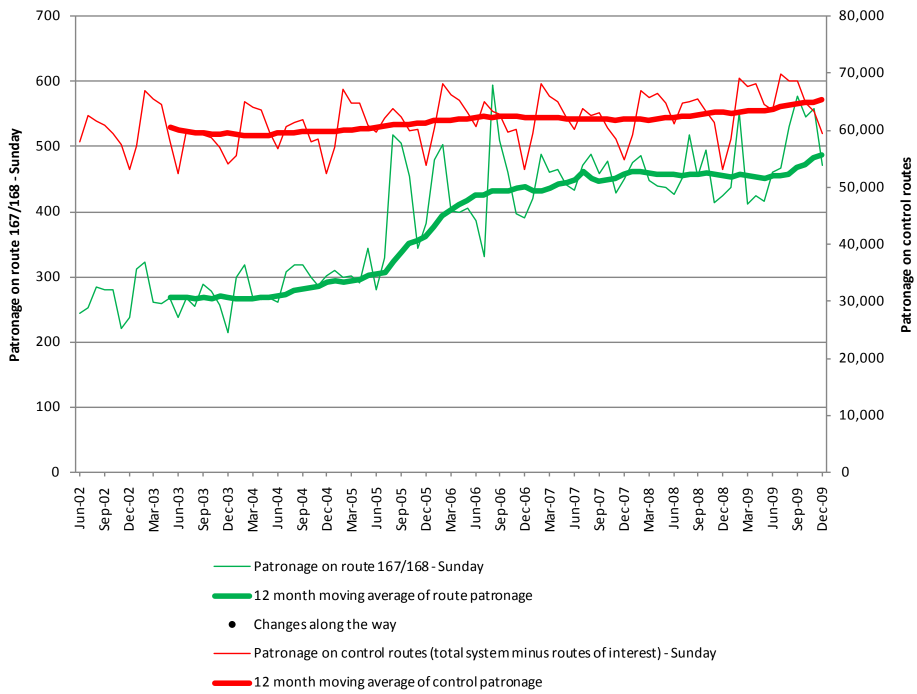
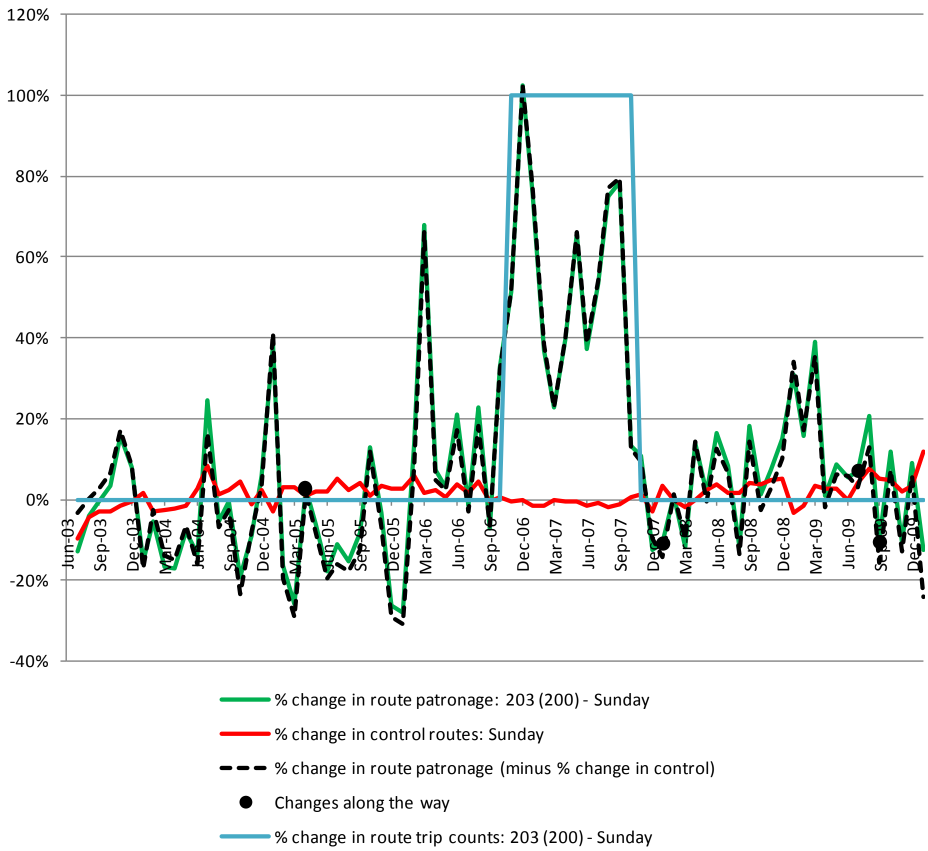


Figure G.42 Patronage changes (year-on-year) on service route and control routes



G5.3.3 Review and conclusions

Figure G.42 indicates a substantial patronage response in the first 12 months, but with substantial volatility (reflecting the apparent patronage volatility over the previous 12 months). After the first 12 months, there appears to be little further patronage response in the second year, but then some significant further increase in the third year (late 08/early 09): we would tend to discount this latter increase as the result of other (unknown) factors rather than the original service increase.

The average elasticity for the first 4 quarters is 0.65, with the same average for the following 4 quarters. On this basis, the Q4 estimate of 0.75 is on the high side: a more representative figure would be around 0.70 (recognising that the Q2 estimate of 0.42 may be too low, as it reflects the apparent high growth in patronage 12 months earlier).

The long-run saturation estimate of 0.70 appears on the low side (especially given the doubts regarding the Q2, Q6 etc estimates): a more reasonable estimate would be around 0.75.

Figure G.43 Monthly/quarterly elasticity estimates and saturation curve

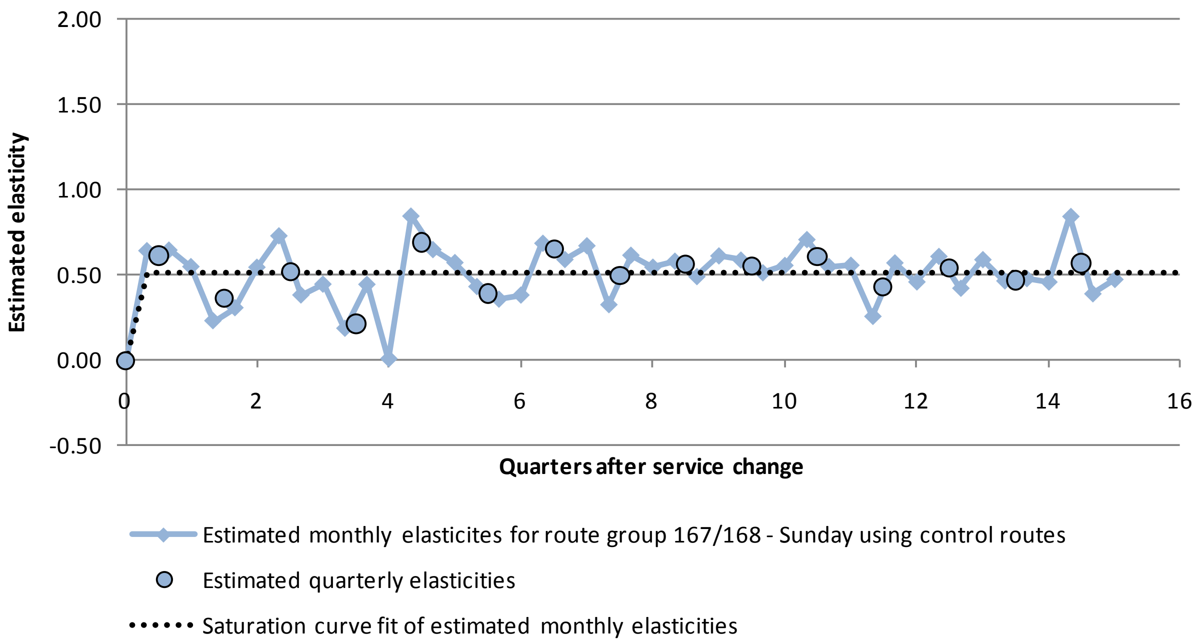


Table G.32 Quarterly elasticity estimates

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Aug-05					0.00	0.00
Q1	Nov-05	492	61,965	1.57	1.03	0.61	0.51
Q2	Feb-06	402	58,073	1.34	1.04	0.36	0.51
Q3	May-06	434	66,545	1.46	1.01	0.52	0.51
Q4	Aug-06	374	62,876	1.21	1.04	0.21	0.51
Q5	Nov-06	521	61,887	1.66	1.03	0.69	0.51
Q6	Feb-07	402	57,487	1.35	1.03	0.39	0.51
Q7	May-07	471	66,334	1.59	1.01	0.65	0.51
Q8	Aug-07	448	62,026	1.45	1.03	0.50	0.51
Q9	Nov-07	475	62,018	1.52	1.03	0.56	0.51
Q10	Feb-08	451	57,478	1.51	1.03	0.55	0.51
Q11	May-08	458	66,357	1.54	1.01	0.61	0.51
Q12	Aug-08	438	63,522	1.42	1.05	0.43	0.51
Q13	Nov-08	488	64,641	1.56	1.07	0.54	0.51
Q14	Feb-09	425	57,589	1.42	1.03	0.47	0.51
Q15	May-09	463	68,291	1.56	1.04	0.57	0.51
Long Run							0.51

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

G5.4 Route 171 (Sunday)

G5.4.1 Service change

This service change in January 2008 involved a doubling of service frequencies, from one trip per hour to two trips per hour (each direction).

Table G.33 Details of service change

Date of service change for route group 171 - Sunday	Sunday, 13 January 2008
Trips (per hour) before	1
Trips (per hour) afterwards	2
Ratio	2.00
Control route/s:	Total system minus routes of interest

G5.4.2 Notes re data

In October 2006, the route was extended a few kilometres to Mitcham Shopping Centre. In addition, the Sunday detour to Carrick Hill was replaced by 172 detouring instead. However, since the service change did not occur until January 2008, this would not have affected the accuracy of the elasticities estimated below.

Figure G.45 indicates quite substantial monthly variability in patronage on the route, with an apparent fall in patronage (in absolute terms and relative to the control routes) in the 12 months prior to the service increase: to the extent this may be an aberration, it may mean that any elasticity estimates are overstated.

Figure G.44 Patronage on service route and control route

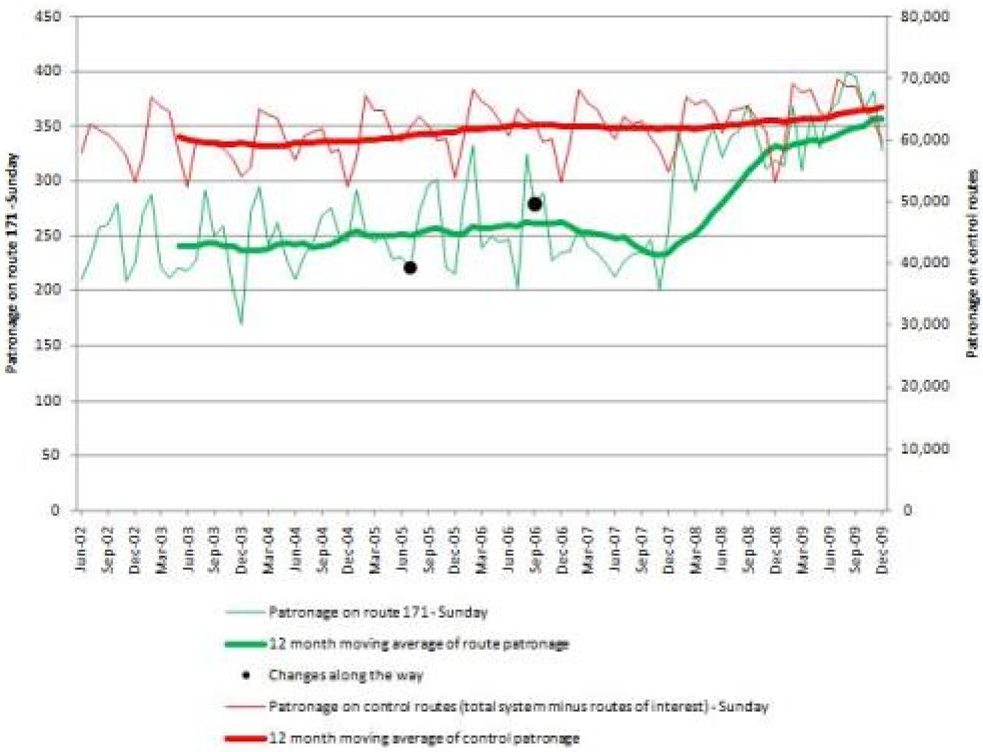
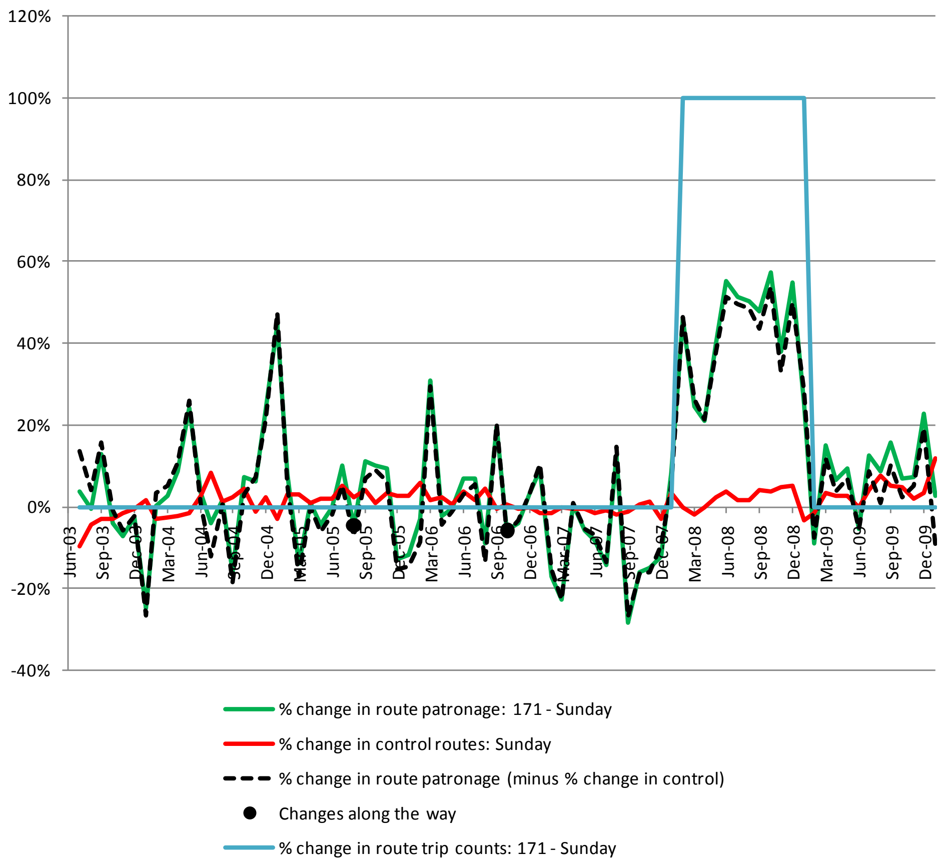


Figure G.45 Patronage changes (year-on-year) on service route and control routes



G5.4.3 Review and conclusions

Figures G.45 and G.46 indicate a substantial patronage response in the first 12 months after the service increase, with a much lesser response in the following 12-month period. There is some volatility in the monthly and, to a lesser extent, the quarterly elasticity estimates.

The average elasticity for the first four quarters is 0.49, and for the following three quarters is 0.54. The Q4 estimate of 0.47 is somewhat on the low side: a more representative estimate would be about 0.52.

The calculated saturation curve has a long-run saturation value of 0.54. This appears to be on the low side, given the quarterly estimates: a more reasonable value would be about 0.58.

Figure G.46 Monthly/quarterly elasticity estimates and saturation curve

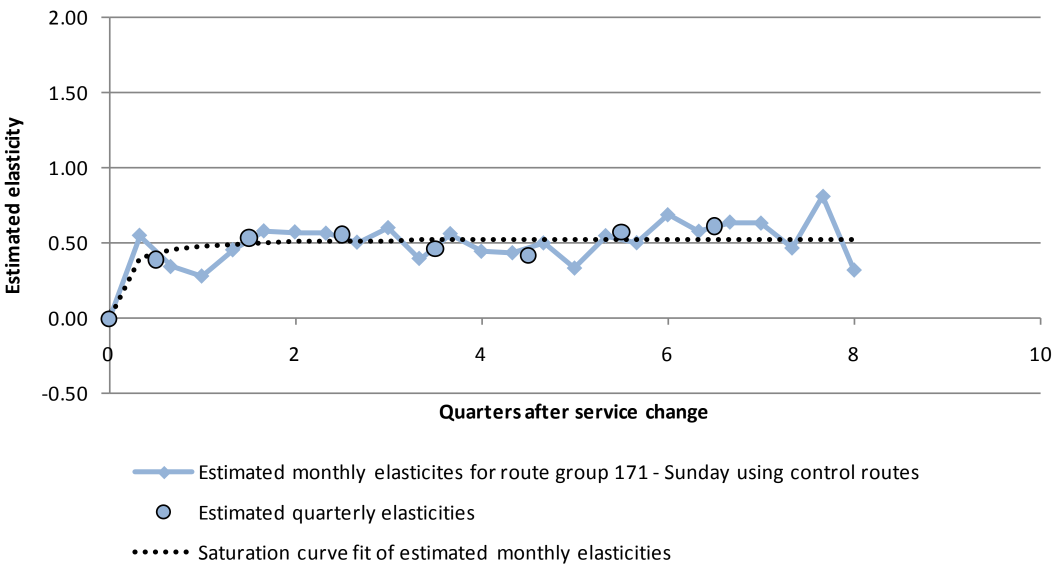


Table G.34 Quarterly elasticity estimates

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Jan-08					0.00	0.00
Q1	Apr-08	319	63,946	1.31	0.99	0.39	0.45
Q2	Jul-08	333	64,084	1.49	1.03	0.54	0.50
Q3	Oct-08	352	65,127	1.52	1.03	0.56	0.52
Q4	Jan-09	324	59,218	1.43	1.03	0.47	0.52
Q5	Apr-09	331	65,040	1.35	1.01	0.42	0.52
Q6	Jul-09	351	65,458	1.57	1.05	0.58	0.53
Q7	Oct-09	388	68,991	1.68	1.09	0.62	0.53
Long Run							0.54

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

G5.5 Route 203 (200) (Sunday)

G5.5.1 Service change

This service change in October 2006 involved a doubling of service frequencies, from one trip per hour to two trips per hour (each direction).

Table G.35 Details of service change

Date of service change for route group 203 (200) - Sunday	Sunday, 15 October 2006
Trips (per hour) before	1
Trips (per hour) afterwards	2
Ratio	2.00
Control route/s:	Total system minus routes of interest

G5.5.2 Notes re data

In September 2009, approximately one-third of trips during the day, on weekdays, were replaced by route 202. Therefore, data from September 2009 onwards were excluded from the estimation of elasticities below.

Figure G.47 Patronage on service route and control route

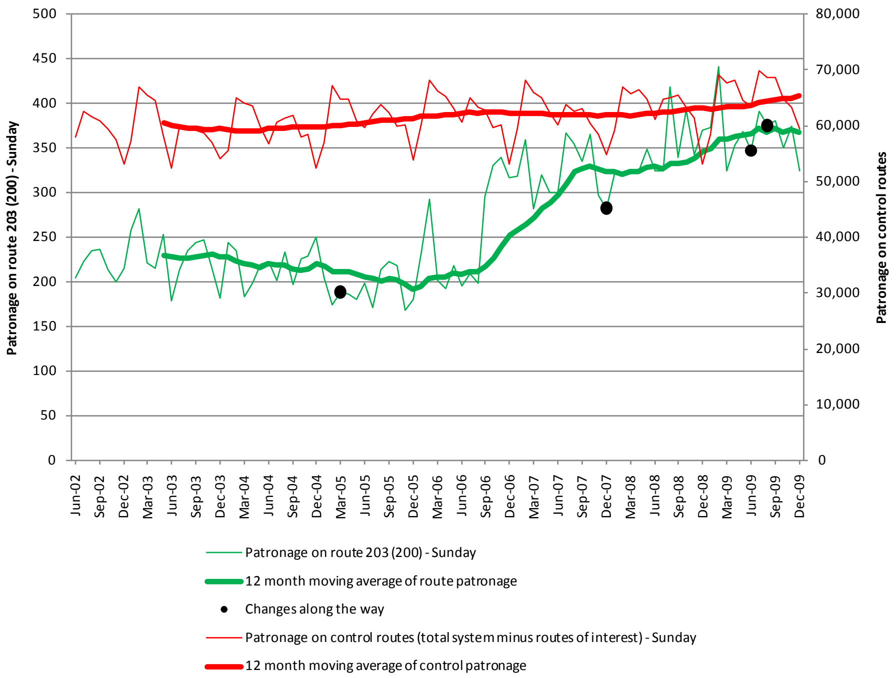
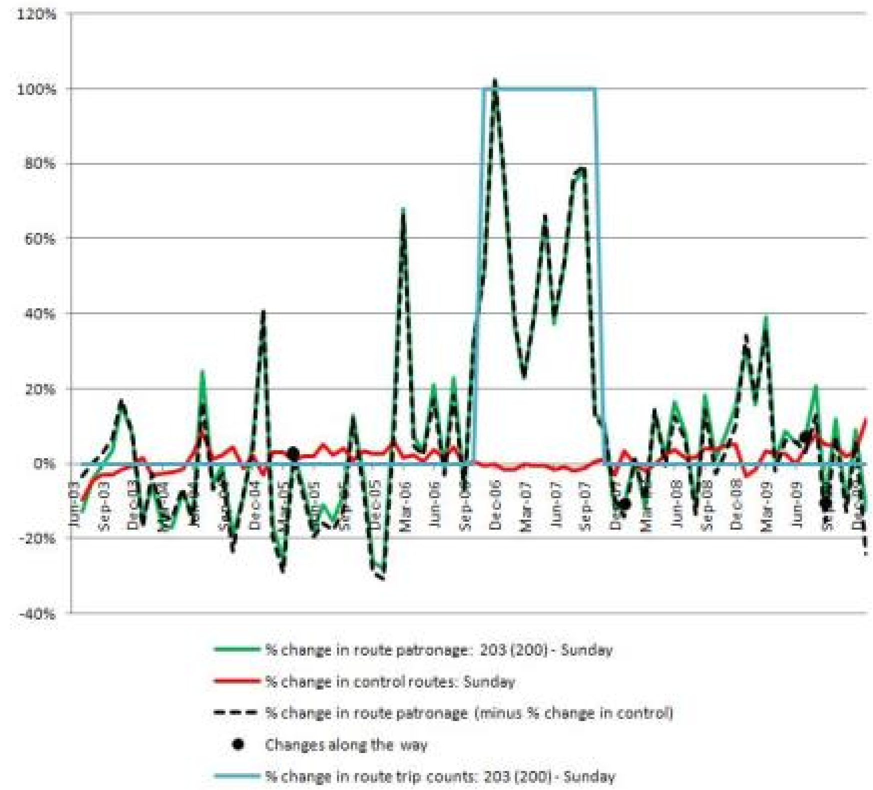


Figure G.48 Patronage changes (year-on-year) on service route and control routes



G5.5.3 Review and conclusions

Figure G.48 indicates a substantial patronage response in the first 12 months, but with substantial volatility (reflecting the apparent patronage volatility over the previous 12 months). After the first 12 months, there appears to be little further patronage response in the second year, but then some significant further increase in the third year (late 08/early 09): we would tend to discount this latter increase as the result of other (unknown) factors rather than the original service increase.

The average elasticity for the first four quarters is 0.65, with the same average for the following four quarters. On this basis, the Q4 estimate of 0.75 is on the high side: a more representative figure would be around 0.70 (recognising that the Q2 estimate of 0.42 may be too low, as it reflects the apparent high growth in patronage 12 months earlier).

The long-run saturation estimate of 0.70 appears on the low side (especially given the doubts regarding the Q2, Q6 etc estimates): a more reasonable estimate would be around 0.75.

Figure G.49 Monthly/quarterly elasticity estimates and saturation curve

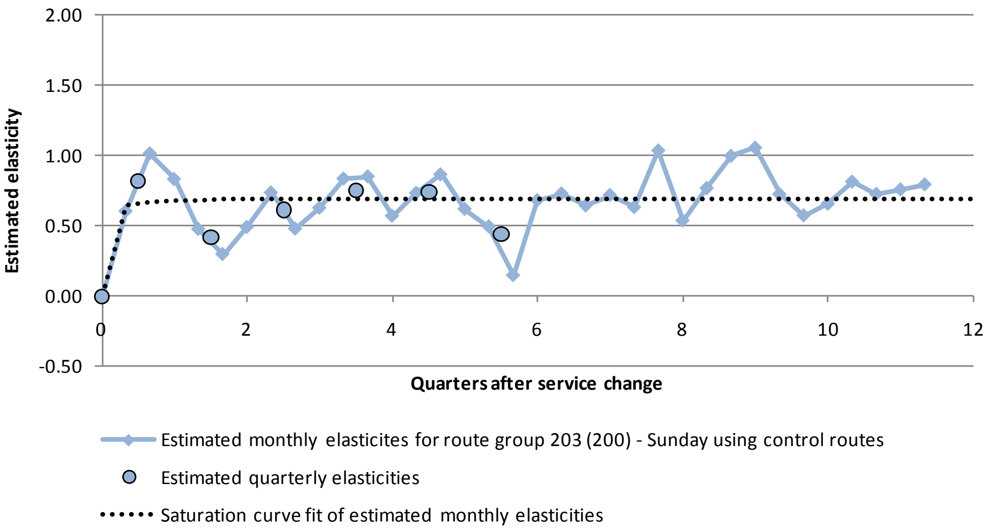


Table G.36 Quarterly elasticity estimates

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Oct-06					0.00	0.00
Q1	Jan-07	329	57,583	1.76	0.99	0.82	0.67
Q2	Apr-07	320	64,460	1.33	0.99	0.42	0.69
Q3	Jul-07	306	62,449	1.52	0.99	0.61	0.69
Q4	Oct-07	352	63,110	1.68	0.99	0.75	0.69
Q5	Jan-08	315	57,873	1.67	1.00	0.74	0.69
Q6	Apr-08	320	63,946	1.35	0.99	0.44	0.69
Q7	Jul-08	333	64,084	1.65	1.02	0.70	0.70
Q8	Oct-08	361	65,127	1.73	1.03	0.73	0.70
Q9	Jan-09	368	59,218	1.96	1.02	0.94	0.70
Q10	Apr-09	380	65,040	1.57	1.00	0.65	0.70
Q11	Jul-09	357	65,458	1.77	1.04	0.77	0.70
Long Run							0.70

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

G5.6 Route 291 (Sunday)

G5.6.1 Service change

This service change in January 2008 involved a doubling of service frequencies, from one trip per hour to two trips per hour (each direction).

Table G.37 Details of service change

Date of service change for route group 291 - Sunday	Sunday, 13 January 2008
Trips (per hour) before	1
Trips (per hour) afterwards	2
Ratio	2.00
Control route/s:	Total system minus routes of interest

G5.6.2 Notes re data

This service started on 21 October 2006; it was previously covered by route 292.

In September 2009, the route number changed to W90 or W91. It previously changed numbers upon reaching the city and continued outwards, but was now marketed as one continuous route (with number change). This appears to be associated with some drop-off in patronage. Therefore, data from September-2009 onwards has been excluded from the estimation of elasticities.

Figure G.50 Patronage on service route and control route

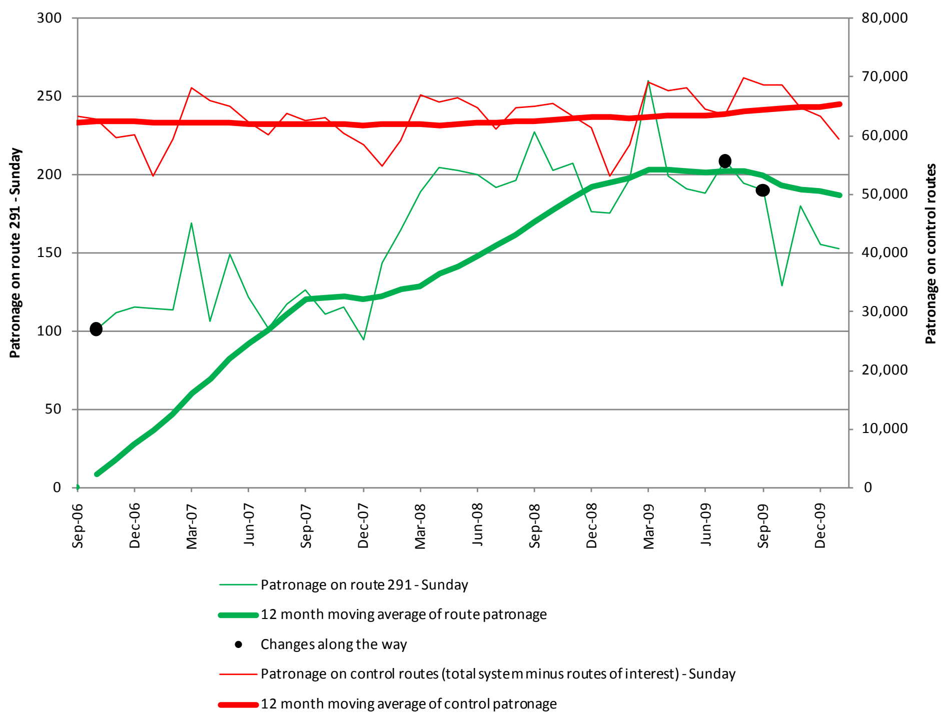
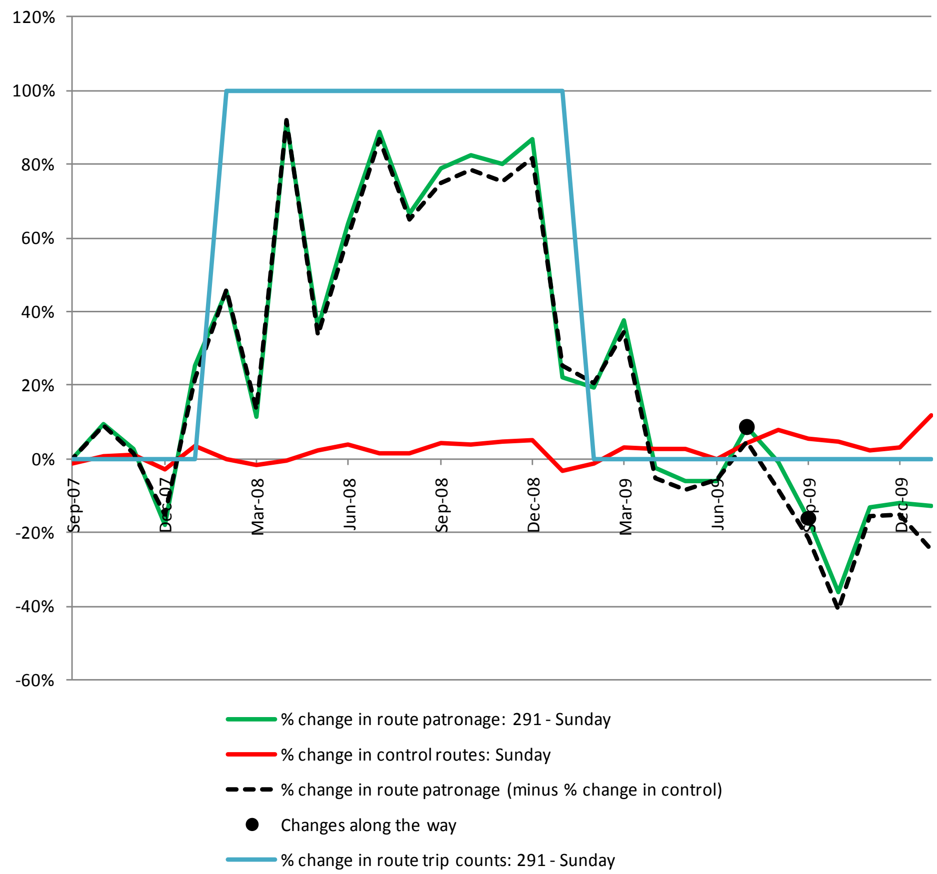


Figure G.51 Patronage changes (year-on-year) on service route and control routes



G5.6.3 Review and conclusions

Figure G.51 indicates a substantial patronage response in the first 12 months, with volatility reflecting the apparent patronage variability in the previous 12 months. There is some indication that the patronage growth continued at the start of the second year (early 2009).

The average elasticity for the first four quarters is 0.68, and that for the start of the second year (two quarters only) also being 0.68. The Q4 figure of 0.74 is consistent with this trend. The saturation value of 0.75 also appears reasonably consistent with all the data.

Figure G.52 Monthly/quarterly elasticity estimates and saturation curve

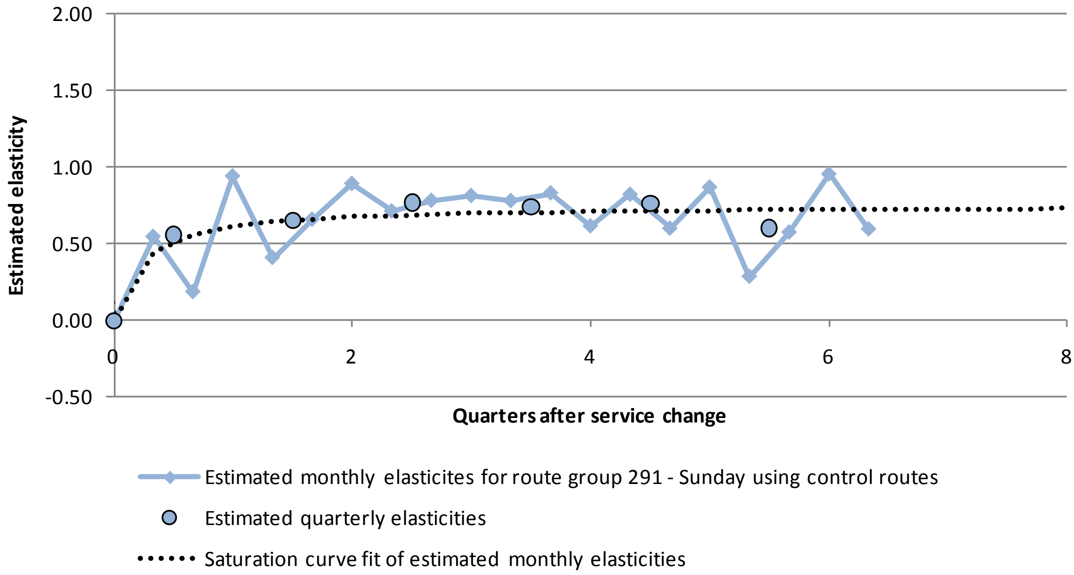


Table G.38 Quarterly elasticity estimates

Number of quarters following introduction	Date at which quarter ends	Average patronage per day		Ratio of route patronage this quarter to route patronage in the same quarter in the year prior to the service change	Ratio of control patronage this quarter to control patronage in the same quarter in the year prior to the service change	Estimated elasticity	Saturation curve fit of estimated elasticity
		Route	Control				
Zero	Jan-08					0.00	0.00
Q1	Apr-08	186	63,946	1.50	0.99	0.56	0.54
Q2	Jul-08	198	64,084	1.63	1.03	0.65	0.66
Q3	Oct-08	209	65,127	1.76	1.03	0.77	0.69
Q4	Jan-09	187	59,218	1.73	1.03	0.74	0.71
Q5	Apr-09	219	65,040	1.72	1.01	0.76	0.72
Q6	Jul-09	196	65,458	1.62	1.05	0.60	0.72
Long Run							0.75

Note: The ratio of route trips after the service change compared to prior to the service change was 2.00

G5.7 Summary of Saturday and Sunday analyses

The results for the weekend elasticity analyses are summarised in tables G.39 (Saturday) and G.40 (Sunday). Of the seven service changes examined, six involved a doubling of service frequencies, from one trip per hour to two trips per hour (each direction), while one involved a halving of frequencies, from two trips per hour to one trip per hour. This case of service reduction (route 155, Saturday) reversed the earlier service increase on that route.

Three sets of service elasticities for Q4 have been produced, as summarised in the tables:

- Actual quarterly elasticities. These range from 0.21 to 0.82, with a mean of 0.59. Apart from the one outlier (0.21), all the other six results are within a range 0.47 to 0.82.
- 'Smoothed' quarterly elasticities (included in the comments column of the tables). These range from 0.50 to 0.74, with a mean of 0.61.

- Saturation curve Q4 estimates. These range from 0.52 to 0.71, with a mean of 0.61. (We have commented that in some cases the saturation curves appear somewhat unreliable, hence the need to derive the separate set of 'smoothed' elasticities above).

We would adopt the 'smoothed' elasticity set as our best Q4 estimates. We would comment as follows:

- These estimates all fall within a relatively narrow range, ie varying by approximately ±20% around the mean value of 0.61.
- The means for the three Saturday changes and the four Sunday changes are virtually identical: there is no evidence that the 'underlying' market responses differ on the two days.
- The Q4 elasticity values for the route 155 service increase (0.65) and the subsequent decrease (0.58) are not significantly different. This would support a hypothesis that frequency elasticities are symmetric for service increases and decreases.

Further discussion of the findings is given in section G.6 and in the main report section 4.7 and chapter 5.

Table G.39 Results summary– Saturday

Route/s	Date of service change	Initial freq. per hr	% freq. increase		Q1	Q2	Q3	Q4	Q5–Q8 (2nd yr)	Q9-Q12 (3rd yr)	Q13–Q16 (4th yr)	Long run	Comment
155 A – Saturday	1 February 2003	1	100%	Estimated elasticities:	0.69	0.56	0.61	0.82	0.63	#N/A	#N/A		Quarterly elasticity estimates somewhat unreliable because of data volatility: best Q4 estimate is 0.65. Saturation curve unreliable (horizontal throughout.)
				Saturation curve fit:	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	
155 B – Saturday	27 August 2005	2	-50%	Estimated elasticities:	0.52	0.43	0.67	0.65	0.58	#N/A	#N/A		Quarterly elasticity estimates somewhat unreliable: best Q4 estimate is 0.58 (as for saturation curve).
				Saturation curve fit:	0.50	0.56	0.57	0.58	0.58	0.59	0.59	0.59	
291 - Saturday	19 January 2008	1	100%	Estimated elasticities:	0.44	0.74	0.59	0.47	#N/A	#DIV/0!	#DIV/0!		Quarterly elasticity estimates somewhat unreliable because of data volatility: best Q4 estimate is 0.59 (as for saturation curve).
				Saturation curve	0.52	0.57	0.59	0.59	N/a	N/a	N/a	0.61	

Table G.40 Results summary – Sunday

Route/s	Date of service change	Initial freq. per hr	% freq. increase		Q1	Q2	Q3	Q4	Q5–Q8 (2nd yr)	Q9–Q12 (3rd yr)	Q13–Q16 (4th yr)	Long-run	Comment
167/168 Sunday	21 August 2005	1	100%	Estimated elasticities:	0.61	0.36	0.52	0.21	0.56	0.54	0.50		Quarterly elasticity estimates somewhat variable: best Q4 estimate is 0.50. Saturation curve unreliable: best estimate is 0.58.
				Saturation curve fit:	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	
171 Sunday	13 January 2008	1	100%	Estimated elasticities:	0.39	0.54	0.56	0.47	0.54	#DIV/0!	#DIV/0!		Quarterly elasticity estimates somewhat variable: best Q4 estimate is 0.52. Saturation curve unreliable: best estimate is 0.58.
				Saturation curve fit:	0.45	0.50	0.52	0.52	0.53	#DIV/0!	#DIV/0!	0.54	
203 (200) Sunday	15 October 2006	1	100%	Estimated elasticities:	0.82	0.42	0.61	0.75	0.65	#N/A	#N/A		Quarterly elasticity estimates somewhat variable: best Q4 estimate is 0.70. Saturation curve unreliable: best estimate is 0.75.
				Saturation curve	0.67	0.69	0.69	0.69	0.70	0.70	N/a	0.70	
291 Sunday	13 January 2008	1	100%	Estimated elasticities:	0.56	0.65	0.77	0.74	#N/A	#DIV/0!	#DIV/0!		OK
				Saturation curve fit:	0.54	0.66	0.69	0.71	0.72	#DIV/0!	#DIV/0!	0.75	

G6 Summary of findings

G6.1 Overview of key outputs

Table G.41 provides a summary of the various elasticity analyses and results derived in this appendix, drawing on tables G.18, G.25, G.39 and G.40.

For each service change, the table shows the date of the change, the initial service frequency, and the % frequency increase. It then provides our best estimate elasticity values for Q4 (ie the average for months 10–12 after the service change, relative to the corresponding period 12 months earlier).

In each case three elasticity values are given:

- derived = direct estimate for 4th quarter (months 10–12) after the service change
- saturation curve = estimate for Q4 taken directly from the saturation curve fitted to the monthly elasticity estimates
- smoothed = more representative estimate derived from inspection of the trend in quarterly elasticity values (equates to the saturation curve where this is judged as reliable).

The ‘smoothed’ values are generally taken as the best estimates, as they effectively ‘smooth out’ the data series, minimising the effects of any ‘noise’ in the data (they are identical to the saturation curve estimates, except where the validity of these is doubtful for particular reasons).

In addition, we provide PTD’s initial elasticity estimates (without use of control routes)[66].

G6.2 Comments on the results

The following comments focus primarily on the table G.41 ‘smoothed’ elasticity values for Q4, as described above.

Key findings are as follows:

- For the weekday interpeak period, the unweighted mean of the eight elasticity results is 0.47 (range 0.35 to 0.61).
- For the weekday evening period, the unweighted mean of the three results is 0.52 (range 0.40 to 0.70).
- For the weekend (Saturday/Sunday) results, the unweighted mean of the seven results is 0.61, with a relatively narrow range between 0.50 and 0.74. There is no evidence of significantly different values between Saturdays and Sundays.

Our conclusions are as follows:

- The elasticities over the various off-peak periods analysed average 0.53 (18 results).
- The mean values for the three periods are 0.47 (interpeak), 0.52 (evening) and 0.61 (weekend). Given the distribution of the individual results within each period, it appears that these three mean values are not significantly different.
- It should be borne in mind that the elasticity estimates derived are ‘own period’ elasticities, ie they do not allow for any patronage effects outside the period in which the services were changed. This is

[66] These estimates were calculated as ‘shrinkage ratios’, ie (patronage increase/ ‘before’ patronage level): (service increase/‘before’ service level).

likely to mean that the elasticities presented understate the full market response to service changes. The extent of this understatement is likely to be greater for interpeak and particularly evening service changes, and less for weekend service changes. There is insufficient evidence to detect any significant variations in elasticities according to either the initial service frequency or the magnitude of the service change.

- There is some (very limited) evidence to support the hypothesis that elasticity values are symmetric, ie with a similar response to service increases and decreases: route 155 showed a similar elasticity to the service decrease (0.58) as it did to the service increase (0.65).
- It remains unclear to what extent the apparent elasticity differences between routes reflect intrinsic differences in the markets of different routes, or whether they are primarily the result of data and analysis issues.

The main report (chapter 5) sets out further conclusions, drawing on the evidence from all the centres covered in the project.

Table G.41 Adelaide off-peak service improvements – service elasticities summary

TABLE 6.1: ADELAIDE OFF-PEAK SERVICE IMPROVEMENTS--SERVICE ELASTICITIES SUMMARY

Route No	Service Change Date	Initial Freq (1-way trips/ hr)	Initial Headway (mins)	Frequency Increase (%)	Q4 Elasticity Estimates (1) Derived	Smoothed	Sat Curve	PTD Elast Estimate (2) (SR unadj)	Notes (3)
		WEEKDAY INTERPEAK (0900-1500)							
113	Jan-04	1	60	100%	0.60	**0.61**	0.61	0.50	
122-125	Jan-03	4	15	50%	0.42	**0.58**	0.58	0.21	
140-142	Jan-03	2	30	100%	0.27	**0.37**	0.37		
143	Jan-03	1	60	100%	0.34	**0.45**	0.45	0.15	
178	Jan-08	2	30	100%	0.35	**0.55**	0.35	0.33	Results beyond Q2 not reliable because of increase in service levels on control routes (from July 2008). Not use for R-U profile
203 (200)	Oct-06	3	20	33%	0.30	**0.35**	0.16	0.13	Not use for R-U profile
263	Oct-06	1.33	45	50%	0.26	**0.35**	0.28	0.10	Not use for R-U profile
864	Feb-07	1	60	100%	0.50	**0.50**	0.44	0.41	Not use for R-U profile.
				Mean	0.38	**0.47**	0.41		
				Min	0.26	**0.35**	0.16		
				Max	0.60	**0.61**	0.61		
		WEEKDAY EVENING (1900-2400)							
172	Oct-06	1	60	100%	0.13	**0.40**	0.40	0.12	Result not v reliable--v erratic pattern of route patronage ; difficult to separate apparent effects of earlier change in peak services. Not use for R-
203 (200)	Oct-06	1	60	100%	0.40	**0.45**	0.45	0.12	
682	Aug-05	2	30	-50%	0.48	**0.70**	0.80	0.02	Erratic patronage pattern, giving not v reliable results--appear to be affected by apparent drop in patronage prior to service redn. Not use for R-
				Mean	0.34	**0.52**	0.55		
				Min	0.13	0.40	0.40		
				Max	0.48	0.70	0.80		
		SATURDAY & SUNDAY							
155	Feb-03	1	60	100%	0.82	**0.65**	0.65	0.47	)Nice illustration of symmetry between service increases and decreases!!
(Sat)	Aug-05	2	30	-50%	0.65	**0.58**	0.58	0.72	) Not use for R-U profile.
291 (Sat)	Jan-08	1	60	100%	0.47	**0.59**	0.59	0.62	Not use for R-U profile.
167-168 (Sun)	Aug-05	1	60	100%	0.21	**0.50**	0.52	0.18	Est elast affected by volatile route pax prior to service change. Not use for R-U profile.
171 (Sun)	Jan-08	1	60	100%	0.47	**0.52**	0.52	0.37	Not use for R-U profile.
203 (200) (Sun)	Oct-06	1	60	100%	0.75	**0.70**	0.69	0.50	Volatile results, because of large pax fluctuations in year prior to service change. Not use for R-U profile.
291 (Sun)	Jan-08	1	60	100%	0.74	**0.74**	0.71	0.78	Not use for R-U profile.
				Mean	0.59	**0.61**	0.61		
				Min	0.21	0.50	0.52		
				Max	0.82	0.74	0.71		

Notes: (1). Three elasticity estimates are given in each case:
Derived = direct estimate of elasticity for 4th quarter (months 10-12) after the service change
Smoothed = more representative estimate derived from inspection of the trend in quarterly elast values (equates to the Sat Curve estimate where this is judged as reliable)
Sat curve = estimate for Q4 taken directly from the saturation curve fitted to the monthly elasticity estimates.
The 'smoothed' figures (highlighted) are taken as the most representative estimates.
(2). Elasticity (shrinkage ratio) estimate derived directly from the PTD data for a single month before and after the service change (with no 'control' routes).
(3). 'R-U' ='ramp-up.

Appendix H: Service elasticity assessments – Melbourne

H1 Introduction

This appendix covers the project analyses of Melbourne's experience since 2002 with increases in bus service levels, principally in off-peak periods. Two main groups (programmes) of service improvements are covered:

- **SmartBus** services – six major new/upgraded routes were introduced over the period 2002–2009, involving increased service frequencies and hours of operation and a range of other measures (bus priorities, real time information at stops, etc).
- **Service span** ('safety net') enhancements – a programme of extensions to the daily span of services, mostly in the evenings (weekdays and weekends), in about 80 cases, over the period 2006–2008.

For both groups of service improvements, the focus was on estimating service frequency elasticities for the day types/time periods on which services had been improved. In particular, the analyses examined how these elasticity values varied by day/time period and over time following the service improvements.

A separate appendix (appendix I) relating to Melbourne's development of and experience with bus service improvements has also been prepared, focusing on previous market research into customer views, attitudes and responses to improvements.

H1.1 Acknowledgements

The research reported in this appendix would not have been possible without the invaluable support received from:

- Department of Transport, Victoria for project funding and provision of validation data and timetable details.
- Chris Loader (Bus Association Victoria) for extensive assistance, making use of his great knowledge of Melbourne's bus system and service developments and his considerable database of bus route and service information.
- A project steering/liaison group established by DoT involving:
  - Nataniel Wolfson and Roberto Evangelio (DoT).
  - Chris Loader (BAV)
  - Laura Flores (Hyder Consulting)[67].

H2 Methodology and data overview

H2.1 Service changes analysed

The main focus of the project was to analyse the effects on patronage of changes in bus service levels (frequencies) at off-peak periods.

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[67] In addition, Peter Don (DoT) and Professor Graham Currie (Monash University) were invited to be members of the steering/liaison group but were unable to attend any meetings.

Since 2002, extensive improvements to bus services have been made in the Melbourne metropolitan area, with most having a particular emphasis on enhancing off-peak service frequencies. This appendix analyses the impacts of those service changes on patronage, with the services considered in two main groups:

- **SmartBus services** – six new major routes introduced over the period 2002–2009. The SmartBus service enhancements typically involved:
  - enhanced service frequencies and hours of operation (evenings and weekends)
  - bus priority measures
  - bus stop upgrades
  - real-time information at major stops
  - local marketing campaigns.

  Our assessment analysed the effects on patronage of the full SmartBus 'package' of measures, with these effects being estimated by separate time periods (weekday evenings, peak, interpeak periods; Saturdays, Sundays). We related the patronage effects in each period to the increase in the service frequency in that period, thus providing 'proxy' service frequency elasticities. While it was not possible to separate out the patronage effects of each component of the SmartBus package implemented on each route, we made broad estimates of adjustment factors that might be applied to these proxy values to derive elasticity estimates reflecting only the service frequency aspects of the combined package.

  Our SmartBus analyses are set out in section H3.

- **Service span** ('safety net') enhancements. Over the period September 2006 to May 2008, the daily spans of services were extended in over 80 cases, both on weekdays and weekends. These span extensions were mostly in the evenings, typically extending the time of the last service from around 1800–1900 out to 2100–2200. In some cases, services were also extended at the start of the day (the first bus started earlier); while in other cases some (usually minor) changes were also made to daytime services.

  Our analyses of these span cases are set out in section H4.

H2.2 Patronage data

The basic unit of 'patronage' used in our analyses was passenger validations/day on an average monthly basis on the routes of interest (both directions combined), by nominated day types and time periods:

- day types – weekday (school term)[68], Saturday, Sunday
- time periods (weekday)[69]
  - evening (1900–2359 departures)
  - interpeak (1000–1459 arrivals)
  - peaks (0700–0859 arrivals, 1500–1759 departures[70]).

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[68] Weekday (school holidays) data were obtained, but set aside for our analyses.

[69] For the span analyses, services were simply divided between 'evening' (defined as those with departures from 1800 hours onwards) and the remainder.

DoT provided monthly total validations data by route, broken down by day type and hour of day (based on time of passenger validation). It also provided a table of the numbers of each day type in each month. This extensive dataset covered the period 2004–2010 for all routes, with additional data for the period 2000–2004 required to cover the earlier (2002) SmartBus introductions.

For most of our analyses, we derived from this dataset the validations per day by time period on an average monthly basis. In some cases, we assembled similar data broken down by hour of the day, to allow more detailed examination and analyses.

DoT advised that, over the period concerned, validations typically covered at least 90% of passenger boardings. While the validation rate would have varied somewhat over the period since 2002, these variations would have been on a system-wide basis, and hence any potential distortions from the incomplete data would largely be eliminated by the use of control routes in all cases, as now outlined.

H2.3 ‘Control’ routes

For all analyses undertaken, we applied ‘control’ routes. The intention was that the ‘control’ route would allow for any factors, other than the service change under examination, that might have affected patronage on the route in question over the analysis period. The use of control routes was seen as particularly important in the context of these analyses, as substantial exogenous changes in Melbourne’s bus patronage occurred over the period concerned, particularly since 2007 (and closely related to fluctuations in petrol prices).

Control routes were selected as routes on which, over the required analysis period, the service had not significantly changed and patronage had not been substantially affected by service changes on other routes in the vicinity. Based on previous analyses of bus patronage trends in Melbourne, two groups of control routes were defined, ie ‘middle’ and ‘outer’, reflecting broadly the distance band of the services from the CBD[71]. As many qualifying routes as possible were included in each band, so as to provide robust estimates of ‘typical’ underlying patronage trends in each band over the analysis period.

H2.4 Scope of analyses

In general, the analyses for each route/time period compared the change in patronage on that route/period following the service frequency increase against the extent of the service increase. This enabled derivation of route/time period service elasticities.

However, potentially, a change in service on a single route/time period may have wider impacts on patronage, ie:

A On the same routes at other time periods

B On other (competing or complementary) routes at the same time period

C On other (competing or complementary) routes at other time periods.

[70] It will be noted that these time periods do not cover the whole day’s services, particularly omitting services in the ‘transition’ periods between the time periods covered. However, analyses were also undertaken for all weekday (school term) services together.

[71] For the early (2002) SmartBus service analyses, an ‘early middle’ subset of the ‘middle’ group of control routes was used, as data for the full set of control routes was not readily available for years prior to 2004.

These ‘secondary’ impacts are often ignored in studies that derive route-based elasticity estimates, but they may be very significant: ignoring them may underestimate or overestimate the true market response to service changes.

We make the following comments on these wider impacts and our treatment of them in the SmartBus and span analyses:

A **Effects in other time periods.** Prima facie, if a service is improved in one time period (eg weekday evenings), the improvement would also be expected to influence patronage in other time periods in which people are travelling on the same round trip or trip chain (eg weekday interpeak or PM peak). Clearly, the extent of any cross-period patronage effects will depend on how the time periods are defined: for example, if the day type is divided into peak/interpeak/evening services, then cross-period effects would be expected to be very significant; while if the day type is not subdivided (eg all services on Saturdays), then the cross-period effects would be expected to be very small.

In most cases, the span changes made affected the evening services only, and we investigated the resulting patronage changes in both the evening period and the earlier (daytime) period. Unfortunately, in most cases, data difficulties were such that robust results were not obtainable for the daytime effects (refer section H4.3.5 for further discussion).

In all cases, the service changes made to SmartBus routes involved increases in service levels across all time periods (to differing extents). It was therefore not possible to separate out the patronage effects that would have occurred if service levels had changed in only a single time period.

It should be noted from the above that several alternative service elasticity concepts may potentially be measured for assessing the effects of a defined service change in a given period:

- ‘own period’ elasticity – single period service changes
- ‘own period’ elasticity – multiple period service changes
- ‘total period’ elasticity – single period service changes.

See section H4.2 and table H.10 for further discussion of different elasticity concepts and their treatment in our analyses.

B and C Effects on other routes. In general, service increases on one route will affect patronage on other routes in the vicinity, either positively or negatively:

- In the case of ‘competing’ routes (broadly parallel to the improved route), the service improvements will generally result in the abstraction of passengers from these competing routes. Thus the system-wide elasticity (net effect on patronage) will be lower than the route-specific elasticity (gross effect).
- In the case of ‘complementary’ routes (which feed passengers to/from the improved routes), the service improvements will generally result in the generation of additional passengers on these complementary routes. In this case the system-wide elasticity will be greater than the route-specific elasticity.
- In practice, the competing routes case tends to be more common than the complementary routes situation. For the SmartBus services in particular, our analyses covered the package of routes that included, apart from the SmartBus route itself, any routes in the vicinity that were judged to be significantly competing or complementary. Thus the results of our analyses should represent system-wide (net) elasticities.

H2.5 Elasticity formulation

We adopted a commonly used elasticity formulation as the basis for our estimation of service frequency elasticities. This was[72]:

$$\text{Elasticity with respect to service frequency} = \frac{\ln(\text{patronage increase factor})}{\ln(\text{service increase factor})}$$

This (natural) logarithmic function has a number of advantages over alternative elasticity functions in terms of the project requirements, including that it provides consistent elasticity results in cases where:

- Two sets of service changes are made on a route: the total patronage effects calculated for the two separate changes will be the same as if the patronage effect was calculated for both changes together.
- A service increase is followed by a service decrease (or vice versa), resulting in no net service change: this method will calculate no net patronage change, while other methods generally do not.

In our estimation of elasticities using the above function:

- We compared patronage in each 'after' monthly period with that of the corresponding month in the 12 months immediately before the service change (thus accounting for any seasonality effects).
- We compared these patronage changes on the route under examination with patronage changes on a specified 'control' (unaffected) route group, and calculated elasticities based on the net patronage change (thus allowing for any other 'external' factors that might have affected patronage over the relevant period).

On this basis, the above elasticity function was expressed as follows:

$$\text{Estimated elasticity } E_e = \frac{\ln\left[(P_R^{Ta} / P_R^{Tb}) / (P_C^{Ta} / P_C^{Tb}) \right]}{\ln (S_R^{Ta} / S_R^{Tb})}$$

where: E_e = service frequency elasticity estimate (specified day type/time period)

P = patronage in specified period

S = number of service trips or service km over time period

R = route experiencing service change

C = control route group

Ta = time period (month, quarter, etc) since the service change

Tb = corresponding month etc in the year immediately before the service change.

H2.6 Estimation of elasticity values

As outlined earlier (section H2.2), patronage (validations) data was provided by DoT on a monthly basis for each of the day types/time periods of interest, for both the routes of interest and the control route.

We used this data to calculate on a monthly (average day) basis:

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[72] This formulation is often also expressed in the form: patronage increase factor = (service increase factor)^E, where E is the service frequency elasticity.

A For the route of interest: ratio of monthly 'after' patronage to patronage in the same month in the 12-month period before the service change.

B For the 'control' route group: similar ratio of monthly 'after' patronage to 'before' patronage.

C The ratio A/B.

The formulation above was then used to derive estimated elasticity values on a monthly basis.

Similarly, averaged elasticities were calculated for longer periods, using average patronage data over these periods. In particular, we calculated average elasticities for each quarterly period[73].

For most of the project work in assessing patterns of elasticity results, we focused on average quarterly periods after the service change. We thus derived elasticity estimates for Q1, Q2, Q3, Q4 etc following the service change. In practice, the continuing rate of growth in market response (and hence elasticity estimates) is much reduced beyond the first 12 months, and hence we derived annual average elasticities beyond the first year. This resulted in a set of average elasticity estimates for the following periods: Q1, Q2, Q3, Q4, Y2, Y3, Y4 etc.

We chose the Q4 elasticity estimate (ie relating to the period 10–12 months after the service change) as our single primary indicator of market response: one reason for this choice is that it is largely consistent with the definition of short-run elasticities generally found in the literature. When examining elasticity trends over time we related these back to the Q4 elasticity value as the base.

H2.7 Saturation curve assessment

As noted above, we estimated elasticity values on a monthly average basis (average of validations for all days of the relevant day type in each month) compared with the same month in the 12-month period prior to the service change. We then derived quarterly average (and annual average) elasticity values from the monthly estimates. As expected, the monthly values on their own showed quite wide variability, although this was reduced when quarterly values were considered; these showed a reasonably smooth curve, increasing over time since the service change but at a gradually decreasing rate.

In order to be able to generalise from the various results, it was useful to fit a smooth curve to the results, indicating the 'underlying' trends over time. In this case, a 'saturation'-type curve was most appropriate, reflecting an expectation that in the long run the elasticity would be expected to approach a fixed value (rather than continue to increase indefinitely).

In developing our saturation curves we adopted a popular equation for curve fitting – the 'two-parameter saturation growth' function:

$$E_s = A.T/(B+T)$$

where T is time (following the introduction of the service change), and A and B are two parameters.

An alternative popular equation used for curve fitting is the 'two parameter exponential' function:

$$Y = A\ (1\text{-}exp(\text{-}B*T))$$

where T is time, and A and B are two parameters (Kirk 2005).

Both of these equations were initially tested and compared. We found that both equations provided a similar fit to the set of elasticity estimates. However, the 'two-parameter saturation growth' method

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[73] For our analyses, the first month (and quarter) was defined as starting at the beginning of the first new month following the service change (as the data provided was on a monthly rather than daily or weekly basis).

generally provided a better fit for off-peak data. That method was therefore employed for our subsequent analyses for the SmartBus routes[74].

Hence the saturation curve formula adopted was:

Curve-fitted elasticity $E_s = A.T/(B+T)$

where: A is a parameter representing the long-run elasticity

B is a parameter representing the speed of convergence to the long-run elasticity

T is time since introduction of service change.

Analysis of the dataset of actual elasticity estimates enables A and B to be estimated so as to minimise the following:

Sum of squared error: $\sum_{t=0}^{t=n}$ (derived elasticity–curve-fitted elasticity)^2

$$= \sum_{Ta=0}^{Ta=n} [E_e - A.T_a/(B+T_a)]^2$$

In most of our reporting of the SmartBus elasticity results in this appendix (eg in examining elasticity changes over time), the saturation curve estimates have been used in place of (or in addition to) the actual period estimates, so as to minimise the effects of random fluctuations in the data.

H3 Smartbus route analyses

H3.1 Service changes assessed

This section presents our assessment of the patronage impacts of the key SmartBus initiatives implemented in the period 2002–2009, ie:

- route 888/9 (August 2002) – Green Orbital Stage 1 (Chelsea – Nunawading)
- route 703 (August 2002) – Blackburn Road (Middle Brighton – Blackburn)
- route 700 (June 2005) – Red Orbital Stage 1/Warrigal Road (Mordialloc – Box Hill)
- route 901 (March 2008) – Yellow Orbital Stage 1/Stud Road (Frankston – Ringwood)
- route 900 (October 2006) – Wellington Road (Stud Park – Caulfield)
- route 903 (April 2009) – Red Orbital Stage 2 (Box Hill – Altona).

Details of these services and the service changes involved are given in table H.1. In the case of the last two of these services, there was no effective service in the corridor prior to the introduction of the SmartBus scheme, and hence effectively no ‘before’ route to provide the base for any elasticity analyses. Hence for these routes, while we have analysed the ‘after’ patronage trends, no elasticity estimates were attempted. Most of our analyses and results presented in this chapter therefore focus on the other four SmartBus routes, for which both patronage trend and elasticity analyses were undertaken.

For each of these SmartBus initiatives, a ‘package’ of routes was defined for inclusion in the before/after analyses, as shown in table H.1. This ‘package’ was intended to cover the group of routes on which patronage was expected to be affected by the SmartBus initiative: the other (non-SmartBus) routes in the package comprised both competing routes (on which patronage would be expected to be reduced as a

[74] This saturation curve approach was applied only in the case of the SmartBus routes, not for the span service changes.

result of the SmartBus initiative) and complementary routes (on which patronage would be expected to increase) – refer to the discussion in section H2.4.

For each SmartBus initiative, a set of control routes was defined to provide a baseline for the analyses: these control routes were essentially a set of routes in the relevant band (distance from the CBD) in which services had not changed significantly during the analysis period, and were unlikely to be affected by the SmartBus initiatives (refer section H2.3). Details of the various control route groups are given in table H.2.

As noted earlier, for each month/quarter after the service change, patronage was compared with the corresponding month/quarter in the 12 months immediately prior to the change (with appropriate adjustments for patronage changes on control routes). These monthly/quarterly analyses were undertaken for as long a period as possible after the service change. In general, these 'after' periods were limited by subsequent service changes to either the SmartBus route itself or to one of the competing or complementary routes. Table H.1 (fourth column) indicates the end of the analysis period for each SmartBus route; it may be seen that these periods varied between a maximum of over four years (SmartBus route 888/9) and a minimum of one year (route 903, the most recent SmartBus route).

Our assessment examined the effects of the SmartBus initiatives separately for weekdays (school term periods), Saturdays and Sundays. Weekday assessments were also undertaken for three separate time periods: evenings (departures after 1900), peaks (arrivals 0700–0859, departures 1500–1759), and interpeak (arrivals 1000–1459).[75]

Table H.1 also shows for each route group/time period:

- before service frequency (average trips per hour and direction for the route group)
- before and after bus trips per day
- % change in services (bus km) on the route group associated with the initiative. This estimate (which was used directly in the elasticity analyses) allowed for the effects of the various service changes on routes of different route lengths (and hence propensity to generate patronage) in the route package.

H3.2 Analysis methodology

H3.2.1 Data inputs

Table H.3 summarises the main data inputs to the before/after patronage and elasticity analyses.

[75] As noted earlier, these three time periods cover the great majority of, but not all, weekday services.

Table H.1 Summary of Smartbus analysis

TABLE 3.1: SUMMARY OF SMARTBUS ANALYSES

SmartBus Route		Implementation	End of Analyis	Route Length	Routes analysed		Control	Time period analysed (2)		Service	Bus Trips/Day (4)		% Service Incr
Number	Name	date	Period	(kms)	Before	After	Routes (1)	Day	Time period	Frequency Before (3)	Before	After	--Bus Km (5)
888/889	Green Orbital Stage 1	5-Aug-02	Nov-06	33	888/9, 885	888/9, 885	Early Middle	Weekday	Evening	#DIV/0!	1	11	1000%
	(Chelsea--								Interpeak	3.0	30	60	100%
	Nunawading)								Peaks	2.8	28	54	93%
									Total	3.0	80	168	110%
								Saturday		1.0	18	65	261%
								Sunday		#DIV/0!	0	13	#DIV/0!
703	Blackburn Rd	5-Aug-02	Nov-04	14	703	703	Early Middle	Weekday	Evening	#DIV/0!	8	12	62%
	(Middle Brighton--								Interpeak	3.1	31	40	39%
	Blackburn)								Peaks	4.0	40	49	32%
									Total	3.4	110	139	24%
								Saturday		1.6	47	64	35%
								Sunday		1.1	28	39	40%
700	Red Orbital Stage 1	14-Jun-05	Apr-09	27	700, 767	700, 767, 766	Middle	Weekday	Evening	#DIV/0!	0	16	#DIV/0!
	/Warrigal Rd								Interpeak	6.1	61	84	26%
	(Mordialloc--								Peaks	6.5	65	102	43%
	Box Hill)								Total	#DIV/0!	204	294	31%
								Saturday		#DIV/0!	109	165	33%
								Sunday		#DIV/0!	29	60	115%
901	Yellow Orbital Stage 1	24-Mar-08	May-10	48	665, 830/1,	901, 832, 833	Outer	Weekday	Evening	#DIV/0!	12	35	305%
	/Stud Rd								Interpeak	5.3	53	82	115%
	(Frankston--								Peaks	6.0	60	111	157%
	Ringwood)								Total	4.6	145	271	159%
								Saturday		2.2	50	141	313%
								Sunday		1.8	33	120	367%
900	Wellington Rd	31-Oct-06	Apr-10	22	n/a	900	Middle	Weekday	Evening	#DIV/0!	0	0	#DIV/0!
	(Stud Park--								Interpeak	0.0	0	0	#DIV/0!
	Caulfield)								Peaks	#VALUE!	#VALUE!	#VALUE!	#VALUE!
									Total	#DIV/0!	0	0	#DIV/0!
								Saturday		#DIV/0!	0	0	#DIV/0!
								Sunday		#DIV/0!	0	0	#DIV/0!
903	Red Orbital Stage 2	20-Apr-09	May-10	54	n/a	903	Middle	Weekday	Evening	#DIV/0!	0	0	#DIV/0!
	(Box Hill--								Interpeak	0.0	0	0	#DIV/0!
	Altona)								Peaks	#VALUE!	#VALUE!	#VALUE!	#VALUE!
									Total	#DIV/0!	0	0	#DIV/0!
								Saturday		#DIV/0!	0	0	#DIV/0!
								Sunday		#DIV/0!	0	0	#DIV/0!

Notes:

(1). Details given in Table 3.2

(2). Day type definitions: Weekday--school term days only; Saturday--all Sat'days; Sunday--all Sundays. Weekday time period definitions: Evening 1900-2159 departures; Interpeak 1000-1459 arrivals; Peaks 0700-0859 arrivals, 1500-1759 departures.

(3). Average trip frequency (services/hour/direction) averaged over the relevant time period, for the group of 'before' routes.

(4). Total trips operated per day, on the group of routes concerned (total of both directions)

(5). Estimated % increase (After/Before) in bus km for the group of routes analysed (may differ from % increase in bus trips, given different route lengths in the route packages analysed). These figures are those used in the elasticity calculations.

Table H.2 Control routes

Middle control routes[a]	Outer control routes
202	364
279	367
284	421
285	422
293	423
295	424
526	671
531	672
538	675
550	680
558	689
560	694
600	783
627	844
704	845
923	849

[a] For the analysis of SmartBus routes 703 and 888/9, an 'early middle' subset of these results was used, as data was not available for all 'middle' routes.

Table H.3 Main SmartBus analysis inputs

Item	Comments
SmartBus route groups	Refer table H.1 and section H3.1.
Control route groups	Refer table H.2 and section H3.1.
Time periods	Refer table H.3 and section H3.1.
Service frequency – before	• Refer table H.1 and section H3.1. • Calculated for the SmartBus route group, by time period.
Extent of service changes	• Refer table H.1 and section H3.1. • Estimated in terms of % change in bus km – allows for the different lengths of the routes within the SmartBus route group.
Period of analysis	For each SmartBus initiative, before patronage data covered a period of 12 months minimum prior to the service change; after patronage data covered a period of at least 12 months, but as long as possible after the change (usually limited by other service changes that affected the route in question).
Patronage data	• Monthly validations data (provided by DoT) by route and hour of day, by day type (weekday school term, weekday holiday[a], Saturday, Sunday), with a tabulation of number of days by day type in each month. Data provided covered years 2000–2010. • Initial analyses derived average daily validations by route by day type, by hour by month.

[a] Weekday school holiday data was not used in the analysis.

H3.2.2 Analyses

The main steps in the analyses were as follows:

1 Calculate % increase in service levels (bus km) for each route group/time period associated with the SmartBus initiative (as table H.1, RH column).

2 Calculate average daily validations by route group (SmartBus groups and control groups) by month/quarter,[76] day type and time period, over the full analysis period.

3 Compare average daily validations for each month/quarter after the service change with the corresponding number in the comparable month/quarter in the 12 months prior to the change, thus deriving a route patronage index.

4 Undertake similar calculations for the control route groups, to derive a control patronage index.

5 Calculate the ratio of these two patronage indices, to derive an adjusted route patronage index (allowing for control route trends).

6 Derive the service elasticity for each month/quarter as the ratio: ln(patronage index)/ln (service index) – refer sections H2.5 and H2.6.

7 Fit a saturation curve to the patronage index values and elasticity values, to derive monthly/quarterly 'saturation' curve elasticity estimates (as described in section H2.7).

Note that the elasticity estimates derived through this methodology are 'own period' elasticities, ie relating the patronage change in the time period in question to the service change in that period: they make no attempt to allow for the effects of service changes in one period on patronage in other periods of the day/week[77].

H3.3 Results and commentary

H3.3.1 Results overview

Table H.4 presents the results of the SmartBus analyses, by route/time period, in terms of the route patronage index (LH columns) and the service elasticity estimates (RH columns):

- Results are given on a quarterly basis for the first 12 months after the service change, on an annual basis thereafter.
- In each case, the table shows actual quarterly data and the saturation curve estimates derived from this data. Long run ('saturation') estimates are also provided.
- The route patronage index and the elasticity saturation curve estimate are also expressed relative to the fourth quarter (Q4, months 10–12 after the service change) as base (=100).

The following summary of results and commentary relates primarily to the elasticity values and in particular to the saturation curve estimates. The first focus is on the Q4 results, followed by results/ commentary on the pattern of variation of elasticities over time.

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[76] Months were grouped into quarters, with Q1 (months 1–3) starting at the beginning of the first new month following the service change.

[77] Such allowance would not be possible for these SmartBus initiatives, given that they involved simultaneous service changes in all time periods. This aspect is addressed further in section H4.

Table H.4 Summary of SmartBus patronage elasticity results

TABLE 3.4: SUMMARY OF SMARTBUS PATRONAGE & ELASTICITY RESULTS

S/Bus Route No.	Time period analysed (2) Day	Time period		Route patronage index (1) Zero (3)	Q1	Q2	Q3	Q4	Q5-Q8 (2nd yr)	Q9-Q12 (3rd yr)	Q13-Q16 (4th yr)	Long-run		Estimated elasticities Q1	Q2	Q3	Q4	Q5-Q8 (2nd yr)	Q9-Q12 (3rd yr)	Q13-Q16 (4th yr)	Long-run
888/9	Weekday	Evening	Qly index	49%	91%	117%	112%	100%	118%	140%	167%		Qly index	1.05	1.10	1.22	1.21	1.18	1.23	1.23	
			Saturation curve fit	49%	67%	87%	101%	112%	129%	145%	154%	187%	Saturation curve fit	1.05	1.16	1.19	1.20	1.21	1.22	1.22	1.23
													Sat curve rel to Q4	87	97	99	100	101	102	102	103
		Interpeak	Qly index	79%	89%	96%	102%	100%	103%	106%	114%		Qly index	0.25	0.42	0.53	0.52	0.53	0.58	0.60	
			Saturation curve fit	79%	88%	95%	99%	102%	105%	108%	110%	114%	Saturation curve fit	0.27	0.41	0.48	0.51	0.55	0.58	0.59	0.62
													Sat curve rel to Q4	53	81	94	100	108	113	116	122
		Peaks	Qly index	80%	83%	79%	104%	100%	100%	100%	105%		Qly index	0.21	0.41	0.47	0.57	0.54	0.53	0.51	
			Saturation curve fit	80%	85%	90%	94%	96%	100%	104%	106%	112%	Saturation curve fit	0.28	0.40	0.45	0.48	0.50	0.52	0.53	0.56
													Sat curve rel to Q4	58	85	95	100	106	110	112	117
		Total	Qly index	78%	85%	88%	104%	100%	102%	105%	112%		Qly index	0.27	0.45	0.53	0.56	0.56	0.58	0.58	
			Saturation curve fit	78%	85%	91%	96%	99%	104%	108%	110%	118%	Saturation curve fit	0.30	0.44	0.49	0.52	0.55	0.57	0.58	0.61
													Sat curve rel to Q4	58	85	95	100	106	110	112	117
	Saturday		Qly index	68%	87%	98%	103%	100%	111%	114%	127%		Qly index	0.48	0.59	0.66	0.65	0.68	0.68	0.76	
			Saturation curve fit	68%	80%	92%	99%	105%	112%	119%	123%	134%	Saturation curve fit	0.46	0.60	0.65	0.67	0.69	0.71	0.72	0.74
													Sat curve rel to Q4	69	90	97	100	104	106	107	110
	Sunday		Qly index	37%	76%	90%	99%	100%	105%	130%	140%		Qly index								
			Saturation curve fit	37%	56%	77%	91%	101%	116%	130%	138%	163%	Saturation curve fit								
													Sat curve rel to Q4								
703	Weekday	Evening	Qly index	86%	103%	93%	117%	100%	118%	#DIV/0!	#DIV/0!		Qly index	0.81	0.55	1.04	0.80	1.03	#DIV/0!	#DIV/0!	
			Saturation curve fit	86%	98%	106%	110%	112%	115%	#DIV/0!	#DIV/0!	120%	Saturation curve fit	0.75	0.90	0.94	0.96	0.98	#DIV/0!	#DIV/0!	1.01
													Sat curve rel to Q4	78	94	98	100	102	#DIV/0!	#DIV/0!	106
		Interpeak	Qly index	98%	96%	88%	112%	100%	103%	#DIV/0!	#DIV/0!		Qly index	0.50	0.41	0.57	0.35	0.60	#DIV/0!	#DIV/0!	
			Saturation curve fit	98%	99%	100%	101%	102%	104%	#DIV/0!	#DIV/0!	125%	Saturation curve fit	0.57	0.57	0.57	0.57	0.57	#DIV/0!	#DIV/0!	0.57
													Sat curve rel to Q4	100	100	100	100	100	#DIV/0!	#DIV/0!	100
		Peaks	Qly index	102%	96%	81%	116%	100%	102%	#DIV/0!	#DIV/0!		Qly index	0.29	0.17	0.34	0.15	0.35	#DIV/0!	#DIV/0!	
			Saturation curve fit	102%	102%	102%	102%	102%	102%	#DIV/0!	#DIV/0!	102%	Saturation curve fit	0.32	0.32	0.32	0.32	0.32	#DIV/0!	#DIV/0!	0.32
													Sat curve rel to Q4	100	100	100	100	100	#DIV/0!	#DIV/0!	100
		Total	Qly index	100%	96%	85%	115%	100%	104%	#DIV/0!	#DIV/0!		Qly index	0.58	0.44	0.68	0.39	0.71	#DIV/0!	#DIV/0!	
			Saturation curve fit	100%	100%	101%	102%	103%	105%	#DIV/0!	#DIV/0!	1228%	Saturation curve fit	0.66	0.66	0.66	0.66	0.66	#DIV/0!	#DIV/0!	0.66
													Sat curve rel to Q4	100	100	100	100	100	#DIV/0!	#DIV/0!	100
	Saturday		Qly index	102%	102%	98%	110%	100%	112%	#DIV/0!	#DIV/0!		Qly index	0.49	0.82	1.05	0.58	0.97	#DIV/0!	#DIV/0!	
			Saturation curve fit	102%	103%	105%	107%	109%	113%	#DIV/0!	#DIV/0!	#############	Saturation curve fit	0.51	0.76	0.86	0.90	0.96	#DIV/0!	#DIV/0!	1.07
													Sat curve rel to Q4	57	84	95	100	106	#DIV/0!	#DIV/0!	118
	Sunday		Qly index	118%	120%	100%	106%	100%	133%	#DIV/0!	#DIV/0!		Qly index		0.67	0.73	0.24	1.21	#DIV/0!	#DIV/0!	
			Saturation curve fit	118%	119%	120%	122%	123%	127%	#DIV/0!	#DIV/0!	#############	Saturation curve fit	0.18	0.42	0.61	0.77	1.07	#DIV/0!	#DIV/0!	2.60
													Sat curve rel to Q4	24	54	79	100	139	#DIV/0!	#DIV/0!	337
700	Weekday	Evening	Qly index	59%	79%	97%	107%	100%	127%	145%	#DIV/0!		Qly index								
767			Saturation curve fit	59%	70%	85%	99%	108%	128%	149%	#DIV/0!	231%	Saturation curve fit								
766													Sat curve rel to Q4								
		Interpeak	Qly index	86%	88%	91%	92%	100%	98%	106%	#DIV/0!		Qly index	0.12	0.49	0.50	0.51	0.62	0.89	#DIV/0!	
			Saturation curve fit	86%	88%	90%	92%	94%	99%	106%	#DIV/0!	238%	Saturation curve fit	0.13	0.29	0.43	0.51	0.67	0.84	#DIV/0!	1.33
													Sat curve rel to Q4	26	57	85	100	133	165	#DIV/0!	263
		Peaks	Qly index	80%	91%	81%	100%	100%	101%	112%	#DIV/0!		Qly index	0.05	0.27	0.30	0.41	0.44	0.60	#DIV/0!	
			Saturation curve fit	80%	83%	87%	92%	95%	102%	112%	#DIV/0!	167%	Saturation curve fit	0.10	0.22	0.31	0.36	0.47	0.57	#DIV/0!	0.84
													Sat curve rel to Q4	28	59	86	100	129	157	#DIV/0!	231
		Total	Qly index	80%	89%	86%	98%	100%	102%	113%	#DIV/0!		Qly index	0.17	0.51	0.53	0.63	0.75	0.98	#DIV/0!	
			Saturation curve fit	80%	83%	88%	93%	96%	103%	113%	#DIV/0!	163%	Saturation curve fit	0.18	0.38	0.54	0.63	0.79	0.94	#DIV/0!	1.31
													Sat curve rel to Q4	29	61	87	100	126	150	#DIV/0!	209
	Saturday		Qly index	87%	96%	101%	107%	100%	119%	131%	#DIV/0!		Qly index	0.75	1.05	1.04	0.99	1.43	1.74	#DIV/0!	
			Saturation curve fit	87%	90%	96%	102%	106%	118%	134%	#DIV/0!	342%	Saturation curve fit	0.48	0.89	1.16	1.29	1.50	1.67	#DIV/0!	2.01
													Sat curve rel to Q4	37	70	91	100	117	130	#DIV/0!	156
	Sunday		Qly index	64%	81%	98%	99%	100%	116%	120%	#DIV/0!		Qly index	0.74	0.75	0.82	0.97	0.92	0.96	#DIV/0!	
			Saturation curve fit	64%	78%	92%	102%	106%	115%	123%	#DIV/0!	139%	Saturation curve fit	0.76	0.87	0.90	0.90	0.92	0.92	#DIV/0!	0.94
													Sat curve rel to Q4	84	96	99	100	101	102	#DIV/0!	104
901	Weekday	Evening	Qly index	16%	55%	76%	94%	100%	103%	#DIV/0!			Qly index	1.13	1.27	1.26	1.26	1.32	#DIV/0!	#DIV/0!	
			Saturation curve fit	16%	55%	78%	89%	95%	102%	#DIV/0!		115%	Saturation curve fit	1.11	1.25	1.29	1.31	1.32	#DIV/0!	#DIV/0!	1.35
													Sat curve rel to Q4	85	96	99	100	101	#DIV/0!	#DIV/0!	103
		Interpeak	Qly index	62%	85%	91%	99%	100%	109%	#DIV/0!			Qly index	0.35	0.52	0.53	0.63	0.68	#DIV/0!	#DIV/0!	
			Saturation curve fit	62%	81%	94%	100%	104%	108%	#DIV/0!		117%	Saturation curve fit	0.33	0.51	0.59	0.63	0.68	#DIV/0!	#DIV/0!	0.77
													Sat curve rel to Q4	52	81	93	100	107	#DIV/0!	#DIV/0!	122
		Peaks	Qly index	68%	83%	92%	87%	100%	100%	#DIV/0!			Qly index	0.25	0.36	0.39	0.39	0.46	#DIV/0!	#DIV/0!	
			Saturation curve fit	68%	82%	90%	94%	97%	99%	#DIV/0!		104%	Saturation curve fit	0.23	0.35	0.40	0.43	0.46	#DIV/0!	#DIV/0!	0.52
													Sat curve rel to Q4	53	81	93	100	107	#DIV/0!	#DIV/0!	121
		Total	Qly index	61%	82%	91%	93%	100%	104%	#DIV/0!			Qly index	0.31	0.45	0.48	0.51	0.57	#DIV/0!	#DIV/0!	
			Saturation curve fit	61%	79%	91%	96%	100%	103%	#DIV/0!		110%	Saturation curve fit	0.29	0.44	0.50	0.54	0.57	#DIV/0!	#DIV/0!	0.64
													Sat curve rel to Q4	55	82	93	100	106	#DIV/0!	#DIV/0!	119
	Saturday		Qly index	35%	77%	96%	103%	100%	106%	#DIV/0!			Qly index	0.39	0.64	0.66	0.56	0.66	#DIV/0!	#DIV/0!	
			Saturation curve fit	35%	77%	94%	100%	103%	106%	#DIV/0!		112%	Saturation curve fit	0.44	0.58	0.63	0.65	0.67	#DIV/0!	#DIV/0!	0.71
													Sat curve rel to Q4	67	89	96	100	103	#DIV/0!	#DIV/0!	110
	Sunday		Qly index	25%	63%	80%	94%	100%	102%	#DIV/0!			Qly index	0.56	0.64	0.68	0.74	0.74	#DIV/0!	#DIV/0!	
			Saturation curve fit	25%	64%	83%	90%	95%	99%	#DIV/0!		107%	Saturation curve fit	0.54	0.67	0.70	0.72	0.74	#DIV/0!	#DIV/0!	0.77
													Sat curve rel to Q4	74	92	97	100	102	#DIV/0!	#DIV/0!	107
900	Weekday	Evening	Qly index	11%	51%	88%	93%	100%	111%	139%	#DIV/0!		Qly index								
			Saturation curve fit	11%	37%	74%	92%	104%	121%	135%	#DIV/0!	165%	Saturation curve fit								
													Sat curve rel to Q4								
		Interpeak	Qly index	12%	51%	90%	103%	100%	112%	142%	#DIV/0!		Qly index								
			Saturation curve fit	12%	40%	78%	96%	108%	124%	137%	#DIV/0!	164%	Saturation curve fit								
													Sat curve rel to Q4	No elasticity estimates possible in this case, as no previous route package available for comparison purposes.							
		Peaks	Qly index	8%	41%	89%	96%	100%	109%	128%	#DIV/0!		Qly index								
			Saturation curve fit	8%	41%	78%	94%	104%	116%	126%	#DIV/0!	145%	Saturation curve fit								
													Sat curve rel to Q4								
		Total	Qly index	9%	45%	88%	97%	100%	111%	133%	#DIV/0!		Qly index								
			Saturation curve fit	9%	40%	77%	94%	105%	119%	130%	#DIV/0!	152%	Saturation curve fit								
													Sat curve rel to Q4								
	Saturday		Qly index	12%	52%	88%	101%	100%	112%	149%	#DIV/0!		Qly index								
			Saturation curve fit	12%	33%	69%	89%	104%	127%	149%	#DIV/0!	203%	Saturation curve fit								
													Sat curve rel to Q4								
	Sunday		Qly index	9%	58%	87%	98%	100%	112%	145%	#DIV/0!		Qly index								
			Saturation curve fit	9%	34%	71%	91%	105%	125%	144%	#DIV/0!	186%	Saturation curve fit								
													Sat curve rel to Q4								
903	Weekday	Evening	Qly index	39%	76%	93%	111%	100%	#DIV/0!	#DIV/0!			Qly index								
			Saturation curve fit	39%	78%	94%	98%	102%	#DIV/0!	#DIV/0!		110%	Saturation curve fit								
													Sat curve rel to Q4								
		Interpeak	Qly index	40%	92%	96%	104%	100%	#DIV/0!	#DIV/0!			Qly index								
			Saturation curve fit	40%	93%	98%	99%	100%	#DIV/0!	#DIV/0!		101%	Saturation curve fit								
													Sat curve rel to Q4	No elasticity estimates possible in this case, as no previous route package available for comparison purposes.							
		Peaks	Qly index	36%	89%	99%	88%	100%	#DIV/0!	#DIV/0!			Qly index								
			Saturation curve fit	36%	90%	96%	97%	97%	#DIV/0!	#DIV/0!		99%	Saturation curve fit								
													Sat curve rel to Q4								
		Total	Qly index	37%	88%	97%	96%	100%	#DIV/0!	#DIV/0!			Qly index								
			Saturation curve fit	37%	89%	96%	98%	98%	#DIV/0!	#DIV/0!		101%	Saturation curve fit								
													Sat curve rel to Q4								
	Saturday		Qly index	#N/A	90%	95%	98%	100%	#DIV/0!	#DIV/0!			Qly index								
			Saturation curve fit	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#DIV/0!		#N/A	Saturation curve fit								
													Sat curve rel to Q4								
	Sunday		Qly index	12%	93%	96%	114%	100%	#DIV/0!	#DIV/0!			Qly index								
			Saturation curve fit	12%	93%	101%	102%	103%	#DIV/0!	#DIV/0!		105%	Saturation curve fit								
													Sat curve rel to Q4								

Notes: (1). Relates to average daily patronage in quarter relative to Q4=100. Excludes any seasonality adjustments or control route adjustments.
(2). Day type definitions: Weekday--school term days only; Saturday--all Sat'days; Sunday--all Sundays. Weekday time period definitions: Evening 1900-2159 departures; Interpeak 1000-1459 arrivals; Peaks 0700-0859 arrivals, 1500-1759 departures.
(3). Relates to average patronage index in period immediately after (remainder of the month) in which service change was introduced.

H3.3.2 Q4 elasticities by time period and route

Table H.5a summarises (from table H.4) the Q4 saturation curve 'own period' elasticity estimates by time period for each of the four SmartBus initiatives for which elasticities could be derived.

We make the following comments on these results:

- While there are a few apparent 'outliers', the level and pattern of elasticity results across the four routes is fairly consistent: for weekday total, interpeak and peak periods and for Sundays, all the individual results are within 15%–20% of the (unweighted) average values. This is regarded as a relatively narrow range, particularly given the differences in the characteristics of the various SmartBus routes[78].
- By day type, in all four cases weekend elasticities are greater than weekday total elasticities. Saturday and Sunday elasticities are not sensibly distinguishable on the limited data available.
- Within weekdays, in all cases:
  - evening elasticities are greater than interpeak elasticities (typically by a factor of c.2.0)
  - interpeak elasticities are greater than peak elasticities (typically by a factor between 1.0 and 1.8).
- Taking the unweighted averages for the four routes, we get the following average values, as shown in the 'averages – base' column of table H.5a:
  - peak 0.40 (68% of weekday total)
  - interpeak 0.55 (93% of weekday total)
  - evening 1.16 (197% of weekday total)
  - weekend 0.85 (144% of weekday total).

H3.3.3 Interpretation of elasticity estimates and differences between routes

The SmartBus initiatives involved a package of service frequency improvements together with other service enhancements, including:

- real time bus arrival information at major stops
- significant bus stop upgrades, including new shelters, hardstands, higher visibility totems
- bus priority measures designed to improve bus travel times and reliability
- local marketing campaigns to promote the upgraded services.

---

[78] Given the underlying variability in the validation data, our judgement is that differences between the routes within such relatively narrow ranges may well not be statistically significant.

Table H.5a SmartBus elasticity summary (Q4)

Time period analysed		SmartBus Route No.					
Day	Time period	888/889	703	700 (+766/7)	901	Averages	
						Base	Adjusted (1)
Weekday	Evening	1.20	0.96		1.31	**1.16**	**0.77**
	Interpeak	0.51	0.57	0.51	0.63	**0.55**	**0.37**
	Peaks	0.48	0.32	0.36	0.43	**0.40**	**0.27**
	Total	0.52	0.66	0.63	0.54	**0.59**	**0.39**
Saturday		0.67	0.90	1.29	0.65	**0.88**	
							0.57
Sunday			0.77	0.90	0.72	**0.80**	

Notes: (1). Previous column multiplied by 0.67 (refer text)

Table H.5b Summary of service frequencies, service increases and Q4 elasticitiesand patronage increases

Day	Time period	Route	Before Service Frequency(1) -Ave trips/hr	Service Increase --% Bus km	Service Elast (Q4)	Effect Pax Increase--% (Q4)
Weekday	Evening	888/889		1000%	1.20	1671%
		703		62%	0.96	59%
		700		#DIV/0!		#DIV/0!
		901		305%	1.31	522%
		Ave--All			**1.16**	
		Ave--Adj (2)			**1.13**	
	Interpeak	888/889	3.0	100%	0.51	42%
		703	3.1	39%	0.57	21%
		700	6.1	26%	0.51	12%
		901	5.3	115%	0.63	62%
		Ave--All			**0.55**	
		Ave--Adj				
	Peaks	888/889	2.8	93%	0.48	37%
		703	4.0	32%	0.32	9%
		700	6.5	43%	0.36	14%
		901	6.0	157%	0.43	50%
		Ave--All			**0.40**	
		Ave--Adj				
	Total	888/889	3.0	110%	0.52	47%
		703	3.4	24%	0.66	15%
		700		31%	0.63	19%
		901	4.6	159%	0.54	67%
		Ave--All			**0.59**	
		Ave--Adj				
Saturday		888/889	1.0	261%	0.67	137%
		703	1.6	35%	0.90	32%
		700		33%	1.29	45%
		901	2.2	313%	0.65	152%
		Ave--All			**0.88**	
		Ave--Adj				
Sunday		888/889		#DIV/0!		#DIV/0!
		703	1.1	40%	0.77	30%
		700		115%	0.90	100%
		901	1.8	367%	0.72	205%
		Ave--All			**0.80**	
		Ave--Adj				

Notes: (1) Represents total 'before' trips/hour (ave both directions) on the route package assessed.
(2) Adjusted average values exclude the less reliable results shaded.

There is no evidence available (from 'after' market research etc) on the proportion of the SmartBus package benefits relating to the service frequency improvements, which would allow adjustments of our estimated total elasticities to represent the service frequency improvements alone. However, the report for DoT (SKM 2004) on the review of SmartBus trial made the following comments:

> *It is not possible to attribute patronage increases proportionally to the various project components (service span and frequency improvements, stop upgrades, real time information, etc) because the market research data does not allow a clear allocation of proportions of users to different causes. However, it is clear from the analysis and discussions that the majority of benefits come from the increased service levels, which give*
>
> *rise to time savings (including waiting time savings) for existing users and are also the primary reason that new users are attracted to the services.* (SKM (2004) Review of SmartBus trial. Final draft report to DoT, Victoria)

The economic evaluations undertaken in this report for SmartBusroutes 703 and 888/9 indicated that between about 50% and 60% of the total user benefits for each scheme were the savings in average waiting time, which is the direct result of the increased service frequencies[79].

We consider that this 50%–60% factor is likely to be on the low side for the group of four SmartBus routes for which elasticities have been derived. As an indicative best estimate of factors across the four routes, we suggest a factor of 0.67 be applied to the 'raw' elasticity estimates derived to represent the 'true' service frequency component. These factored elasticity results are included in table H.5a (RH column), with the following average values:

- weekday evening 0.77
  - interpeak 0.37
  - peak 0.27
  - total 0.39
- Saturday/Sunday 0.57

These figures should be regarded as no more than indicative, but are considered to be a better guide to the 'true' service frequency elasticities (Q4) associated with the SmartBus routes than the 'raw' estimates derived initially.

H3.3.4 Effects of initial service frequency and extent of service changes

We inspected the table H.5a elasticity results in the light of the table H.1 statistics, to assess whether there was any clear pattern of elasticity variations with A) before service frequency, or B) % service increase. The relevant data is summarised in table H.5b. It was obvious there would be considerable difficulties in identifying any such patterns of variation, given that for each time period elasticity estimates were available for only four routes and the ranges of these estimates were quite narrow:

A **Service frequency – w**ithin each time period, the before service frequencies typically varied by a factor of around 2.0. However, the narrow range of the elasticity estimates was such that there was clearly no statistical correlation between the service frequency and the elasticity estimates.[80]

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[79] The other components of the user benefits related to reliability improvements (c.25%), improved information (c.10%) and faster in-vehicle travel (c.10%).

[80] A priori, the expectation was that elasticities would reduce as service frequencies increased (eg the percentage patronage response from a frequency change from six buses/hour to 12 buses/hour would be less than from a change from one bus/hour to two buses/hour).

B **Service increase** – the service (bus km) increases varied over a wide range, from about 25% to some 10 times. However, given the narrow range of the elasticity estimates within each time period, it was again not possible to identify any statistically significant correlation between the proportionate service increase and resulting elasticity.

These aspects are re-visited in section H4, where a larger dataset of elasticity values is analysed.

H3.3.5 Effects of route 'package' analysed

As noted earlier (sections H2.4 and H3.1), our SmartBus analyses covered a 'package' of routes on which patronage was expected to be affected by the SmartBus initiative: the routes included in these packages are listed in table H.1.

To examine the typical sensitivity of elasticity results to the composition of the route package, for SmartBus route 700 we estimated elasticities for three package alternatives: route 700 alone, routes 700 + 767, and routes 700 + 767 + 766. Table H.6 provides a summary of the results, and these are discussed in the form of pair-wise comparisons, as follows:

- **Routes 700/767 v route 700 alone.** For the weekday time periods, the estimated elasticity values reduced by between some 10% and 25% when route 767 was included. It appears that, on the introduction of the SmartBus initiative, some passengers switched from route 767 to the improved route 700. Thus, if the analyses considered the effects of route 700 alone, the (net) elasticity would be overestimated: a truer value was obtained by considering both routes together. It is unclear why a different pattern of results was found for Saturdays.
- **Routes 700/767/766 v 700/767.** As above, and for all time periods, the estimated elasticity values reduced, by between about 15% and 40%, when route 766 was included. This result would suggest that the average loadings on route 766 (which was a new route introduced at the same time as the SmartBus initiative) were significantly lower than the incremental loadings on route 700 resulting from the SmartBus initiative.

These results confirmed the importance of taking account of any significant patronage effects on potentially competing and complementary routes when estimating service frequency elasticities. Given that the inclusion in the package of both route 767 and route 766 had significant effects on the elasticity estimates, all our main analyses focused on the full package of routes 700/767/766.

H3.3.6 Elasticity changes over time from service change

All the preceding SmartBus analyses focused on the elasticity estimates for Q4 (ie average of months 10, 11 and 12 following the service change). In this section, we summarise the evidence (drawn from table H.4) on how elasticities vary over time, relative to the Q4 values.

Table H.7 shows, for each time period and SmartBus route, the average elasticity (saturation curve values), relative to Q4 = 100, by quarters, years and in the long run ('saturation' level). For each time period (and for all periods together), it includes the average of the values for each route, and an adjusted average omitting apparently anomalous results: the following commentary focuses on these adjusted averages.

Over all time periods and routes, the average (adjusted) elasticity values relative to Q4 (=100) are:

Q1 66%

Q2 88%

Q3 96%

Q4 100%

Y2 (Q5–Q8) ave 104%

Y3 (Q9–Q12) ave 108%

Y4 (Q13–Q16) ave 109%

Long run 113%.

Figure H.1 plots these all-period averages and also shows the corresponding averages for the separate periods. Given the variability between routes of the results for each quarter, our judgement is that these apparent differences in growth trends between the various time periods are most likely not significant. However, they do illustrate the range of growth trend results that might be expected.

Further comments are provided on elasticity growth trends over time in the context of the span analyses in the next section.

Table H.6 Smartbus elasticity estimates (Q4) – effects of route package assessed

Time period analysed		SmartBus Route Package			
Day	**Time period**	**700**	**700+767**	**700+767 766**	**Notes**
Weekday	Evening	--	--	--	No eve services prior to SB introduction--elast estimates not possible.
	Interpeak	1.10	0.85	0.51	
	Peaks	0.52	0.43	0.36	
	Total	0.80	0.73	0.63	
Saturday		1.51	1.75	1.29	
Sunday		0.90	0.90	0.90	No Sunday services on routes 767,766.

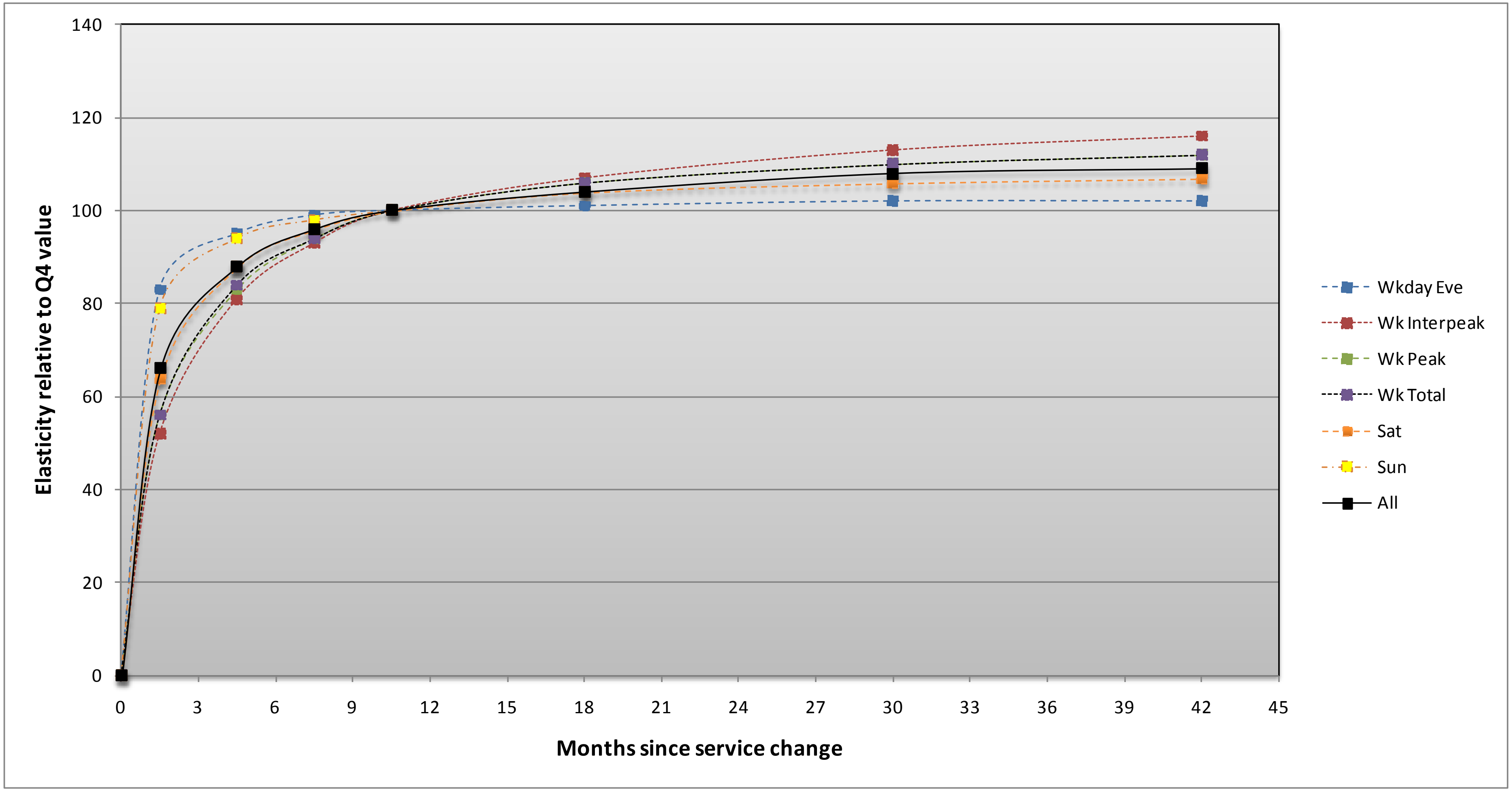
Route 766 introduced at same time as route 700 upgraded to SB standards (June 05)
Route 767 not changed at time of SB introduction--but upgraded subsequently, Oct 06 (upgrading not included in service change calculation).

Table H.7 Elasticities relative to Q4 values (saturation curve values)

Time period		Route	Elasticity relative to Q4=100							
Day	Time period		Q1	Q2	Q3	Q4	Q5-Q8 (2nd yr)	Q9-Q12 (3rd yr)	Q13-Q16 (4th yr)	Long-run
Weekday	Evening	888/889	87	97	99	100	101	102	102	103
		703	78	94	98	100	102	#DIV/0!	#DIV/0!	106
		700/766/7								
		901	85	96	99	100	101	#DIV/0!	#DIV/0!	103
		Ave--All	**83**	**95**	**99**	**100**	**101**	**102**	**102**	**104**
		Ave--Adj (1)								
	Interpeak	888/889	53	81	94	100	108	113	116	122
		703	100	100	100	100	100	#DIV/0!	#DIV/0!	100
		700/766/7	26	57	85	100	133	165	#DIV/0!	263
		901	52	81	93	100	107	#DIV/0!	#DIV/0!	122
		Ave--All	58	80	93	100	112	#DIV/0!	#DIV/0!	152
		Ave--Adj (1)	**52**	**81**	**93**	**100**	**107**	**113**	**116**	**122**
	Peaks	888/889	58	85	95	100	106	110	112	117
		703	100	100	100	100	100	#DIV/0!	#DIV/0!	100
		700/766/7	28	59	86	100	129	157	#DIV/0!	231
		901	53	81	93	100	107	#DIV/0!	#DIV/0!	121
		Ave--All	60	81	93	100	110	#DIV/0!	#DIV/0!	142
		Ave--Adj (1)	**56**	**83**	**94**	**100**	**106**	**110**	**112**	**119**
	Total	888/889	58	85	95	100	106	110	112	117
		703	100	100	100	100	100	#DIV/0!	#DIV/0!	100
		700/766/7	29	61	87	100	126	150	#DIV/0!	209
		901	55	82	93	100	106	#DIV/0!	#DIV/0!	119
		Ave--All	61	82	94	100	110	#DIV/0!	#DIV/0!	136
		Ave--Adj (1)	**56**	**84**	**94**	**100**	**106**	**110**	**112**	**118**
Saturday		888/889	69	90	97	100	104	106	107	110
		703	57	84	95	100	106	#DIV/0!	#DIV/0!	118
		700/766/7	37	70	91	100	117	130	#DIV/0!	156
		901	67	89	96	100	103	#DIV/0!	#DIV/0!	110
		Ave--All	57	83	94	100	107	#DIV/0!	#DIV/0!	123
		Ave--Adj (1)	**64**	**88**	**96**	**100**	**104**	**106**	**107**	**112**
Sunday		888/889								
		703	24	54	79	100	139	#DIV/0!	#DIV/0!	337
		700/766/7	84	96	99	100	101	102	#DIV/0!	104
		901	74	92	97	100	102	#DIV/0!	#DIV/0!	107
		Ave--All	61	81	92	100	114	#DIV/0!	#DIV/0!	182
		Ave--Adj (1)	**79**	**94**	**98**	**100**	**102**	**#DIV/0!**	**#DIV/0!**	**105**
All periods		888/889	67	88	96	100	105	108	109	113
		703	53	77	91	100	116	#DIV/0!	#DIV/0!	187
		700/766/7	44	71	90	100	120	139	#DIV/0!	188
		901	66	88	96	100	104	#DIV/0!	#DIV/0!	112
		Ave--All	62	83	94	100	109	**#DIV/0!**	**#DIV/0!**	140
		Ave--Adj (1)	**66**	**88**	**96**	**100**	**104**	**108**	**109**	**113**

Notes: (1) Adjusted average values exclude the 'anomalous' results shaded.

Figure H.1 SmartBus elasticity growth patterns over time (relative to Q4 values)



H4 Service span analyses

H4.1 Service changes assessed

This chapter presents our assessment of the patronage impacts of a large number of service span ('safety net') initiatives implemented in the period September 2006–May 2008. These initiatives predominantly involved extending the hours in which services were provided in the evenings, from finishing in the early evening to finishing in the mid-evening. They covered weekday, Saturday and (in a few cases) Sunday services.

Figure H.2 provides a categorisation of the weekday and weekend changes examined. It shows that, in a number of cases, data deficiencies (including the lack of any evening 'before' services) were such that reliable elasticity estimates could not be derived; and, for the other cases, it categorises them according to the type of service change involved. In summary, of the types of service change:

- In total, 44 cases were examined for weekdays and 39 for weekends (of which three related to Sundays, the remainder to Saturdays)[81].
- Out of these totals, it was possible to estimate robust evening elasticities for 30 weekday cases and 25 weekend cases.
- For both weekdays and weekends, the main category of changes involved an extension of the service span in the evenings, typically from the last service operating in the period 1800–1900 to the last service operating in the period 2100–2200, accompanied by some service frequency increases in the early evening period. Typical service frequencies were set at about two trips per hour (each direction) in this extended evening period. Other, lesser, changes were made to services earlier in the day in some cases.
- A minority of these evening span increases were accompanied by service span (and/or frequency) increases at the beginning of the day (prior to the AM peak).
- Also, in a few weekend cases where services had previously finished around Saturday lunchtime/early PM, these were extended to operate through until mid-evening (c.2100).

The service changes assessed are listed in detail in table H.8 (weekdays) and table H.9 (weekends). These tables include:

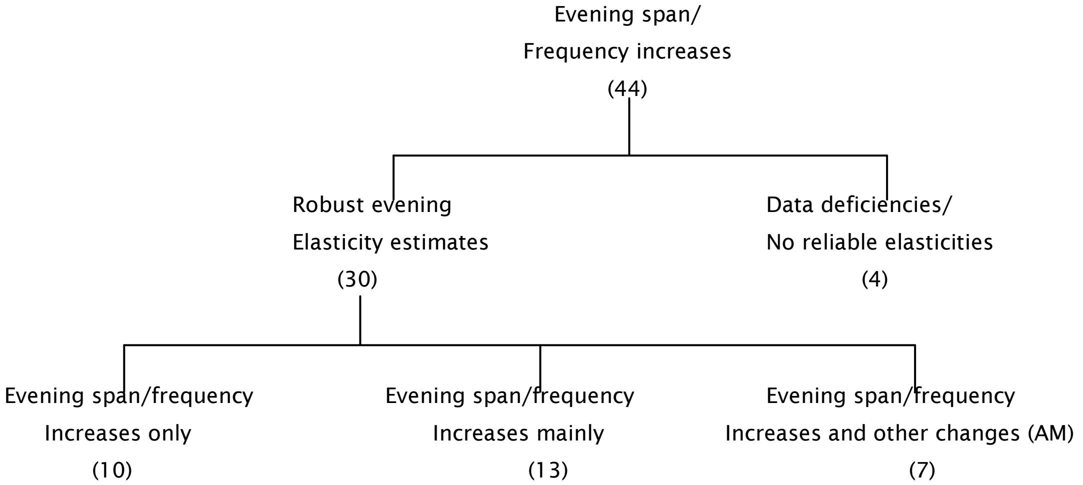
- date of service change
- length of route
- initial bus trips per day (evening, total)
- % increase in bus trips per day (evenings, total).

As for the SmartBus analyses, a group of control routes was defined for each service change examined: four separate control route groups were used (inner, middle, outer, eastern freeway), according to the area in which the service being examined was located.

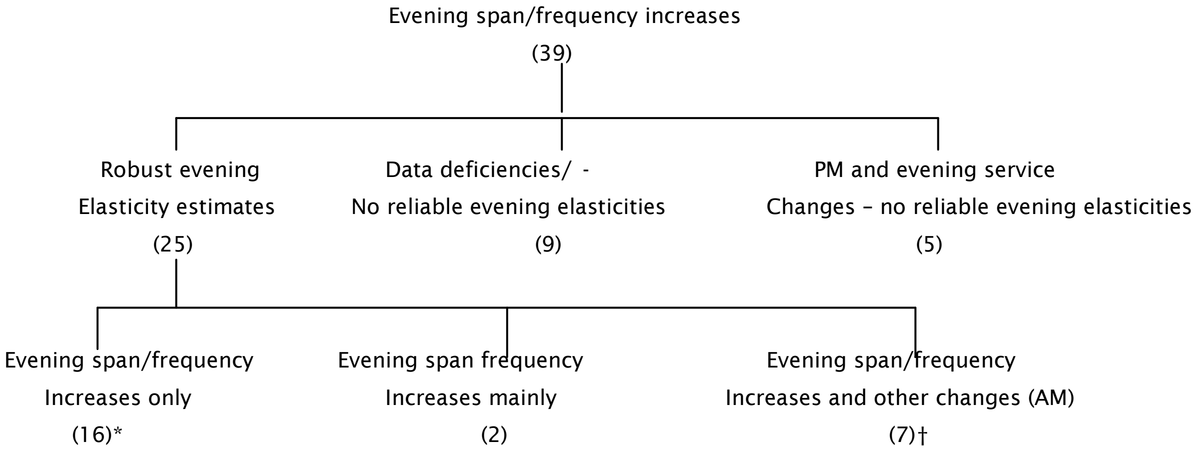
[81] Given the very limited sample of Sunday cases, these cases have been combined with the Saturday cases for analysis purposes.

Figure H.2 Overview of service span changes examined

Weekday service changes



Weekend service changes



* Includes one Sunday route

† Includes two Sunday routes

H4.2 Analysis methodology

H4.2.1 Approach

Given that in all cases the service changes predominantly affected the evening services[82], the main focus of data analyses was to examine the effects of the evening service changes on patronage, both in the evenings and earlier in the day, and where possible to derive relevant service elasticity estimates.

Three elasticity measures were examined, as outlined in table H.10. For reasons outlined in this table, our analyses concentrated primarily on the evening 'own period' measure A; while estimates for evening 'total' elasticity B and daily elasticity C were derivable only in limited cases. In addition, we derived a number of patronage-related measures for the 'after' patronage levels in the evening period, as described in the next section.

H4.2.2 Data inputs

Table H.11 summarises the main data inputs to the before/after patronage and elasticity analyses.

H4.2.3 Analyses

The main steps in the analyses were as follows:

1 Calculate % increase in service levels (bus trips) for each span route, for evenings and total day (as tables H.8 and H.9).

2 Calculate average (daily) evening validations (for each route and corresponding control routes) by month/quarter,[83] over the full analysis period.

3 Compare average evening validations for each month/quarter after the service change with the corresponding number in the comparable month/quarter in the 12 months prior to the change, thus deriving a route patronage index.

4 Undertake similar calculations for the relevant control route group, to derive a control patronage index.

5 Calculate the ratio of these two patronage indices to derive an adjusted route patronage index (allowing for control route trends).

6 Derive the service elasticity for each of the three elasticity definitions (table H.10) for each month/quarter as the ratio: ln (patronage index)/ln (service index) (refer sections H2.5 and H2.6).[84]

7 For Q4 only, derive average route patronage **by hour** throughout the day on three bases i) before the service change (ie Q-1); ii) after the service change (ie Q4); and iii) after the service change adjusted for control route patronage changes (ie Q4 adjusted). (These outputs were plotted (histograms) for each route to allow more detailed examination of the patronage changes by hour of day, and hence to facilitate judgements as to the extent to which the results appeared to be affected by external factors influencing patronage.)

8 Also, for Q4 only, derive four measures of evening patronage levels for each route, as detailed below.

[82] For this section, 'evening' services were defined as all services starting at or after 1800.

[83] Months were grouped into quarters, with Q1 (months 1–3) starting at the beginning of the first new month following the service change.

[84] Unlike for the SmartBus analyses, in these span analyses a saturation curve was not fitted to the elasticity results to show the trends over time.

Table H.10 Elasticity measures examined

B Evening 'total' elasticity	Numerator: change in total daily patronage/ initial evening patronage Denominator: % change in evening service level (bus trips operated)	• By taking into account changes in patronage earlier in the day, should give a more complete measure of the impacts of evening service changes – hence would generally expect higher elasticity values than measure A. • Can only be used to assess these impacts in cases of change in evening services only (a large proportion of the cases examined). • In practice, found in most cases that the daytime patronage was being affected by undefined external influences (not addressed through control routes) more than by any likely daytime impacts of the evening service changes. Hence not possible in these cases to derive reasonably robust elasticity estimates.
C Daily elasticity	Numerator: % change in total daily patronage Denominator: % change in total daily service level (bus trips operated)	• This is the 'normal' measure of daily elasticity. • To the extent that the service changes examined are entirely/predominantly to evening services, in effect gives a daily service elasticity relating to evening service changes. • This is considered to be a not very useful concept, not readily transferable between situations: the values would generally be significantly lower than values under measure A (as evening patronage levels/bus trip are generally considerably lower than the daily average levels). • For the same reasons as given above (measure B), it was found in practice to be not possible in most cases to derive reasonably robust elasticity estimates on this measure.
A Evening 'own period' elasticity	Numerator: % change in evening patronage Denominator: % change in evening service level (bus trips operated)	• Main focus of elasticity analyses. • Covers patronage changes in evenings only, hence likely to understate the true impacts of service increases (refer measure B). • Given the large % increases in evening services in most cases, would expect that reasonably robust elasticity estimates could be obtained (undefined external influences on patronage likely to have relatively small effects). • In some cases, no initial services operated after 1800, hence no elasticity estimate possible; in other cases, were very few initial services after 1800, hence elasticity derivable but may be less robust. Also arguable whether the market in the mid-evening (eg 2100–2200) is similar in behaviour to that in the early evening (eg 1800–1900).

Table H.11 Main span analysis inputs

Item	Comments
Span routes	Refer tables H.8 and H.9 and section H4.1.
Control route groups	Refer table H.2 and section H4.1.
Time periods	• Separate analyses for weekday, Saturday, Sunday cases. • Evening defined to cover services starting at/after 6pm.
Service level (evening) – before/ after	Defined as number of (one-way) trips on route starting in evening period.
Service level (daily) – before/ after	Defined as number of (one-way) trips on route over whole day.
Extent of service change (%)	Ratio of above two items (evening and daily).
Period of analysis	For each span initiative, before patronage data covered a period of 12 months minimum prior to the service change; after patronage data covered a period of at least 12 months, but as long as possible after the change (given the service change dates, in most cases maximum after period was two or three years).
Patronage data	• Monthly validations data (provided by DoT) by route and hour of day, by day type (weekday term, weekday holiday[a], Saturday, Sunday), with tabulation of number of days by day type in each month. Data provided covered years 2004–2010. • Initial analyses derived average daily validations by route, by day type, by hour by month.

[a] Weekday holiday data was not used in the analyses undertaken.

H4.3 Results and commentary

H4.3.1 Results overview

The results for each service span change are shown in tables H.12 (weekday) and H.13 (weekend). These include:

- increase in bus trips (%), for both evenings and total day
- evening patronage rates for Q4 after the service change, in terms of:
  - total evening patronage per day
  - total evening patronage per hour (in which service operates)
  - total evening patronage per bus trip
  - total evening patronage per bus km
- elasticity estimates for Q4, based on the three elasticity measures set out in table H.10
- elasticity estimates, based on measure A (evening 'own period' elasticity), over time by quarter and year
- evening 'own period' elasticity estimates expressed relative to Q4 = 100.

The following summary of results and commentary relates to the elasticity values and patronage rates given in these tables for each service span change and to supplementary analyses of these sets of results.

H4.3.2 Evening (Q4 'own period') elasticity results

Table H.14 summarises the mean Q4 'own period' evening elasticity estimates for the weekday and weekend service span changes. The corresponding distributions of these estimates are illustrated in figures H.3a (weekday) and H.3b (weekend).

We make the following comments:

- We examined the weekday elasticity values to check whether their mean values differed significantly between service changes involving i) evening changes only, ii) evening changes predominantly, and iii) both evening and early AM changes. The differences between these three mean values were small and not significant. Hence all the results (for both the weekday and weekend cases) were considered in a single group.
- The weekend mean value was approximately 50% greater than the weekday mean value. From inspection of the two distributions, this difference is clearly significant.

H4.3.3 Potential factors influencing evening (Q4, own period) elasticity results

Of interest is whether elasticity values were affected by:

- the extent of the service increases in each case
- the absolute evening level of services (total trips), either before or after the service increase.

In regard to this first potential effect, we examined whether there was a significant relationship between the extent of the evening service increase (in terms of % increase in evening trips) and the resultant Q4 elasticity. The relationships are shown in figures H.4a (weekday) and H.4b (weekends). These analyses indicated a very slight positive relationship in both cases, but neither of these were statistically significant (different from zero).

In regard to the second potential effect above, inspection of the data also indicated no significant relationships between the level of service (either before or after the change) and the Q4 elasticity.

H4.3.4 Evening patronage performance

Table H.15 (drawn from the detailed data in tables H.12 and H.13) presents key performance statistics for evening patronage measures for both the weekday and weekend (principally Saturday) services that were subject to span increases, in the fourth quarter (months 10–12) after these increases.

Findings of interest are:

- **Passengers/day.** The weekday mean value was 107 pax/day, with weekend service values being typically around 30% lower than weekday values.
- **Passengers/hour. T**he pattern was similar to that for passengers/day (most of the increased services operate for four hours in the evenings).
- **Passengers/trip.** Here the values for the weekday and weekend services were closer, with the mean value being slightly above nine passengers/trip for both weekdays and weekends. On both day types, about half the routes averaged 7.5 or fewer evening passengers/trip.
- **Passengers/bus km.** Here the values for the weekday and weekend services were again fairly close, with the mean for both day types being around 0.5–0.6 passengers/bus km (with the weekend values slightly higher than the weekday values). About 25% of the routes had values below about 0.3, and 25% values above about 0.65. (These may be compared with average values for all Melbourne bus services over all time periods of around 1.0.)

Table H.12 Weekday span changes

Route of interest	Time of day	Date of service change	Type of service change	Route km (ave each direction)	Control routes	Initial trips: Evening	Initial trips: Tot daily	% increase in trips: Evening	% increase in trips: Tot daily	Hr of last service: Before	Hr of last service: After	Evening pax in 4th quarter: Evening pax per day	Evening pax per hr	Evening pax per trip	Evening pax per bus km	Q4 Elasticities: %Δ in evening pax, relative to %Δ in evening service level	Δ in tot daily pax as a % of initial eve pax, rel to %Δ in eve service level	%Δ in tot daily pax, relative to %Δ in tot service level	Evening elasticity through time: Q1	Q2	Q3	Q4	Q5-8	Q9-12	Q13-16	Evening elasticity through time, as a % of Q4: Q1	Q2	Q3	Q4	Q5-8	Q9-12	Q13-16
670	Weekdays	May-07	Eve (span/freq) only	16.1	outer	9	70	44%	6%	19	21	131.1	32.8	10.1	0.63	0.32	-0.50	-0.26	-0.04	0.47	0.59	0.32	0.49	0.46		-14%	147%	183%	100%	155%	145%	
690	Weekdays	May-08	Eve (span/freq) only	15.7	outer	6	49	50%	6%	20	20	51.6	17.2	5.7	0.36	0.46	0.55	0.21	0.24	0.19	0.15	0.46	0.45			51%	41%	32%	100%	97%		
425	Weekdays	Sep-06	Eve (span/freq) only	11.5	outer	2	40	250%	13%	18	21	68.7	17.2	9.8	0.85	0.59	0.85	0.96	0.33	0.52	0.62	0.59	0.59	0.64	0.59	56%	87%	105%	100%	100%	108%	99%
693	Weekdays	Oct-06	Eve (span/freq) only	28.1	outer	3	47	267%	17%	18	21	79.5	19.9	7.2	0.26	0.61	0.76	0.46	0.24	0.49	0.38	0.61	0.52	0.50		40%	80%	63%	100%	85%	81%	
567	Weekdays	Apr-08	Eve (span/freq) only	13.1	inner	6	73	217%	18%	19	21	146.9	36.7	7.7	0.59	0.63	1.04	0.88	0.49	0.58	0.60	0.63	0.66			78%	92%	95%	100%	105%		
419	Weekdays	Sep-06	Eve (span/freq) only	14.8	outer	4	54	125%	9%	19	21	62.7	15.7	7.0	0.47	0.68	0.12	-0.06	0.07	0.42	0.68	0.68	0.62	0.71	0.81	11%	62%	99%	100%	91%	103%	119%
555	Weekdays	Jun-07	Eve (span/freq) only	13.5	middle	8	75	113%	12%	19	21	82.2	20.5	4.8	0.36	0.72	0.55	0.10	0.62	0.79	0.56	0.72	0.79	1.05		85%	109%	77%	100%	109%	144%	
564	Weekdays	Apr-08	Eve (span/freq) only	14.3	outer	7	66	100%	11%	19	21	86.1	21.5	6.1	0.43	0.78	1.79	1.45	0.82	0.48	0.72	0.78	0.58			104%	62%	92%	100%	74%		
552	Weekdays	Apr-08	Eve (span/freq) only	13.5	middle	7	98	86%	6%	19	21	142.1	35.5	10.9	0.81	0.85	1.54	1.03	0.19	0.42	0.91	0.85	0.83			23%	49%	106%	100%	98%		
307	Weekdays	Sep-06	Eve (span/freq) only	27.0	E Fwy	6	63	100%	10%	19	21	317.4	79.4	26.5	0.98	0.87	-0.13	0.41	0.70	1.04	0.87	0.87	0.98	0.94	0.97	81%	119%	100%	100%	113%	108%	111%
563	Weekdays	Oct-06	Eve (span/freq) mainly	33.1	outer	7	58	71%	10%	19	21	82.9	20.7	6.9	0.21	0.35	-0.45	-0.17	0.58	0.33	0.42	0.35	0.16	0.41		166%	96%	121%	100%	45%	116%	
765	Weekdays	May-08	Eve (span/freq) mainly	16.1	middle	6	66	83%	9%	19	21	160.5	40.1	14.6	0.91	0.44	0.89	0.73	0.19	0.41	0.39	0.44	0.61			43%	92%	88%	100%	138%		
753	Weekdays	May-08	Eve (span/freq) mainly	23.7	outer	8	75	50%	5%	19	21	105.5	26.4	8.8	0.37	0.46	1.72	1.21	0.05	0.18	0.43	0.46	0.39			12%	40%	94%	100%	84%		
785	Weekdays	Mar-08	Eve (span/freq) mainly	25.1	outer	2	26	300%	31%	18	22	54.3	10.9	6.8	0.27	0.51	-0.38	-0.13	0.07	0.22	0.30	0.51	0.45			13%	44%	60%	100%	88%		
553	Weekdays	Apr-08	Eve (span/freq) mainly	9.8	middle	2	50	350%	10%	18	21	29.1	7.3	3.2	0.33	0.55	-0.92	-0.34	0.83	0.71	0.74	0.55	0.80			152%	131%	136%	100%	147%		
755	Weekdays	May-08	Eve (span/freq) mainly	23.7	outer	5	56	80%	9%	19	21	67.5	16.9	7.5	0.32	0.61	1.49	0.68	-0.08	0.42	0.29	0.61	0.56			-13%	69%	47%	100%	91%		
850	Weekdays	May-07	Eve (span/freq) mainly	18.5	middle	5	55	100%	9%	19	20	173.2	57.7	17.3	0.93	0.64	0.49	0.33	0.36	0.52	0.60	0.64	0.66	0.69		57%	82%	94%	100%	103%	108%	
742	Weekdays	May-08	Eve (span/freq) mainly	28.7	middle	10	78	50%	8%	19	21	212.8	53.2	14.2	0.50	0.64	1.21	0.73	0.21	0.62	0.40	0.64	0.73			33%	96%	63%	100%	114%		
556	Weekdays	Jun-07	Eve (span/freq) mainly	19.1	middle	7	76	100%	9%	19	21	96.5	24.1	6.9	0.36	0.73	0.86	0.31	0.63	0.53	0.96	0.73	0.75	1.04		87%	72%	131%	100%	103%	142%	
475	Weekdays	Jun-07	Eve (span/freq) mainly	12.6	middle	9	66	67%	11%	19	21	64.2	16.1	4.3	0.34	0.78	1.53	0.52	0.45	0.63	0.52	0.78	0.67	0.90		58%	81%	67%	100%	85%	116%	
412	Weekdays	Mar-08	Eve (span/freq) mainly	23.8	middle	8	52	50%	6%	20	21	151.5	37.9	12.6	0.53	0.91	0.79	0.53	0.64	0.55	0.83	0.91	0.67			69%	60%	91%	100%	73%		
708	Weekdays	Oct-06	Eve (span/freq) mainly	29.5	middle	4	55	150%	20%	18	21	128.9	32.2	12.9	0.44	0.93	1.40	0.41	1.03	0.97	0.95	0.93	1.05	1.13		111%	104%	102%	100%	113%	122%	
824	Weekdays	Oct-06	Eve (span/freq) mainly	22.2	middle	6	81	100%	7%	19	21	198.1	49.5	16.5	0.75	1.01	1.05	0.66	0.44	0.67	0.92	1.01	0.97	0.99		43%	66%	91%	100%	96%	98%	
736	Weekdays	May-08	Eve (span/freq) mainly + AM	29.2	middle	7	52	57%	10%	19	21	157.9	39.5	14.4	0.49	0.47	0.88	0.61	0.37	0.28	0.58	0.47	0.64			78%	58%	123%	100%	135%		
440	Weekdays	May-07	Eve (span/freq) mainly + AM	#N/A	outer	6	47	67%	13%	19	21	90.2	22.6	9.0	#N/A	0.50	0.81	0.63	0.41	0.62	0.61	0.50	0.81	0.79		82%	124%	123%	100%	163%	159%	
734	Weekdays	May-08	Eve (span/freq) mainly + AM	10.4	middle	7	66	86%	12%	19	21	89.9	22.5	6.9	0.66	0.52	0.96	0.41	0.02	0.51	0.58	0.52	0.64			4%	97%	111%	100%	124%		
848	Weekdays	Oct-06	Eve (span/freq) mainly + AM	18.1	middle	1	24	500%	33%	18	20	33.4	11.1	5.6	0.31	0.66	0.68	0.14	0.92	1.09	0.79	0.66	0.85	0.92		140%	166%	120%	100%	129%	141%	
813	Weekdays	Oct-06	Eve (span/freq) mainly + AM	20.4	middle	3	27	167%	22%	19	21	73.3	18.3	9.2	0.45	0.67	1.02	0.46	0.60	0.51	0.72	0.67	0.75	0.80		90%	76%	109%	100%	112%	120%	
701	Weekdays	Sep-06	Eve (span/freq) mainly + AM	9.5	middle	5	51	100%	14%	19	21	31.1	7.8	3.1	0.33	0.67	0.32	0.02	0.49	1.08	0.99	0.67	0.60	0.66	0.89	73%	161%	148%	100%	90%	98%	132%
780	Weekdays	Jun-07	Eve (span/freq) mainly + AM	9.2	outer	3	31	233%	26%	18	21	28.9	7.2	2.9	0.32	0.83	0.95	0.34	0.58	0.76	0.84	0.83	0.87	1.04		70%	92%	101%	100%	106%	126%	
													10		AVE (A)	0.65	0.66	0.52	0.37	0.54	0.61	0.65	0.65	0.71	0.79	59%	83%	93%	100%	100%	118%	110%
													13		AVE (B)	0.66	0.74	0.42	0.41	0.52	0.60	0.66	0.65	0.86		64%	80%	91%	100%	99%	117%	
													7		AVE (C)	0.62	0.80	0.37	0.48	0.69	0.73	0.62	0.74	0.84	0.89	77%	111%	119%	100%	123%	129%	132%
													30		**AVE ALL**	**0.65**	**0.73**	**0.44**	**0.41**	**0.57**	**0.63**	**0.65**	**0.67**	**0.80**	**0.81**	**63%**	**89%**	**99%**	**100%**	**106%**	**120%**	**115%**

NB: Span changes for the following routes have NOT been included in the final reporting of results (based on inspection of the data inputs).

Route of interest	Time of day	Date of service change	Type of service change	Route km (ave each direction)	Control routes	Initial trips: Evening	Initial trips: Tot daily	% increase in trips: Evening	% increase in trips: Tot daily	Hr of last service: Before	Hr of last service: After	Evening pax per day	Evening pax per hr	Evening pax per trip	Evening pax per bus km	%Δ in evening pax, relative to %Δ in evening service level	Δ in tot daily pax as a % of initial eve pax, rel to %Δ in eve service level	%Δ in tot daily pax, relative to %Δ in tot service level	Q1	Q2	Q3	Q4	Q5-8	Q9-12	Q13-16	Q1	Q2	Q3	Q4	Q5-8	Q9-12	Q13-16
451	Weekdays	May-07	Eve (span/freq) only	11.8	middle	14	98	29%	4%	19	21	103.0	25.7	5.7	0.48	0.79	-3.14	-1.29	1.08	1.30	1.55	0.79	1.77	2.28	#DIV/0!	136%	164%	195%	100%	224%	288%	#DIV/0!
467	Weekdays	Oct-07	Eve (span/freq) only	3.7	inner	16	98	25%	4%	20	21	107.0	26.7	5.3	1.44	0.06	-0.90	-0.59	-0.56	-0.26	-0.27	0.06	-0.29	#DIV/0!	#DIV/0!	-885%	-406%	-426%	100%	-449%	#DIV/0!	#DIV/0!
472	Weekdays	no date	Eve (span/freq) only	16.9	inner	12	112	58%	6%	19	21	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	######	#DIV/0!	#DIV/0!	#DIV/0!
540	Weekdays	Mar-08	Eve (span/freq) only	7.0	outer	13	86	38%	6%	20	21	44.7	11.2	2.5	0.35	-0.34	-1.35	-0.60	0.52	0.39	-0.37	-0.34	0.22	#DIV/0!	#DIV/0!	-154%	-117%	110%	100%	-66%	#DIV/0!	#DIV/0!
580	Weekdays	Feb-08	Eve (span/freq) only	9.3	outer	8	58	75%	10%	19	21	27.5	6.9	2.0	0.21	1.17	2.87	2.66	0.14	0.58	0.35	1.17	0.81	#DIV/0!	#DIV/0!	12%	49%	30%	100%	69%	#DIV/0!	#DIV/0!
623	Weekdays	Jun-07	Eve (span/freq) mainly + AM	22.0	middle	3	51	167%	16%	18	20	113.8	37.9	14.2	0.65	1.02	1.58	0.77	0.82	1.01	0.98	1.02	1.18	1.39		80%	99%	96%	100%	115%	135%	
663	Weekdays	Mar-08	messy changes	34.9	outer	4	49	50%	6%	19	20	29.9	10.0	5.0	0.14	0.02	2.30	2.17	0.17	0.32	0.38	0.02	-0.05	#DIV/0!	#DIV/0!	784%	1495%	1786%	100%	-234%	#DIV/0!	#DIV/0!
683	Weekdays	Oct-06	messy changes	48.6	outer	7	45	-14%	2%	20	20	123.4	41.1	20.6	0.42	0.10	-1.80	3.20	-0.23	-0.16	-0.26	0.10	-0.02	0.29	#DIV/0!	-237%	-169%	-263%	100%	-24%	302%	#DIV/0!
688	Weekdays	May-08	Eve (span/freq) only	22.5	outer	10	62	20%	3%	20	21	60.6	15.2	5.1	0.22	-0.30	-14.29	-2.45	-0.38	-0.52	-0.09	-0.30	-0.46	#DIV/0!	#DIV/0!	129%	176%	30%	100%	154%	#DIV/0!	#DIV/0!
738	Weekdays	Oct-06	Eve (span/freq) mainly + AM	10.8	outer	7	41	57%	15%	19	21	47.7	11.9	4.3	0.40	1.15	2.10	1.01	0.29	0.98	0.84	1.15	0.91	0.46		25%	85%	73%	100%	79%	40%	
784	Weekdays	Mar-08	Eve (span/freq) mainly + AM	23.9	outer	3	28	200%	32%	19	21	78.7	19.7	8.7	0.37	1.08	1.62	1.01	0.52	0.89	1.00	1.08	0.98			48%	82%	92%	100%	91%		
811	Weekdays	Oct-06	Eve (span/freq) mainly	43.8	middle	0	29	#DIV/0!	21%	17	20	113.7	37.9	19.0	0.43	#DIV/0!	#DIV/0!	0.49	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	######	#DIV/0!	#DIV/0!	#DIV/0!
812	Weekdays	Oct-06	Eve (span/freq) mainly	38.7	middle	1	23	600%	43%	18	21	46.7	11.7	6.7	0.17	0.33	0.65	0.20	0.18	0.28	0.31	0.33	0.31	0.33	#DIV/0!	53%	84%	92%	100%	94%	99%	#DIV/0!
825	Weekdays	Oct-06	Eve (span/freq) only	14.2	middle	12	87	-42%	-7%	21	19	66.8	33.4	9.5	0.67	-1.52	-3.61	-2.33	-0.58	-1.01	-1.43	-1.52	-1.42	-1.70	#DIV/0!	38%	67%	94%	100%	94%	112%	#DIV/0!

Table H.13 Weekend span changes

						Initial trips		% increase in trips		Hr of last service		Evening pax in 4th quarter				Q4 Elasticities					Evening elasticity through time							Evening elasticity through time, as a % of Q4						
Route of interest	Time of day	Date of service change	Type of service change	Route km (ave each direction)	Control routes	Evening	Tot daily	Evening	Tot daily	Before	After	Evening pax per day	Evening pax per hr	Evening pax per trip	Evening pax per bus km	%Δ in evening pax, relative to %Δ in evening service level	Δ in tot daily pax as a % of initial evening pax, relative to %Δ in evening service level	%Δ in tot daily pax, relative to %Δ in tot service level	R/Q	S/Q	Q1	Q2	Q3	Q4	Y2 (Q5-8)	Y3 (Q9-12)	Y4 (Q13-16)	Q1	Q2	Q3	Q4	Y2 (Q5-8)	Y3 (Q9-12)	Y4 (Q13-16)
555	Saturday	Jun-07	Span: eve (17-21)	13.5	middle	1	38	900%	26%	18	21	30.0	7.5	3.0	0.22	0.55		-0.69			0.61	0.53	0.59	0.55	0.60	0.86		109%	95%	107%	100%	108%	155%	
690	Saturday	May-08	Span: eve (18-21)	15.7	outer	1	22	700%	32%	18	21	35.6	8.9	4.4	0.28	0.63	0.59	0.42			0.43	0.65	0.63	0.63	0.70			69%	105%	101%	100%	111%		
701	Saturday	Sep-06	Span: eve (18-21)	9.5	middle	1	23	700%	30%	18	21	19.0	4.8	2.4	0.25	1.64	1.82	0.95	1.11	0.58	1.61	1.92	1.32	1.64	1.39	1.43	1.52	98%	117%	80%	100%	85%	87%	92%
670	Saturday	May-07	Span: eve (18-21)	16.1	outer	3	34	167%	15%	19	21	55.1	13.8	6.9	0.43	0.58	0.04	-0.06			0.21	0.55	0.94	0.58	0.70	0.76		36%	95%	164%	100%	122%	131%	
419	Saturday	Sep-06	Span: eve (19-21)	14.8	outer	2	24	250%	21%	18	21	27.2	6.8	3.9	0.26	0.67	0.32	0.23			0.25	0.51	0.98	0.67	0.80	0.83	1.03	37%	76%	146%	100%	119%	124%	153%
467	Saturday	Oct-07	Span: eve (19-21)	3.7	inner	4	46	250%	22%	18	21	29.9	7.5	2.1	0.58	0.70	0.88	0.70	1.26	1.00	-0.04	-0.16	0.45	0.70	0.63			-6%	-23%	65%	100%	90%		
556	Saturday	Jun-07	Span: eve (19-21)	19.1	middle	3	41	233%	17%	18	21	54.3	13.6	5.4	0.28	1.09	1.71	1.17			1.40	1.21	1.23	1.09	1.43	1.34		128%	111%	112%	100%	131%	123%	
737	Saturday	Oct-06	Span: eve (19-21)	34.8	middle	3	41	233%	17%	19	21	218.0	54.5	21.8	0.63	1.04	1.38	1.91			0.76	0.83	0.97	1.04	1.01	1.08		73%	79%	93%	100%	97%	103%	
440	Saturday	May-07	Span: eve (19-21)	#N/A	outer	3	37	200%	16%	18	21	66.8	16.7	7.4		1.58	1.37	1.10			0.92	1.23	1.58	1.58	1.36	1.37		58%	78%	100%	100%	86%	87%	
567	Saturday	Apr-08	Span: eve (19-21)	13.1	inner	5	46	180%	20%	19	21	104.4	26.1	7.5	0.57	1.31	1.86	1.70			0.84	1.05	0.91	1.31	1.17			64%	80%	69%	100%	90%		
472	Saturday	May-07	Span: eve (19-21)	16.9	inner	4	68	175%	10%	19	21	84.3	21.1	7.7	0.45	0.73	1.00	0.53	1.38	0.74	0.55	0.71	0.44	0.73	0.72	0.76		75%	97%	60%	100%	99%	105%	
733	Sunday	Oct-06	Span: eve (19-21)	21.7	middle	3	24	100%	13%	19	20	187.6	62.5	31.3	1.44	0.44	0.54	0.88			0.93	0.25	0.13	0.44	0.36	0.31		210%	56%	29%	100%	81%	70%	
765	Saturday	May-08	Span: eve (20-21)	16.1	middle	3	43	167%	12%	19	21	60.3	15.1	7.5	0.47	1.14	0.94	0.49			0.79	1.03	1.19	1.14	1.25			69%	90%	104%	100%	109%		
580	Saturday	Feb-08	Span: eve (20-21)	9.3	outer	8	58	75%	10%	19	21	18.9	4.7	1.4	0.15	0.80	0.70	2.88			0.44	0.39	0.82	0.80	1.20			55%	49%	103%	100%	150%		
733	Saturday	Oct-06	Span: eve (20-21)	21.7	middle	7	50	43%	6%	20	21	226.3	56.6	22.6	1.04	0.81	1.24	1.66			0.13	0.65	0.59	0.81	0.51	0.75		16%	80%	72%	100%	63%	92%	
688	Saturday	May-08	Span: eve (21)	22.5	outer	5	28	40%	11%	20	21	42.0	10.5	6.0	0.27	0.39	0.22	0.44			-0.44	0.32	-0.43	0.39	-0.08			-112%	83%	-110%	100%	-21%		
780	Saturday	Jun-07	Span: eve (19-21) + minor changes	9.2	outer	1	20	700%	45%	18	21	16.7	4.2	2.1	0.23	1.10		-0.41			1.04	0.61	0.96	1.10	0.94	0.97		94%	55%	87%	100%	86%	88%	
412	Saturday	Mar-08	Span: eve (20-21) + minor PM changes	23.8	middle	5	20	40%	15%	20	21	123.9	31.0	17.7	0.74	1.20	-0.18	0.23			0.51	1.20	1.62	1.20	1.15			43%	100%	135%	100%	96%		
566	Saturday	Jun-07	Span: eve (18-21) + early AM	30.0	middle	1	39	1100%	33%	18	21	102.5	25.6	8.5	0.29	0.55	0.75	0.75	1.36	1.36	0.40	0.39	0.45	0.55	0.49	0.51		73%	71%	82%	100%	89%	92%	
440	Sunday	May-07	Span: eve (18-21) + early AM	#N/A	outer	1	21	700%	38%	18	21	54.7	13.7	6.8		1.64	1.81	0.77	1.10	0.47	1.23	1.80	1.25	1.64	1.54	1.58		75%	110%	76%	100%	93%	96%	
425	Saturday	Sep-06	Span: eve (19-21) + early AM	11.5	outer	2	25	200%	16%	18	21	39.0	9.8	6.5	0.56	1.13	1.11	1.72			0.52	0.75	1.06	1.13	0.81	0.83	1.01	46%	66%	94%	100%	72%	74%	89%
510	Saturday	Jan-08	Span: eve (19-21) + early AM	13.1	inner	4	44	150%	20%	19	21	102.1	25.5	10.2	0.78	0.75	1.37	1.27			0.41	1.05	1.01	0.75	1.07			55%	140%	135%	100%	144%		
540	Saturday	Mar-08	Span: eve (19-21) + early AM	7.0	outer	4	34	150%	21%	19	21	38.6	9.7	3.9	0.55	1.10	-0.28	-0.22			0.22	0.90	0.47	1.10	0.77			20%	82%	43%	100%	70%		
410	Sunday	Mar-08	Span: eve (19-21) + early AM	8.6	inner	3	20	133%	30%	19	21	101.4	25.3	14.5	1.69	0.83	1.15	0.78	1.37	0.93	0.17	0.14	0.69	0.83	0.63			20%	17%	82%	100%	75%		
410	Saturday	Mar-08	Span: eve (19-21) + early AM	8.6	inner	6	64	67%	14%	19	21	154.0	38.5	15.4	1.79	1.24	1.84	0.80	1.48	0.64	0.50	0.78	0.92	1.24	0.91			40%	62%	74%	100%	73%		
								All				**79.7**	**20.6**	**9.1**	**0.61**	**0.95**	0.96	0.80			0.57	0.77	0.83	0.95	0.88			58%	79%	84%	100%	93%	102%	112%
								All with 3 values								**1.12**	**1.42**	**1.01**	**1.29**	**0.82**	0.57	0.78	0.84	0.96	0.89			56%	78%	83%	100%	92%	98%	112%
								All with >2 Before eve trips								**0.92**	0.93	0.96																

NB Span changes for the following routes have NOT been included in the final reporting of results (abnormal service changes/dubious input data).

451	Saturday	May-07	Span: eve (18-21)	11.8	middle	0	33		24%	17	21	80.0	20.0	10.0	0.85			1.19																
475	Saturday	Jun-07	Span: PM + eve (13-21)	12.6	middle	0	20		125%	14 or le	21	29.5	7.4	2.7	0.21			1.07																
477	Saturday	Aug-07	Span: PM + eve (13-21)	22.9	middle	0	30		97%	14 or le	21	68.2	17.1	5.7	0.25			0.45																
552	Saturday	Apr-08	Span: PM + eve (15-21)	13.5	middle	1	56	900%	23%	18	21	90.0	22.5	9.0	0.66	1.02	1.02	0.24			0.96	0.95	1.27	1.02	1.18			95%	93%	125%	100%	116%		
623	Saturday	Jun-07	Span: eve (17-20)	22.0	middle	0	21		38%	16	20	65.7	21.9	11.0	0.50			1.22																
693	Saturday	Oct-06	Span: eve (17-21)	28.1	outer	0	20		40%	17	21	37.9	9.5	5.4	0.19			0.92																
734	Saturday	May-08	Span: PM+eve (14-21)	10.4	middle	0	14		107%	14 or le	21	26.3	6.6	3.3	0.31			0.36																
738	Saturday	Oct-06	Span: eve (18-21)+minor changes	10.8	outer	0	18		56%	17	21	20.5	5.1	2.6	0.24			0.44																
753	Saturday	May-08	Span: eve (17-21)	23.7	outer	0	22		45%	16	21	30.4	7.6	3.8	0.16			0.65																
755	Saturday	May-08	Span: eve (18-20) + early AM	23.7	outer	0	22		27%	17	20	50.7	16.9	8.4	0.36			1.15																
782	Saturday	Jun-07	Span: eve (19-21) + daytime increases	65.9	outer	1	12	700%	142%	18	21	75.1	18.8	9.4	0.14	1.26	1.40	0.70			0.79	0.97	1.14	1.26	1.02	1.12		62%	77%	91%	100%	81%	89%	
784	Saturday	Mar-08	Span: eve (18-21) + early AM	23.9	outer	0	19		58%	17	21	59.8	14.9	7.5	0.31			1.42																
789	Saturday	No date??	Span: eve (19)	10.2	outer	1	17	200%	12%	18	19																							
824	Saturday	Oct-06	Span: eve (17- 21) + minor changes	22.2	middle	0	30		33%	17	21	69.3	17.3	8.7	0.39			1.64																

H4.3.5 Results for other elasticity measures

As noted in table H.10 and section H4.2.1, three elasticity measures were examined, but most of our analyses focused on only one of these, the evening 'own period' elasticity. Difficulties were found in deriving reasonably robust estimates for the other two elasticity measures, because of the apparent effects of undefined external influences (not neutralised by use of control routes) on patronage. This section presents limited comparisons between the three measures for weekend span changes, for the seven cases for which we could derive reasonably robust estimates for all three measures.

For these seven cases, the **ratios** of elasticity values on measure B (evening – total elasticity), measure C (daily – elasticity) and measure A (evening – own period elasticity) were as follows:

- measure B/measure A: mean ratio 1.29 (range 1.10 – 1.48)
- measure C/measure A: mean ratio 0.82 (range 0.47 – 1.36)
- measure B/measure C: mean ratio 1.57.

We would make the following comments:

- **Measure B/measure A.** This represents the ratio between the total patronage generated by the enhanced evening service and the number of these passengers who made their trips in the evening period. Thus the mean ratio of 1.29 indicates that, for every 100 additional passengers generated in the evening from the enhanced evening services, another 29 (net) were generated prior to 1800 hours. This result seems very plausible, for instance with an improved evening service:
  - assume 50% of customers generated made their return trip entirely within the evening period (ie each generated two new evening boardings)
  - assume the other 50% of new customers made their outward trip prior to the evening period, their return trip in the evening (ie each generated one daytime boarding, one evening boarding)
  - in this case, generation would be one daytime trip for three evening trips, ie a ratio for measure B/measure A of 1.33 (close to the 1.29 figure above).

  There appears to be very little research on this topic (in Australasia or internationally) with which these estimates may be compared.
- **Measure B/measure C.** This represents the ratio of elasticities for evening service enhancements when calculated, based on the total generation in patronage resulting from these enhancements relative to the % change in B) evening service levels and C) total daily service levels. The 1.57 ratio indicates that the elasticity value was substantially higher if calculated on the % change in evening service levels than if based on the % change in total daily service levels. The higher value for the measure based on evening service levels was typical, reflecting that average loadings were usually lower in the evenings than those averaged over the whole day. The distinction between the two measures is important, but often not apparent in the literature. Again, while the 1.57 ratio appears very plausible, there is little international evidence with which it can be compared.

H4.3.6 Elasticity changes over time from service change

As for the SmartBus analyses (section H3.3.6 and table H.6), we made an assessment of how the evening 'own period' elasticity values varied over time from the service change. It may be seen from tables H.12 and H.13 that individual routes showed considerable variability in their trends: this reflects (at least in part) that for the span changes no saturation curve analyses were undertaken to smooth the quarterly data points, whereas such smoothing was carried out for the SmartBus analyses.

Taking the means for each quarter of all the elasticity ratios (relative to Q4 = 100) gives the 'crude' results shown in table H.16. While these average results were generally consistent with those from the SmartBus analyses (table H.16 and figure H.1), we consider that less reliance should be placed on them. Inspection of elasticity trend results for the individual routes shows that in many cases results for some or all of the earlier periods (Q1–Q3) exceeded 100% and in a few cases were negative.

We would therefore recommend primary reliance on the SmartBus results on this topic, rather than use of the results from the span analyses given here.

Figure H.3a Distribution of Q4 (own period) elasticity values – weekdays (mean 0.65)

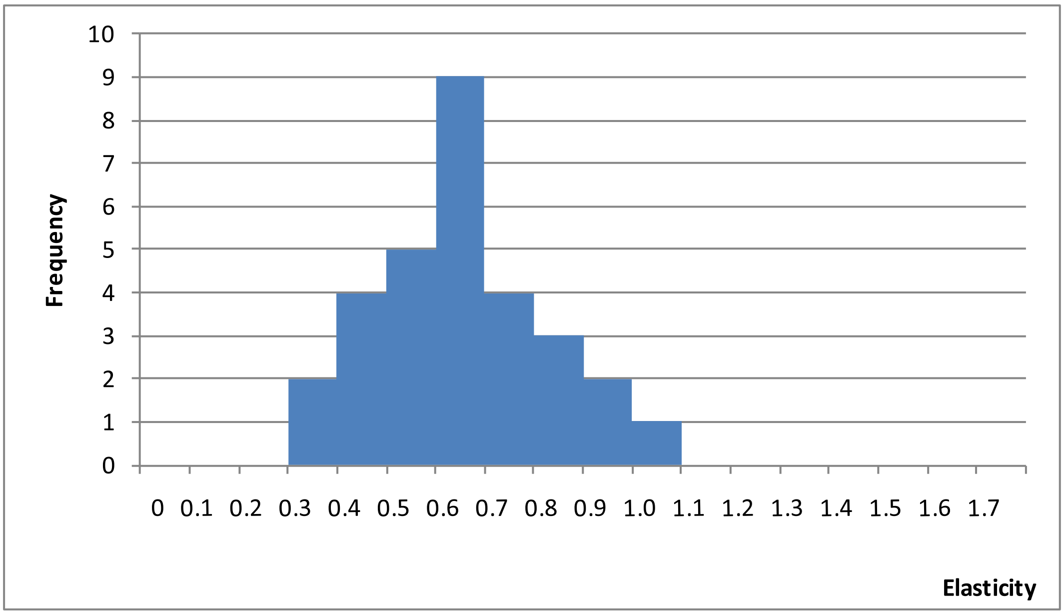


Figure H.3b Distribution of Q4 (own period) elasticity values – weekends (mean 0.95)

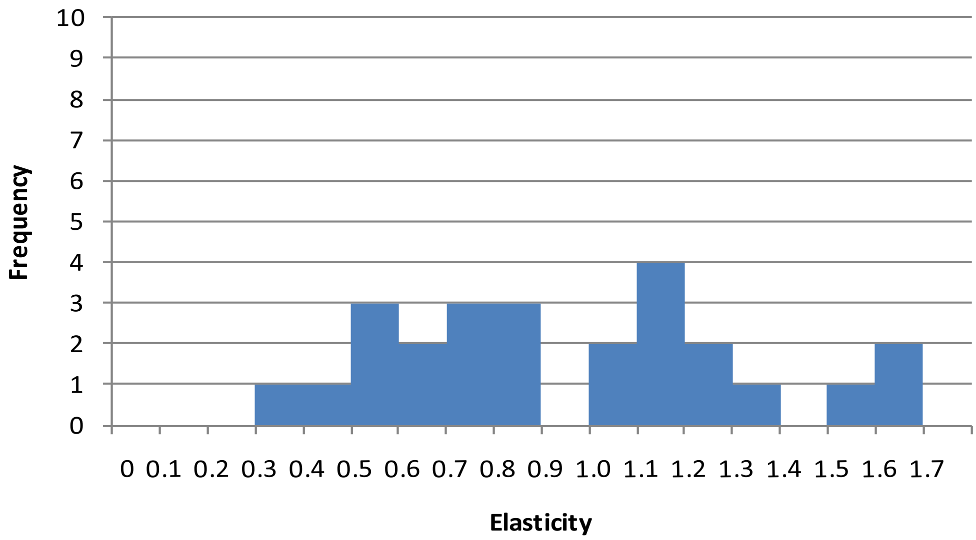


Table H.14 Evening Q4 (own period) elasticity mean values

	Weekday	Weekends
No. of cases with derived values	30	25
Mean Q4 elasticity	0.65	0.95

Table H.15 Evening patronage performance statistics (Q4)[(a)]

Performance measures	Day	Mean	25%ile	50%ile	75%ile
Passengers/day	Weekday	106.6	63.8	88.0	148.1
	Weekend	79.7	32.8	55.1	103.4
Passengers/hour[(b)]	Weekday	27.3	16.7	22.0	37.0
	Weekend	20.6	8.2	13.8	25.9
Passengers/bus trip	Weekday	9.3	6.0	7.6	12.7
	Weekend	9.1	3.9	6.9	12.3
Passengers/bus km	Weekday	0.50	0.33	0.44	0.64
	Weekend	0.61	0.27	0.47	0.74

Notes:

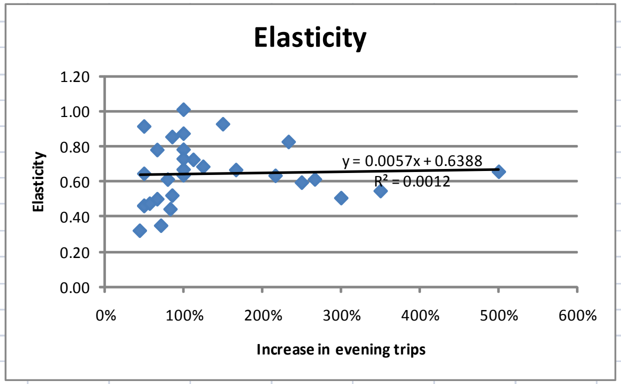
[(a)]All figures relate to average evening (1800-) patronage in fourth quarter after service change. Weekday figures relate to school term weekdays only.

[(b)] 'Hour' represents the overall duration of evening services, eg if the last service operates at 21.30, then this counts as four hours of service duration (starting at 1800).

Table H.16 Mean elasticities relative to Q4 values (evening 'own period' elasticities)

Period	Weekday ratio (no. in sample)		Weekend ratio (no. in sample)	
Q1	63%	(30)	58%	(25)
Q2	89%	(30)	79%	(25)
Q3	99%	(30)	84%	(25)
Q4	100%	(30)	100%	(25)
Q5–Q8 (year 2)	106%	(30)	93%	(25)
Q9–Q12 (year 3)	120%	(17)	102%	(14)
Q13–Q16 (year 4)	115%	(4)	112%	(3)

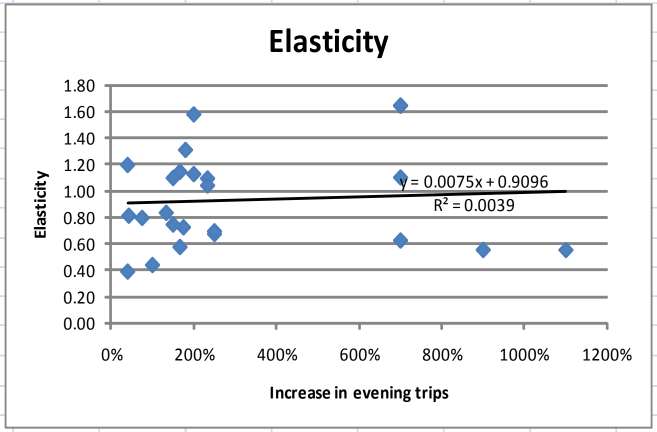
Figure H.4a Relationship between Q4 elasticity and % increase in evening trips – weekdays



X=% increase in evening trips

SUMMARY OUTPUT						
Regression Statistics						
Multiple R	0.04					
R Square	0.00					
Adjusted R Square	-0.03					
Standard Error	0.18					
Observations	30.00					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1.00	0.00	0.00	0.03	0.85	
Residual	28.00	0.87	0.03			
Total	29.00	0.87				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.64	0.05	12.07	0.00	0.53	0.75
% increase in eve services	0.01	0.03	0.19	0.85	-0.06	0.07

Figure H.4b Relationship between Q4 elasticity and % increase in evening trips – weekends



SUMMARY OUTPUT						
Regression Statistics						
Multiple R	0.03					
R Square	0.00					
Adjusted R	-0.04					
Standard Er	0.37					
Observatio	25.00					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1.00	0.00	0.00	0.02	0.88	
Residual	23.00	3.18	0.14			
Total	24.00	3.19				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.93	0.11	8.69	0.00	0.71	1.16
% increase	0.00	0.03	0.15	0.88	-0.05	0.06

H5 Summary of findings

H5.1 Overview of analyses

This appendix reports on analyses of the patronage responses to bus service improvements implemented in Melbourne in the period since 2002, in two groups:

- SmartBus routes, introduced/extended over the period 2002–2009.
- service span enhancements on numerous routes over the period 2006–2008, typically involving an extension of evening operating hours (both weekdays and weekends) from around 1800–1900 to around 2100–2200.

These analyses examined the patronage responses over time following the implementation of the service changes, for up to four to five years where suitable data was available. A particular focus was given to analysing the extent of responses in the fourth quarter (ie months 10–12) after the service changes, which was often taken to represent a typical 'short run' period.

Patronage responses were analysed in terms of service frequency elasticities wherever appropriate. In all cases, patronage responses on the improved services were compared against patronage trends on 'control' route groups: this approach differentiated these analyses from some previous service frequency elasticity analyses undertaken in Melbourne. The analyses undertaken focused on 'own period' elasticities (ie measuring the effects of service changes in a given period on patronage in the same period): these elasticities may have understated the total patronage response from service changes.

H5.2 Elasticity estimates - Melbourne

Table H.17 summarises the mean Q4 elasticity estimates for each time period for both the SmartBus and service span changes. The following comments may assist in interpreting these results:

- Two sets of (mean) elasticity results are given for the SmartBus analyses:
  - The 'base' elasticity figures were derived on the assumption that the full patronage increase was attributable to the service frequency component of the SmartBus 'package' of service improvement measures.
  - The 'adjusted' elasticity figures were estimated from these base figures on the assumption that only two-thirds of the patronage increase resulted from the service frequency improvements: this assumption is considered more realistic, but its accuracy is uncertain (refer section H3.3.3).
- On either set of elasticity estimates, the SmartBus results showed substantial differences in values between day type and time period: the highest elasticity was for weekday evenings (mean base estimate 1.16), followed by weekends (0.85), weekday interpeak (0.55) and weekday peaks (0.40). This ordering is broadly consistent with prior expectations, based on evidence from elsewhere – although the literature on this topic is rather limited (both in Australia and internationally).
- It might have been expected, a priori, that the SmartBus elasticity estimates (after adjustment) would be greater than the corresponding span estimates – as generally the SmartBus initiatives involved service frequency improvements across all time periods, whereas the span initiatives involved predominantly evening service improvements only:
  - For weekday evenings, the results were consistent with this expectation: the mean span elasticity of 0.65 was lower than the SmartBus 'adjusted' elasticity of 0.77.

– Such a check was not possible for the weekend span analyses, as these related to evening services only whereas the SmartBus results coveedr the whole day. Based on the pattern of SmartBus weekday results by time period, it appears that the span weekend evening elasticity of 0.95 was very broadly consistent with the SmartBus overall weekend elasticity (adjusted) of 0.57.

Table H.17 Summary of Melbourne Q4 elasticity estimates[(a)]

Time period	SmartBus				Spans		
	Sample no.	Range	Mean 'base'	Mean 'adjusted'	Sample no.	Range (inter-quartile)	Mean
Weekday evening	3	0.96 to 1.31	1.16	0.77	30	0.51 to 0.78	0.65
interpeak	4	0.51 to 0.63	0.55	0.37			
peaks	4	0.32 to 0.48	0.40	0.27			
total	4	0.52 to 0.66	0.59	0.39			
Weekends evening					25	0.65 to 1.17	0.95
total	7	0.65 to 1.29	0.85	0.57			

(a) All elasticity estimates relate to 'own period' effects.

H5.3 Elasticity estimates –some interstate comparisons

Table H.18 provides some comparisons between the Melbourne elasticity estimates (Q4) for both SmartBus and span changes (from table H.17) and equivalent estimates derived in the project for service frequency elasticities for Adelaide (see appendix G) and Brisbane (see appendix F).

In interpreting these comparisons it should be noted that:

- All elasticities given related to Q4, ie average of months 10–12 following the service change.
- All elasticities were 'own period' elasticities, ie representing the relationship between the service change for the specified day type/time period and the patronage change in that day/period. By excluding any patronage effects in other periods, these elasticities would tend to understate the total market response to the service change.
- The SmartBus results related to situations where services had been improved across all periods of the day; whereas in almost all the other cases, the results reflected situations in which services were improved in the period in question only. In this regard, it would be expected to find somewhat higher elasticities in the SmartBus cases.

The following comments on the comparisons between the results from the four main groups of sources, by day type/time period:

H5.3.1 Weekday evening

- The mean values were SmartBus 0.77 (adjusted), span 0.65, Adelaide 0.55, Brisbane 0.59.
- Apart from SmartBus, the other three results were in a relatively narrow range (0.60 ± 0.05) and did not appear to be significantly different (in a statistical sense).
- The higher value for SmartBus was consistent with the comment above that higher values would be expected in situations where services were improved throughout the day.

Table H.18 Elasticity (Q4) results summary – Melbourne (MEL), Adelaide (ADL) and Brisbane (BNE)

Time period analysed		MEL SmartBus (Averages)				MEL Spans			ADL			BNE		
Day	**Time period**	**Cases**	**Base**		**Adjusted Mean (1)**	**Cases**	**Mean**	**Range**	**Cases**	**Mean**	**Range**	**Cases**	**Mean**	**Range**
			Mean	**Range**				**(Inter-quartile)**						
Weekday	Evening	3	1.16	0.96 to 1.31	0.77	30	0.65	0.51 to 0.78	3	0.55	0.40 to 0.80	5	0.59	0.47 to 0.70
	Interpeak	4	0.55	0.51 to 0.63	0.37				11	0.61	0.35 to 1.37			
									9	0.46	0.35 to 0.60			
	Peaks	4	0.40	0.32 to 0.48	0.27									
	Total	4	0.59	0.52 to 0.66	0.39									
Saturday		4	0.88	0.67 to 1.29	0.59				3	0.61	0.58 to 0.65	6	0.73	0.49 to 0.83
			(0.85 ave)		(0.57 ave)	25	0.95	0.65 to 1.17						
Sunday		3	0.80	0.72 to 0.90	0.54	(Eve only)			4	0.61	0.52 to 0.71	5	0.74	0.65 to 0.84
Notes:	(1). Base mean multiplied by 0.67 (refer text)													

H5.3.2 Weekday interpeak

- The mean value for Adelaide (excluding outliers) was 0.46; while the corresponding SmartBus mean was 0.55 before adjustment, 0.37 after adjustment.
- The sample sizes and spread of results in each case indicated that the SmartBus adjusted mean value appeared to be significantly lower than the Adelaide mean value. This result was contrary to expectations – the SmartBus mean value was expected to be somewhat higher than the Adelaide mean value, given that the SmartBus services were improved throughout the day.

H5.3.3 Weekend full day

- The mean values were:
  - SmartBus (adjusted) Saturday 0.59 (4 cases), Sunday 0.54 (3 cases)
  - Adelaide Saturday 0.61 (3), Sunday 0.61 (4)
  - Brisbane Saturday 0.73 (6), Sunday 0.74 (5).
- Given the small number of cases involved, the Saturday and Sunday mean values were remarkably close to each other in all the three cities and any differences were clearly not significant. Therefore both days were considered together.
- It also appears that the differences between the three cities were not significant.
- The (unweighted) mean of the values across the three cities for Saturdays/Sundays was 0.65.

H5.3.4 Weekend evening

- Only the Melbourne span improvements were in this category. These had a mean elasticity value of 0.95.
- This value was approximately 50% greater than the above full weekend mean of 0.65. A relativity of this order of magnitude is unsurprising: the SmartBus weekday analyses indicated that the weekday evening mean value was close to double the weekday all-day value.

H5.4 Influences on elasticity estimates

For the span schemes in particular, examination of the datasets and statistical tests was undertaken to investigate whether any particular factors would help to account for the range of elasticity values found within each day type/time period. From the data available, no specific explanatory factors could be identified: the elasticity values obtained were not affected significantly (in a statistical sense) by either the service frequency levels (before or after the service changes) or the extent of the service change. This result should not be taken to imply that no such relationships existed, only that it was not possible to detect them from the relatively small samples available.

H5.5 Patronage rates

Analyses were undertaken for the span schemes of patronage levels and performance ratios in Q4 following the scheme introduction. A number of performance statistics were calculated (refer table H.13); these could potentially be used to compare performance between the various span schemes and against existing services more generally. It was found that passenger loadings on the new/enhanced evening services averaged 0.5-0.6 passengers/bus km, on both weekday and weekend evenings: this was around 50%–60% of the average loadings on Melbourne bus services overall, and seems likely to be on a par with Melbourne's evening bus loadings more generally.

H5.6 Changes in patronage response over time

For both the SmartBus initiatives and the span initiatives, the trends in patronage growth were examined on a quarterly basis from the date of the scheme implementation, relative to the Q4 figures on which all the other analyses focused.

The results are summarised in table H.19 (refer also figure H.1). We note that:

- The SmartBus results are regarded as generally more accurate than the span results.[85]
- Up to Q4, both sets of results were broadly consistent. For periods beyond Q4, the span results were particularly subject to a wide margin of uncertainty.
- The SmartBus results indicated that some two-thirds of the total patronage growth up to Q4 occurred in Q1. This implies that around 80% of the patronage growth that occurred by the end of the first year had been achieved by the end of the first quarter.[86]
- Further growth continued after the first year, but at a continually diminishing rate. By the end of year four, further growth was only about an additional 10% more than the growth at the end of year one.
- In the long run (as estimated through the saturation curve analysis), further growth of around 5% (above the year four level) was indicated. While such long-run estimates are inevitably uncertain, it is notable that they were much lower than generally quoted in the international literature for most transport demand elasticities, including service frequency elasticities.[87]

Table H.19 Summary of elasticity trends over time (mean elasticities over time since service improvement, relative to Q4 average)

Time from service improvement	SmartBus[(a)]	Span[(b)(c)]	
		Weekday	Weekend
Q1	66	63	58
Q2	88	89	79
Q3	96	99	84
Q4	100	100	100
Y2 (Q5–8)	104	106*	93*
Y3 (Q9–Q12)	108	120*	102*
Y4 (Q13–16)	109	115*	112*
Long run	113		

(a) Taken from table H.7.

(b) Taken from table H.16.

(c) Estimates denoted by * are considered to be the least reliable.

85 In part this is because the SmartBus results were based on the saturation curve quarterly estimates, whereas the span results were been ‘smoothed’ in this way.

86 Given the growth pattern, an 80% factor by end Q1 would be consistent with a 66% factor average over Q1 (refer figure H.1).

87 The international literature suggests that long-run elasticity values (relating to periods 5–10 years or more after scheme implementation) are typically around 1.5 times to 2.0 times the short-run (12 months) values (refer appendix A, table A.1).

Appendix I: Market research review of bus service improvements – Melbourne

I1 Introduction

The primary focus of the project was on the estimation of patronage impacts of off-peak bus service changes and hence on service level (frequency) elasticities.

A secondary aspect of the project, addressed in this appendix, was appraisal of the market research evidence on other effects resulting from bus service improvements, including:

- factors influencing decisions to use or not to use enhanced bus services
- alternative means of travel of existing and new bus users
- perceived importance of bus service features and perceived performance against these features
- enhanced accessibility to opportunities offered by improved bus services.

This appendix summarises findings from a number of market research studies undertaken in Melbourne since 2004, which largely focused on surveys of bus users (and, in some cases, non-users) following bus service improvements. We note that more extensive research on this topic has been undertaken in Melbourne over the last 5–10 years than in any other Australasian city.

The main findings from individual market research studies are set out in the annexes and brought together and summarised on a theme basis in section I3.

I1.1 Acknowledgements

The research reported in this appendix would not have been possible without the invaluable support received from the Department of Transport (DoT), Victoria, which provided project funding, and a project steering/liaison group established by DoT involving: Nataniel Wolfson and Roberto Evangelio (DoT)/Chris Loader (Bus Association Victoria)[88] and Laura Flores (Hyder Consulting).[89]

I2 Melbourne market research study overview

As noted above, considerable market research has been undertaken with bus users (and, in some cases, non-users), in Melbourne since 2004. This has been largely focused on surveys of their responses to bus service improvements. This research has covered the two main programmes of service improvements undertaken in Melbourne, ie the SmartBus programme of new/enhanced routes and the service span ('safety net') programme of extending the daily span of existing routes, mostly in the evenings.

Table I.1 provides an overview of the research reports available: the market research scope and findings from each of these reports are summarised in section I3 following and set out in more detail in the annexes.

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[88] Now with DoT Vic.

[89] In addition, Peter Don (DoT) and Professor Graham Currie (Monash University) were invited to be members of the steering/liaison group but were unable to attend any meetings.

Table I.1 Relevant market research reports – overview

Title	Author	Client/ publication	Date	Scope, notes
1 Review of SmartBus trial – final draft report	SKM	DoI Vic	Oct 2004	• Post-evaluation review of first two SmartBus routes – 703 (Blackburn Rd), 888/889 (Springvale Rd). • Surveyed 1800 SmartBus users. • Covered extent of new/increased users, reasons for new/increased use and user satisfaction.
SmartBus market research – report of research findings: 2 Routes 700/900 3 Route 901 4 Route 903 5 Route 902	Market Solutions P/L	DoT Vic	Dec 2007 May 2009 Nov 2009 April 2011	• Post-evaluation reviews of SmartBus routes, approximately 12 months after introduction. • On-bus surveys with samples in order of 1000 passengers. • Covered previous mode used, reasons for new/increased use, alternative modes, new travel opportunities, importance of SmartBus features, customer satisfaction and underlying reasons.
6 Impacts of new bus services in outer suburban Melbourne – final report	Multi-modal Transport Solutions (Doug Bell)	BAV	Aug 2006	• Phone survey and focus groups of bus users, potential users and non-users in Pakenham area following introduction of new/upgraded bus services in early 2006. • Surveyed 400 local residents (split between users, potential users and non-users) and held two focus groups. • For bus users, covered trip purpose, trip frequency, previous modes, performance vs importance comparisons of service features, changes in travel patterns and new activities undertaken. • For non-users and potential users, covered travel modes, reasons for non-use, desired service enhancements to encourage use.
7 Growing bus patronage and addressing transport disadvantage – the Melbourne experience	Loader, C and J Stanley	Thredbo 10	2007	• Survey of users of new/extended evening bus services in Dandenong and Greensborough areas (October 2007). • Covered 101 interviews. • Addressed alternative modes available for trip, prior travel mode, trip purpose and activities facilitated by new services.
8 The value of weekend bus services	Loader, C	Bus Solutions Issue 4, BAV	March 2011	• Report on surveys of c.450 users of improved weekend bus services, at four transport interchanges/shopping centres (Broadmeadows, Chadstone, Dandenong, Doncaster). • Focused on frequency of weekend bus use, trip purpose, car availability, impacts on bus usage patterns.
9 Melbourne's booming buses – trends and patterns in bus patronage growth	Loader, C	BAV	Oct 2008	• Reports on survey of users of new/extended bus services in Dandenong and Greensborough areas (October 2007) – refer item 7 above. • Also reports on Metlink bus O-D surveys (33,000 interviews May 2007–October 2008). • Addressed car access, alternative modes to bus, PT transfer behaviour.

I3 Summary of market research findings

I3.1 Previous PT use (annex IB)

- In the case of SmartBus routes 700/900, 27% of SmartBus users stated they did not use PT at all prior to starting use of the SmartBus service, ie they were new PT users. Of the remainder, most had previously used PT at least once per day (57%) or at least two to three days/week (further 28%).

I3.2 Reasons for new/increased bus use (annexes IA, IB, IC)

- For SmartBus routes 700/900, the main factors promoting increased use of the new/improved services, by both 'old' users and 'new' users were: increased frequencies, more direct route (faster travel time), longer hours of service, improved reliability, greater comprehensibility of timetables, etc.
- For SmartBus routes 901/2/3, the main reason given (70%–80%) for use of the new route was that the service was more direct and/or convenient than alternatives. Its reliability was the next most common reason (c.10%). Specific SmartBus service features were reported as a reason for usage by around 5% of respondents (although noting that SmartBus-related features were also implicit in some of the other responses).

I3.3 Alternative means of travel for existing/new bus users (annexes IB, IC, ID, IE, IG)

- The research evidence on this topic is summarised in tables I.1 and I.2.
- For each survey, the tables show, by chosen travel mode:
  - the proportions of all respondents by each mode
  - the proportions of respondents who would not have used PT (any services) for that trip, by each mode (bracketed figures).
- These results need to be interpreted with considerable care:
  - The research reported in table I.1 asked bus users what was their previous means of travel for the trip in question (on which they were surveyed). In the Pakenham case, the question was delivered through a random on-board survey of bus users (frequent users are more likely to be sampled than infrequent users).
  - The research results reported in table I.2 came from random on-board surveys of bus users; but in this case the question asked was what would be their means of travel for the trip in question if the bus service was not available. In the Metlink case, the survey covered a random sample of all Melbourne bus users; while in the SmartBus cases it covered a random sample of SmartBus users, focusing on either their 'main' SmartBus trip purpose and/or their secondary SmartBus trip purpose. Many of these respondents would have recently switched from non-PT modes for their trip in question (ie their travel behaviour was likely to be more responsive than that of the average bus user).
  - In general, we note that the responses in the table I.1 cases, which directly reflect actual behavioural change (at the margin), are likely to provide more useful evidence on how the market might respond to service changes than the responses from the table I.2 (SmartBus and Metlink) surveys, which take no account of different users' propensity to switch modes at the margin.

Table I.2 Previous mode used for trip prior to improved bus service

Alternative travel means	Pakenham bus users (ID3)				Dandenong/ Greensborough – increased span (IE3)		SmartBus main trip purpose (IC)					
	New routes		Improved route				Route 901		Route 903		Route 902	
Other PT (all way)	16%		43%	-	13%		32%	-	25%	-	38%	-
Other PT –P&R/K&R access												
Car driver	10%	(12%)	20%	(35%)	11%	(11%)	27%	(40%)	16%	(21%)	21%	(34%)
Car passenger (lift)	15%	(18%)	10%	(18%)	52%	(50%)						
Taxi/other	4%	(5%)	2%	(4%)	15%	(14%)	15%	(22%)	31%	(41%)	10%	(16%)
Walk/cycle	49%	(58%)	23%	(40%)	17%	(16%)	5%	(7%)	3%	(4%)	3%	(5%)
Not make trip	6%	(7%)	2%	(4%)	6%	(9%)	21%	(31%)	25%	(33%)	28%	(45%)
Travel less often	-	-			7%[b]	-						
Total	100%	(100%)	100%	(100%)	121%[a]	(100%)	100%	(100%)	100%	(100%)	100%	(100%)

[a] Add to more than 100%because of multiple answers.

[b] Assume this is equivalent to 3% 'not make trip'.

Table I.3 Alternative means of making trip if bus service not available

Alternative travel means	SmartBus users (routes 700/900) (IB3)				Metlink – all bus services (IG3)				SmartBus secondary trip purpose (IC)					
	Main SmartBus trip purpose		Secondary SmartBus trip purpose		City area		Outer area		Route 901		Route 903		Route 902	
Other PT (all way)	87%	-	78%	16%	16%		43%	-	51%	-	75%	-	71%	-
Other PT –P&R/K&R access	6%	-	8%						4%	-	3%	-	3%	-
Car driver	14%	(37%)	19%	10%	10%	(12%)	20%	(35%)	17%	(27%)	17%	(39%)	8%	(31%)
Car passenger (lift)	6%	(16%)	7%	15%	15%	(18%)	10%	(18%)	23%	(36%)	8%	(18%)	9%	(35%)
Taxi/other	5%	(13%)	8%	4%	4%	(5%)	2%	(4%)	6%	(9%)	4%	(9%)	2%	(8%)
Walk/cycle	9%	(24%)	8%	49%	49%	(58%)	23%	(40%)	9%	(14%)	9%	(20%)	3%	(11%)
Not make trip	4%	(11%)	6%	6%	6%	(7%)	2%	(4%)	9%	(14%)	6%	(14%)	4%	(15%)
Travel less often	-		-	-	-	-								
Total	131%[(a)]	(100%)	134%[(a)]	100%	100%	(100%)	100%	(100%)	119%	(100%)	122%	(100%)	100%	(100%)

[(a)] Add to more than 100% because of multiple answers.

I3.3.1 Other PT services

- Unsurprisingly, the proportions of respondents who used PT as their previous and/or alternative mode for the trip in question varied considerably across the various surveys. In terms of previous modes used for the trip prior to the introduction of new/improved bus services (table 3.1), PT was used by less than half the respondents in all cases. The PT use proportions varied between 13% (Dandenong/Greensborough increased span cases) and 43% (Pakenham improved route). The lower proportions reflect situations where there was little or no PT available for the corridor in question, before the service improvements.
- In terms of alternative modes (if the improved bus service were not available), the PT proportions were much higher, with one exception varying between 55% (SmartBus 901, secondary trip purpose) and 93% (SmartBus 700/900, main trip purpose). These higher proportions reflect situations where alternative PT services are more readily available.
- The market shares outlined below for other modes are expressed as proportions of the total market **excluding** those who chose the PT alternative.

I3.3.2 Car drivers

- The car driver proportions showed a reasonable consistency. The Metlink survey of alternative modes gave proportions varying between 64% in the city area (reflecting that a substantial proportion of bus users in inner areas have a car available) and 24% in the outer areas (where most users are 'captive'), with an overall average of about 37%. This is very similar to the proportions for improved routes of 37% and 40% for SmartBus users (alternative modes) and 35% for the Pakenham improved route (prior modes)[90]. For the users of new routes (mostly 'captive'), the driver proportions (prior modes) were much lower, at 12% for the Pakenham new routes, 11% for Dandenong/Greensborough.

I3.3.3 Car passengers

- In most cases, the 'car passenger' mode appeared to involve a family member (or friend) giving a lift to the person surveyed, most likely with the lift giver making a car driver trip that would not otherwise have been made (although this was not clear from the surveys). Assuming this was the case, the trip would involve the lift giver (driver) in one return trip and the passenger in a single trip, in place of a single bus trip. Thus such lift giving behaviour typically involved twice the car kilometres (including fuel) of the car driver alternative, as well as the driver time for a return trip.
- Most of the survey evidence showed car passenger mode shares of around 15%; the Metlink survey (alternative modes) had an average of 14% (city area 6%, outer area 20%), the SmartBus route 700/900 survey had figures of 16% and 15%, the SmartBus 901/2/3 secondary trip surveys had figures in the range 18% to 36%, and the Pakenham survey (prior modes) figures of 18% and 18%. The 'outlier' was the Dandenong/Greensborough survey, with a 'lift giving' proportion of 50%: we hypothesised that this much higher mode share reflected that the trips were being made in the evening, when walk/cycle in particular is a less attractive alternative for most people.
- The ratios of car passengers: car drivers in tables I.1 and I.2 varied considerably. In the case of the improved services and the Metlink surveys, the ratios were between 1:2 and 1:3; whereas in the case of new routes the ratios were 1.5:1 for Pakenham and about 4.5:1 for Dandenong/Greensborough. The higher ratios tend to reflect situations where a large proportion of the bus users did not have a

[90] These results are very consistent with those from previous NZTA research. BAH (2000) analysed market research evidence internationally and concluded that 'A standard car driver 'diversion rate' in the range of 35%–40% is recommended for use in New Zealand urban/metropolitan centres'.

car available for the trip in question (captive to PT), which typically occurred in the outer areas and particularly for evening travel (as in the Dandenong/Greensborough case).

I3.3.4 Walk/cycle

- The walk/cycle proportions were mostly in the range 4%–24%; for prior mode, the proportions for SmartBus 901/2/3 main purpose were 4%–7%, and for Dandenong/Greensborough 16%; for alternative modes they were all within the range 11%–24%. The 'outlier' here was the Pakenham survey with figures of 58% for the new route and 40% for the improved route; these relatively high figures most likely reflect relatively low car ownership/availability, relatively short distance trips and daytime (rather than evening) trips.

I3.3.5 Not make the trip

- The proportions who said they would not make the trip in question prior to the improved/new bus service (table I.1) varied between 4% and 9% for the Pakenham and Dandenong/Greensborough surveys, but were much higher at 31%–45% for the SmartBus 901/2/3 main trip purpose. We suspect that the SmartBus figures are misleading, as they would appear to include people who changed their trip-making habits in the c.12-month period between the introduction of the new SmartBus services and the survey for reasons which had nothing to do with the new service (eg change in home or employment locations).
- The proportions who said they would not make the trip if their bus service were not available (table I.2) were between 11% and 15% in all cases, with the exception of the Metlink survey for outer areas (32%). This latter high figure may be typical of situations where car availability is low, the trips are relatively long (hence walking/cycling is a less attractive option) and where the trips are predominantly for social/recreational purposes; these are situations in which the availability of bus services is a significant factor in reducing social exclusion.
- The 4%–9% range for 'not make the trip' in response to the 'prior mode' question and the 11%–15% range for the 'alternative mode' question were generally consistent with the substantial Norwegian research on this topic, which found about 6% of bus passengers in the 'not make the trip' category.[91]

I3.4 Reasons for not using new/improved services (non-users) (annex ID)

- Only one of the surveys covered non-users: the Pakenham research included a random (phone-based) survey of non-users.
- The dominant reason given for non-use of buses was the availability of a car. Other reasons given by at least 5% of non-users were: 'I don't know where the buses go' (16%), 'buses are not close to my area' (9%) and 'buses are too infrequent' (5%). These results are unsurprising.

I3.5 Bus service features to encourage use (non-users) (annex ID)

- Again, only the Pakenham survey covered this aspect. In response to the question 'What changes in the bus service would be required for you to consider using buses in Pakenham?', the main changes nominated by non-users were (percentages of those who nominated any changes):
  - routes closer to home (30%)

[91] Refer BAH (2000). However, note that Adelaide research on the impacts of bus service improvements indicated that around 35% of new PT users (both peak and interpeak periods) would otherwise have not made the trip. This relatively high figure may be misleading, for the same reasons as noted in relation to the SmartBus figures above.

- more information (27%)
- more frequent services (22%)
- new routes (10%)
- routes going where I want (10%)
- better connections (7%).

Again, these results are largely unsurprising, given the nature of the area and the bus services provided.

I3.6 User attitudes to service features

I3.6.1 Importance of service features in decision to use enhanced services (annexes IB.4, IC.4)

- For the SmartBus routes market research, those people who used the SmartBus services were asked to rate each feature of the services in terms of its impact on their decision to use the service: ratings were high (4), medium (3), low (2) and none (1).
- For the route 901/2/3 surveys, the highest rating was given to more frequent services, followed by stop-specific timetables, direct routing along main roads and longer service hours. The ordering was very similar for the route 700/900 surveys.

I3.6.2 Importance ratings of service features (annexes IB.5, ID.3)

- The SmartBus route 700/900 market research also asked users to allocate 100 points across SmartBus features in terms of their relative importance rating of these features. On this basis, the highest importance features were frequency (32 points) and longer hours of service (24 points). Other features scored 10 points or fewer, in order: stop-specific timetables (10), bus routes following the main roads (8), real-time passenger information (7), dedicated bus lanes (6) and next stop information on buses (5).
- Users of the new/improved Pakenham bus service were asked to rate the importance of a number of different attributes of the services they travelled on, using a rating scale 1...5.
- The highest ratings were given to attributes relating to service reliability, good service frequency and services running close to the user's desired origins and destinations.
- While the performance scale approach applied in the Pakenham market research is commonly used, it tends not to be very effective in differentiating between attributes. In this regard, the 'bag of points' approach used in the SmartBus research appears to be more discriminating, and may be considered preferable in this regard.

I3.6.3 Service features performance vs importance (annex ID.3)

- The Pakenham users were also asked to rate the performance of their bus services against each of the attributes which they had rated in terms of importance. A 'quadrant analysis' was then performed, assessing for each attribute the difference between performance and importance ratings.
- It was notable that the performance score was lower than the importance score for all attributes (they were all 'under-achievers').
- The attributes with the greatest shortfall between performance and importance were as follows (with rating differences in brackets):
  - bus stops of high standard (1.3)
  - good connections to other PT (1.1)
  - services run at weekends (1.0)

- operates to timetable (0.8)
- frequent services (0.8)
- information on services (0.8).

I3.7 User satisfaction (annexes IA.7, IB.6, IC.4)

- Questions relating to user satisfaction with new/enhanced services were included in all the SmartBus market research assignments.
- In relation to SmartBus routes 703 and 888/9, users were asked about their overall satisfaction with the services: 91% said they were satisfied with the SmartBus services, and 60% felt they were better than other bus services. This reflects a high level of satisfaction with SmartBus and a strong preference for SmartBus services.
- In relation to SmartBus routes 700/900 and 901/2/3, users were asked to rate their satisfaction with various attributes of the services on a scale between totally satisfied (= 100 points) and totally dissatisfied (= 0 points). A Customer Satisfaction Index (CSI) was then constructed, based on the mean scores.
- The mean satisfaction scores for routes 700/900 were as follows, in descending order: SmartBus service overall (83), longer service hours (81), service reliability (81), good frequency (80), low floor buses (79), bus route keeps to main roads (78), accessible bus stops (77), stop-specific timetables (77), dedicated bus lanes (76), real-time passenger information (75) and next stop information on buses (74). These scores are all quite high (80 = very satisfied, 60 = somewhat satisfied).
- The satisfaction rankings from the 901/2/3 surveys gave broadly similar results. However, it was noted that both service frequency and operating hours were rated highly for weekdays, but relatively poorly for weekends.
- Respondents were also asked about their reasons for satisfaction with the SmartBus services overall. For the 700/900 surveys, the dominant reasons were: service runs on time (28%), good/convenient service overall (25%), good service frequency (24%), reliable (12%) and extended hours of service (9%). All other reasons were given by 7% or fewer respondents. Similarly, for the route 901/2/3 surveys, the dominant reasons for satisfaction were: good service frequency (average 19%), good/convenient service overall (16%), quick/direct (15%), service runs on time (13%). All other reasons were given by fewer than 8% of respondents.

I3.8 Access to opportunities – bus users (annexes IB, IC, ID, IE, IF)

I3.8.1 Travel opportunities provided (annexes IB.4, IF.6)

- Analysis of results from the SmartBus route 700/900 research indicated that, for people who used SmartBus at least once every two to three months and had no alternative transport, the SmartBus service provided for approximately 400 additional trips per week among 93 users (average 4.3 trips per week per user). Some 57% of these travel opportunities related to the user's main travel purpose, the remainder to other travel purposes.
- Around half of respondents to the market research on weekend bus services stated they were now travelling more often by bus as a result of the upgraded services. It is surmised that this increase largely translates into increased overall trip making and reduced levels of social exclusion (as well as perhaps a small shift away from car travel).

I3.8.2 Enhanced access to activities (annex IE.4)

- In the Dandenong/Greensborough research, respondents who had been using the bus route prior to the extension of hours were asked what activities were now easier to do, given the extended service hours. The main reported impact (63%) was greater access to social activities (including seeing friends and family). Other significant responses were shopping (24%), new work opportunities (22%) and working later (20%).

I3.8.3 Changes in travel behaviour (D3.3)

- In the Pakenham survey, 59% of users of the new/enhanced services reported they had changed their travel behaviour, in general terms, as follows:
  - I can get to places when I need to (30% of changers/18% of all users)
  - I travel more often (28%/16%)
  - I am less reliant on others for lifts (21%/12%)
  - I drive my car less (13%/8%).

I3.8.4 Social exclusion aspects (annex ID.4)

The Pakenham report (executive summary) summarised the research findings relating to the impacts of bus service improvements on social exclusion, as follows:

> *The surveys confirmed that bus users are often drawn from those groups of people more likely to be experiencing social exclusion. Much of the increase in usage has come from people who previously achieved mobility in other ways. There was a change from walking, cycling and being driven by someone else, to using the bus. The changes in bus usage has increased mobility, accessibility, self-reliance and choices for some people with people reporting that they were now able to access employment, health services and undertake leisure activities. The new buses were found to increase the opportunities for accessibility and participation and ultimately may facilitate the generation of social capital. The feeling of mobility was said to be important in feeling good about the community in which you live.*

Considerable further research has been undertaken in Melbourne over the last few years on the role of improved PT (principally bus) services in helping to reduce social exclusion. A summary/review of this work is beyond the scope of the current project.

I3.9 Changes in bus use – 'new' vs 'old' users (annex IA)

- The SmartBus routes 703 and 888/9 research categorised the SmartBus users into 'new' and 'old' users: 41% had started using the bus service within the previous 12 months, ie since the SmartBus introduction ('new' users); while 59% had been using the service for at least 12 months ('old' users).
- Of the 'old' users, 36% said they were using the services more often than prior to the SmartBus introduction and 17% were using them less often. The net 19% figure using the services more often is certainly significant.
- While the survey did not identify the frequency of use of the two groups (including before the SmartBus introduction for the 'new' users), it does illustrate that a substantial proportion of additional patronage resulting from bus service improvements comprises 'old' passengers using the service more often, as well as 'new' passengers.

I4 Melbourne market research conclusions

I4.1 Prior mode of travel of users of new/improved services

- In situations where new services were introduced in areas and at times where no service previously operated, only a minority (generally one-third or less) of the users of the service would previously have made the trip in question by PT (of any sort). In situations where previous services were improved (maybe involving some rerouting), the majority of the users of the improved services were previously users of the service replaced or upgraded.
- The increases in patronage associated with new/improved services resulted from both 'new' passengers (for the trip in question) and 'old' passengers making additional trips. The balance between these sources of increased patronage depended very much on the nature of the service change, and in particular, the extent to which it served new catchment areas and provided for new PT trip opportunities.

I4.2 Alternative means of travel (if specific PT service not available)

- Similar to the prior mode comments above, the 'next best' alternative for passengers if the specific bus service was not available, would depend very much on whether there were other PT services that would enable them to make the trip in question. In most Melbourne suburban situations, the majority of passengers would use another PT service as their 'next best' alternative. Not surprisingly, the proportion using another PT service tended to be higher in the inner suburban areas than in the outer areas.
- For those passengers who would **not** use another PT service, typical alternative mode shares were:
  - car driver c.30%–40%
  - car passenger (lift) c.15%–25%
  - walk/cycle c.10%–20%
  - taxi/other c.5%–15%
  - not make trip c.10%–20%.
- These proportions were generally consistent with results from market research elsewhere. However, the proportions would have been influenced by the specific situation, as discussed in section I3.

I4.3 Desired service improvements

- For typical low-frequency suburban services, users' highest priority aspects for bus service improvements to increase patronage were good service frequencies and extended service hours (to run in evenings and weekends).
- Other priority aspects included: more direct services (follow the main roads), improved reliability, improved bus stops, real-time passenger information and stop-specific timetables.
- For PT services to attract current non-users who had access to a car, key aspects for improvement were:
  - more frequent services
  - services to better match required origins (home) and destinations
  - more or better information and marketing of services.

I4.4 User response to service improvements

- The SmartBus market research indicated that features of the services that most influenced people's decision to use the services were: the improved frequencies, faster travel/direct routings, longer service hours and stop-specific timetables/real-time information. These features were also those for which SmartBus users expressed the highest levels of satisfaction. These findings for improved services were generally consistent with the priority improvements desired by users of 'unimproved' services (above).

The evidence indicated that:

- A substantial proportion of new passengers using improved PT (particularly suburban bus) services tended to be people with limited mobility options, who were most likely to be experiencing a significant degree of social exclusion.
- The improved PT services were likely to promote increased mobility, accessibility and self-reliance, providing better access to employment, health services and leisure activities. This contributed to reducing social exclusion.

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Annex IA: SmartBus routes 703 (Blackburn Road) and 888/889 (Springvale Road) – post market research of users

IA.1 Introduction

The first two SmartBus routes, route number 703 (Blackburn Rd) and route 888/9 (Springvale Rd) were introduced in August 2002.

In August 2003, market research was undertaken of a random sample of users of these routes (sampling on bus), with a sample size of 1800 passengers. The survey results are reported in SKM (2004) and key results are summarised in this annex[92].

IA.2 New vs old users

- Refer table IA.1.
- 41% of users had started using the bus service in the previous 12 months, ie since the introduction of SmartBus.

IA.3. 'New' users – reasons for use

- Refer table IA.2.
- Most 'new' users had started using the service because of factors unrelated to SmartBus, principally because of moving house, changing job or changing school.
- Some 22% of new users had started using the service for reasons related to the attractiveness of SmartBus (compared with the previous services).
- Of these new users, the primary reason given for switching to SmartBus was its 'more direct route'. Other significant reasons related to its better frequency, reliability and comprehensibility.

IA.4 'Old' users – changes in use

- Refer table IA.3.
- Of the 'old' users, 36% said they were using the service more often than prior to SmartBus introduction, 17% were using it less often.
- The net 19% using the services more often is certainly significant.

IA.5 'Old' users – reasons for increased use

- Refer table IA.4.
- Of the 'old' users, 36% were using the service more often than prior to SmartBus (as above): somewhat over half these (23% relative to 36%) had increased their use for reasons relating to the more attractive service provided by SmartBus. Over half this group cited the more direct route as the reasons for their greater use, while others cited the better frequency, reliability, increased hours of service and comprehensibility.

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[92] The market research report provided results for each of the routes separately and in total. Here we report only on the totals for both routes together.

IA.6 User categories

- Ticket data indicated that adult patronage increased proportionately more than concession patronage following the SmartBus introduction.

IA.7 User satisfaction

- The survey found that 91% of passengers were satisfied with the SmartBus services and 60% felt they were better than other bus services. This reflects a strong relative preference for SmartBus services.

IA.8 Summary

- Of the users of the SmartBus services one year after their introduction:
  - 41% were new users, with 22% of these (9% of all users) having become users because of the SmartBus features.
  - 59% were 'old' users, with 36% of these (21% of all users) increasing their frequency of use of the route and over half of these (14% of all users) increasing their use because of the SmartBus features.
- This indicates that a substantial proportion of the increased patronage on the SmartBus services was from 'old' users using the service more frequently[93].
- The primary SmartBus-related reason given for greater use of the SmartBus services (by both 'old' and new users) was the 'more direct route'. Other reasons (including service frequency, improved reliability, longer hours of service) were given less often[94].
- The growth in adult patronage using the SmartBus services was greater (in proportionate terms) than the growth in concession patronage.
- 91% of passengers expressed satisfaction with the SmartBus services and 60% considered SmartBus to be better than other bus services.

Table IA.1 When did you first start using the bus?

Time	Total
Within the last three months (from May 2003)	14%
Within three months to six months (from February 2003)	17%
Within last year (from August 2002)	11%
Total new users	**41%**
More than a year ago ('old' users)	59%
Total	**100%**

Source: SKM (2004) table 3.4.

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[93] The survey questions were such that it is not possible to quantify the proportions of new patronage attributed to 'old' and 'new' users. The SKM (2004) report states that 'growth comprises travel by new bus users and more travel by existing users in broadly equal amounts'.

[94] This conclusion that the 'more direct route' is the primary reason for greater use of SmartBus appears at odds with the statement in the SKM (2004) report (section 4.3) that: 'It is clear from the analysis and discussions that the majority of benefits come from the increased service levels, which give rise to time savings (including waiting time savings) for existing users and are also the primary reason that new users are attracted to the services'.

Table IA.2 Why have you started using the bus in the last year?

Reason	Total (all)	Total (new users)
Other (mostly moving house)	15%	37%
Going to new school	10%	24%
Going to new job	8%	20%
No longer have access to a car	4%	10%
Cost	1%	2%
Total non- SmartBus related	**38%**	**93%**
More direct route	5%	12%
Prefer public transportation	1%	2%
Frequency of buses	0.9%	2.2%
Improved reliability/punctuality of bus	0.7%	1.7%
Easier to understand bus service	0.5%	1.2%
Better information on route directions and bus stop locations	0.4%	1.0%
Longer hours of service	0.2%	0.5%
Overall bus service improvement	0.1%	0.2%
Better information on buses	0.0%	0.0%
Total SmartBus related	**8.8%**	**21.5%**
Been using bus for more than a year/can't remember	**59%**	
Total	**100%**	

Source: SKM (2004) table 3.5.

Note that multiple answers were permitted so the totals add to more than 100%.

Table IA.3 Are you using the bus more or less frequently than you did a year ago?

Reason	Total (all)	Total (old users)
More often than a year ago	21%	36%
Same as a year ago	28%	47%
Less often than a year ago	10%	17%
Sub-total 'old' users	59%	100%
Was not on it at all more than a year ago	41%	
Total	**100%**	

Source: SKM (2004) table 3.6.

Table IA.4 Why are you using the bus more or less frequently than you did a year ago?

Reason	Total (all)	Total (old users)
Going to new school	4%	7%
Going to new job	3%	5%
No longer have access to a car	2%	3%
Other (mostly moving house)	2%	3%
Cost	0%	0%
Total non-SmartBus related	**11%**	**19%**

Reason	Total (all)	Total (old users)
More direct route	9%	15%
Prefer public transportation	1%	2%
Frequency of buses	1.5%	2.5%
Improved reliability/punctuality of bus	0.7%	1.2%
Longer hours of service	0.6%	1.0%
Easier to understand bus service	0.3%	0.5%
Overall bus service improvement	0.2%	0.3%
Better information on buses	0.2%	0.3%
Better information on route directions and bus stop locations	0.1%	0.3%
Total SmartBus related	**13.6%**	**23.1%**
Have not been using bus more frequently	79%	
Total	**100%**	

Source: SKM (2004) table 3.7.

Note that multiple answers were permitted so the totals add to more than 100%.

Annex IB: SmartBus routes 700 (Box Hill – Mordialloc) and 900 (Stud Park – Caulfield) – post market research of users

IB.1 Introduction

This market research (Market Solutions P/L 2007) covered a survey of passengers on SmartBus routes 700 (Box Hill – Mordialloc, introduced June 2005) and 900 (Stud Park – Caulfield, introduced October 2006). An on-board survey of 1550 passengers on the two routes was conducted in August/September 2007.

IB.2 Becoming a SmartBus user

IB.2.1 Starting to use the SmartBus (4.1)[95]

- Most respondents (64%, 'new' users) started using route 700 after the SmartBus upgrade in June 2005.
- Of those who were users prior to the upgrade ('old' users), 61% reported increasing their usage since the introduction of the SmartBus to route 700.
- Nearly half of the route 900 respondents began using the route within three months of its introduction.

IB.2.2 Before the SmartBus (4.2)

- PT use (for any trips) before the uptake of the SmartBus service was varied; however, most used either trains or buses, depending on which SmartBus route they travelled.
- More than a quarter (27%) of respondents did not use PT at all before they started to use the SmartBus.
- Most (57%) of the respondents who used PT before the SmartBus reported regular daily usage; however, a significant proportion reported using other services two to three days per week.

[95] The references here (4.1) and in the following sub-sections refer to the section of the Market Solutions P/L 2007 report from which the material is drawn.

IB.2.3 Reasons for using the SmartBus or using more often (4.3)

- Overwhelmingly, the most common reason (67%) reported for becoming a SmartBus user was that the route was more direct or more convenient than alternatives.
- SmartBus features were specifically reported as a reason for usage by 11% of respondents (new and increased PT users).
- The most commonly cited SmartBus features were the service frequency (5%), the directness of the route (3%) and the longer service hours (2%).

IB.3 Using the SmartBus

IB.3.1 Frequency and time of SmartBus Use (5.1)

- 42% of respondents used the SmartBus service at least daily, and a further 30% used it at least two to three days/week.
- Nearly half (48%) of all respondents reported that they used the services in **both** the morning and afternoon peak, and a further 19% reported that they used the service in **either** the AM or the PM peak. 19% reported weekday off-peak usage.

IB.3.2 Connecting to other public transport (5.3)

- About one third (36%) of passengers reported that they did not connect to other PT. However, a similar proportion (33%) reported that they connected both before and after using the SmartBus service.
- Satisfaction with the ease of making the connection was high.

IB.3.3 Reasons for use and consideration of alternatives –main travel purpose (5.3)

- Most passengers (73%) reported that they commuted to and from school, university, technical and further education college (TAFE) and work using the SmartBus. This was not surprising considering the high levels of students using the services.
- A notable proportion (12%) reported shopping as their main reason for using the SmartBus service.
- If the SmartBus service was not available to them, 87% of respondents said they would make their main SmartBus trips by PT (43% by another bus, 39% by train, 5% by tram), and a further 6% would access PT by car or getting a lift. 14% would travel by car (as driver) all the way, 6% would get a lift all the way, 5% would travel by taxi and 9% would walk or cycle. 4% said they would not make the trip[96].

IB.3.4 Reasons for use and consideration of alternatives - additional trips (5.4)

- Fewer than half (46%) of all respondents reported that they made additional trips on the SmartBus that were unrelated to their main travel purposes.
- The main reason for additional trips was travel to and from shops (43% of those making additional trips). Leisure/social activities, work, visiting family and friends, school/uni/TAFE and personal appointments were also reported by notable proportions of passengers.
- If the SmartBus service was not available, the proportion of respondents by each alternative mode was generally similar to the proportions for the main travel purpose. 78% would make the trip by other PT services, and a further 8% would access PT as car driver or passenger. 19% would travel by car all the way and 7% get a lift all the way; 8% would travel by taxi and 8% would walk or cycle. 6% said they would not make the trip.

[96] Figures add to more than 100% as multiple choices were accepted.

IB.4 Impacts of the SmartBus

IB.4.1 Travel opportunities provided (6.1)

- Analysis of users who reported SmartBus travel at least once every two to three months with no alternative transport indicated that the SmartBus provided approximately 400 opportunities or trips per week among these users.

IB.4.2 Potential car travel prevented (6.2)

- As noted above, the preferred alternative means of travel if SmartBus was not available was by car for 20% of respondents for their main travel purpose and for 26% of respondents making additional trips.
- Analysis of the users who reported travel at least once every two to three months with cars (excluding taxis) as alternative transport indicated that the SmartBus potentially prevented some 2200 car travel opportunities or trips per week among these users.

IB.5 Features of the SmartBus services

IB.5.1 Influence on the decision to use the SmartBus (7.1)

- Respondents were asked to rate each feature of the SmartBus services in terms of its impact on their decision to use the service: ratings were high (3), medium (2) and low (1).
- The frequency of service was given the highest rating (average 2.6). Second equal rating (2.5) was given to accessible bus stops, stop-specific timetables and longer hours of service. Next highest ratings were given to real-time passenger information (2.4), low floor buses and bus routes following the main roads (2.3).

IB.5.2 Importance of features (7.2)

- Respondents were asked to allocate 100 points across SmartBus features in terms of their relative importance rating of these features. On this basis, the highest importance features were frequency (32 points) and longer hours of service (24 points). Other features scored 10 points or fewer, in order: stop-specific timetables (10), bus routes following the main roads (8), real-time passenger information (7), dedicated bus lanes (6) and next stop information on buses (5).

IB.6 Satisfaction (8.1)

IB.6.1 Customer Satisfaction Index (CSI) scores (8.1)

- Respondents were asked to rate their satisfaction with various aspects of SmartBus services on a scale between totally satisfied (100 points) and totally dissatisfied (0 points). A Customer Satisfaction Index (CSI) was then constructed, based on the mean scores.
- The mean satisfaction cores were as follows, in descending order: SmartBus services overall (83), longer service hours (81), service reliability (81), good frequency (80), low floor buses (79), bus route keeps to main roads (78), accessible bus stops (77), stop-specific timetables (77), dedicated bus lanes (76), real-time passenger information (75) and next stop information on buses (74). These scores are all quite high (80 = very satisfied, 60 = somewhat satisfied).

IB.6.2 Reasons for satisfaction (8.2)

- In response to the question on reasons for satisfaction/dissatisfaction with the SmartBus service overall, the dominant reasons for satisfaction were: service runs on time (28%), good/convenient service overall (25%), good service frequency (24%), reliable (12%) and extended hours of service (9%). All other reasons were given by 7% or fewer respondents.

Annex IC: SmartBus routes 901, 902, 903 – post market research of users

IC.1 Introduction

Market research by Market Solutions P/L (2009a; 2009b; 2011) covered random on-board surveys of passengers on three SmartBus routes:

- Route 901 (Ringwood – Frankston) – introduced March 2008, surveys April/May 2009 (944 passengers surveyed).
- Route 903 (Altona – Mordialloc) – introduced April 2009, surveyed October 2009 (1021 passengers surveyed).
- Route 902 (Chelsea – Airport West) – introduced April 2010, surveyed February 2011 (1007 passengers surveyed).

Key features of the SmartBus services are:

- increased frequency (running every 15 minutes between 6.30am and 9.00pm on weekdays and every 30 minutes at other times)
- longer operating hours
- timetables specific to the bus stop
- real-time information signs at selected stops
- ‘next stop’ information on buses
- low floor buses and accessible bus stops.

This appendix reports the results for the three routes together, on a comparable basis[97].

IC.2 Becoming a SmartBus user

IC.2.1 Starting to use the SmartBus

- Before the introduction of the SmartBus service, the typical breakdown of respondents by their previous mode used for the trip in question was:
  - another bus route 30%
  - car (driver/passenger) 20%
  - walk/cycle 5%
  - other means 20%
  - did not make this trip 25%.

  Further details are given in table IC.1.
- Of those respondents who had used other (non-bus) transport modes for this trip prior to SmartBus, around 50% reported frequency of use of the other mode of at least four to five days/week, around 25% of two to three days week, 10% around once per week, and around 10% less often.

[97] Data drawn largely from the route 902 survey report (Market Solutions P/L, 2011).).

IC.2.2 Reasons for using the SmartBus or using more often

- Overwhelmingly, the most common reason reported for becoming a SmartBus user was that the route was 'more direct or more convenient' than alternatives (table IC.2).
- SmartBus features were specifically reported as a reason for usage by around 5% of respondents (although noting that other SmartBus features were also implicit in some of the other responses, such as directness/convenience and reliability).
- Of those who specifically mentioned SmartBus features, the most prominent feature was the frequency of the service (around 70%) and the longer operating hours (around 15%) (table IC.3).

IC.3 Using the SmartBus

IC.3.1 Frequency and time of SmartBus use

- Around 70% of respondents stated they used the SmartBus service at least two to three days per week, with many using it four to five days per week or more often (table IC.4).
- Around 60%–70% of all respondents said their main use of the SmartBus services was in the weekday peak periods (one or both peaks), around 20% in the weekday off-peak periods and 10%–15% at the weekends (table IC.5).

IC.3.2 Connecting to other public transport

- Somewhat over half of passengers interviewed reported that they **connected** to other PT, either before or after their SmartBus travel: around 15%–20% of passengers used another PT service both before and after their SmartBus travel (table IC.6).
- For those passengers making connections, the majority were either very satisfied or totally satisfied with the ease of making the connection.

IC.3.3 Purposes of SmartBus use

- The majority of passengers reported that their main trip purpose in using SmartBus was commuting either to/from work (c.40%) or to/from school or tertiary education (c.25%). A further 10%–15% said their main use was for shopping trips, and a similar proportion for visiting family or friends.
- Around 35%–40% of passengers said they also used the service for making trips for other than their main trip purpose. For this group, the dominant trip purposes for these 'other' trips were shopping (30%–40%), visiting family or friends (20%–25%), leisure/social activities (10%–15%) and school/tertiary education (c.10%).

IC.3.4 Alternative modes

- Passengers' alternative modes for their trip in question prior to the introduction of SmartBus were summarised earlier (IC2.2, table IC.1).
- Passengers' alternative modes for their 'other' trips, or if the SmartBus service was not available, would be primarily by another bus service (30%–40%), or by train or tram (30%–35%). Around 15% said they would drive a car (all the way) and a further 10%–20% would get a lift (all the way). Around 5% would walk or cycle, and a further c.5% said they would not make the trip (table IC.7).

IC.4 Features of the SmartBus services

IC.4.1 Influences on the decision to use the SmartBus

- Respondents were asked to rate the main features of the SmartBus services in terms of their impact on their decision to use the service: ratings were high (4), medium (3), low (2) and none (1), and overall weighted averages were calculated.
- Averaged over the three routes, the highest rating was given to more frequent services, followed by stop-specific timetables, direct routing along main roads and longer operating hours: all these had average ratings of 3.0 or higher (table IC.8).

IC.4.2 Satisfaction with SmartBus features

- Respondents were asked to rate their level of satisfaction with each of the main features of the SmartBus services, and a weighted average score (Customer Satisfaction Index) was calculated.
- It is seen that (table IC.9):
  - The SmartBus service overall rated very highly.
  - Of the features that were the main influence on people's decision to use the service, the service frequency was rated highly on weekdays, relatively poorly on weekends; and similarly the hours of operation were rated highly on weekdays, relatively poorly on weekends. The provision of timetable information at bus stops (both real time and information generally) ranked reasonably highly. On-time performance was also ranked moderately.
  - Overall, it appears that the most significant aspects in terms of influencing usage, where the satisfaction levels were relatively low, were for weekend service frequency and hours of operation.

IC.4.3 Reasons for overall satisfaction/dissatisfaction

- Further analysis of the decision influences and satisfaction levels with the SmartBus services indicated that the key drivers of satisfaction related to the services being:
  - Frequent (19%)
  - Good and convenient overall (16%)
  - Quick and direct (15%)
  - Running on time (13%)
  - (All others below 8%).
- Similarly, the key drivers of dissatisfaction related to:
  - Service not running on time (10%)
  - Inadequate frequency and hours of operation outside weekday daytime period (6%)
  - (All others below 3%).

Table IC.1 Alternative modes used prior to SmartBus

HOW MOSTLY TRAVELLED BEFORE SMARTBUS (Q6)	902	903	901
Base: All Answering	Total (n=1004)	Total (n=1021)	Total (n=944)
	%	%	%
Another bus route	37.9	25.1	32.4
Car	20.8	15.7	26.9
Walked/cycle	3.4	2.8	4.9
Other	10.3	31.3	14.9
Did not make this trip ^	27.6	25.1	20.9

Table IC.2 Reasons for starting to use SmartBus

REASON STARTED USING SMARTBUS (Q1)	902	903	901
Base: All Answering	Total (n=1003)	Total (n=1021)	Total (n=944)
	%	%	%
The route is more direct/ convenient	68.2	71.3	80.6
More reliable service	13.4	11.3	8.9
I moved into the area & this is the best route for me	8.6	9.6	8.3
Cheaper than driving/ parking	7.7	0.4	1.9
My travel patterns changed & this suits my new needs	7.0	-	-
I was using a bus that the Route 902 replaced	7.0	3.4	0.0
SmartBus features (Specify features)	3.7	4.6	7.0
Other (Specify)	12.6	0.0	0.1
No particular reason	-	0.1	0.3

Table IC.3 Specific SmartBus features influencing use

SPECIFY SMARTBUS FEATURES (Q1)	902	903	901
Base: Specified SmartBus Feature	Total (n=37)	Total (n=47)	Total (n=66)
	%	%	%
More frequent bus services	64.9	76.6	66.7
Longer operating hours	24.3	19.1	1.5
Next stop information on buses	5.4	2.1	0.0
Low floor buses	5.4	-	-
Stop specific timetables	2.7	0.0	7.6
Real time passenger info at selected stops	2.7	-	-
Accessible bus stops	2.7	2.1	0.0

Table IC.4 Frequency of SmartBus use

FREQUENCY OF SMARTBUS USE (Q8) *Base: All Answering*	902 Total (n=1004)	903 Total (n=1021)	901 Total (n=944
	%	%	%
First time	7.0	10.3	8.1
6-7 days per week	14.2	39.0	43.5
4-5 days per week ^	42.2	-	-
2-3 days per week	21.9	29.5	30.1
Once a week	8.0	10.9	9.4
Once a fortnight	3.2	3.5	4.1
Once a month	1.7	3.3	2.4
Once every 2-3 months	1.0	1.8	1.3
Less often	0.8	1.8	1.1

Table IC.5 Time periods of SmartBus use

WHEN MOSTLY TRAVEL ON SMARTBUS (Q10) *Base: Have used Route 902 service before*	902 Total (n=930)	903 Total (n=916)	901 Total (n=868)
	%	%	%
Weekday morning peak (6:30-9am)	24.2	7.2	7.8
Weekday afternoon peak (4-7pm)	16.5	10.5	6.1
Weekday morning & afternoon peak	35.8	44.0	46.3
Weekday off-peak	15.9	22.5	24.7
Weekend peak (9am-6pm)	6.1	11.2	11.6
Weekend off-peak	1.5	4.6	3.5

Table IC.6 PT connections before/after SmartBus use

CONNECTIONS WITH OTHER PT (Q13) *Base: All Answering*	902 Total (n=997)	903 Total (n=1021)	901 Total (n=944)
	%	%	%
Before	17.1	16.6	14.6
After	22.5	19.4	23.7
Before and after (both)	13.1	15.5	25.4
Don't connect	47.3	48.6	36.2

Table IC.7 Alternative modes for 'other' trips

HOW WOULD MAKE OTHER JOURNEYS IF BUS NOT AVAIL (Q18)	902	903	901
Base: Make other trips	Total (n=347)	Total (n=450)	Total (n=287)
	%	%	%
Another bus	40.5	40.7	19.2
Train	25.3	29.3	27.5
Lift - all the way	8.9	8.0	22.6
Car - all the way	8.0	17.3	16.7
Tram	5.0	7.8	4.5
Walk/ ride bike	3.0	8.9	9.4
Lift - to other public transport	2.4	0.7	2.1
Taxi	1.7	3.8	6.3
Car - to other public transport	0.9	2.0	1.4
Wouldn't make the journey	3.7	6.2	9.4
Other	0.6	0.0	0.0
Don't know/ can't say	0.0	0.0	2.8

Table IC.8 Impacts of SmartBus features on decision to use

IMPACT OF SMARTBUS FEATURES (Q2)	902	903	901
Base: All Answering	Total (n=1007)	Total (n=1021)	Total (n=944)
Mean: High=4 thru Low=1	MEAN	MEAN	MEAN
a. Longer operating hours	3.0	2.9	3.1
b. More frequent bus services	3.3	3.3	3.5
c. Bus lanes in selected locations	2.6	2.6	2.9
d. Bus takes a direct route along main roads	3.1	2.9	3.1
e. Timetables specific to bus stop location	2.8	3.1	3.3
f. Real time travel information at selected bus stops	2.8	2.9	3.1
g. Next stop information on buses	2.7	3.0	3.0
h. Quality of bus stop infrastructure ^	2.6	3.1	3.1
i. Low floor buses	2.4	2.5	2.5

Table IC.9 Level of satisfaction with SmartBus features

SATISFACTION WITH SMARTBUS FEATURES	902	903	901
Base: All Answering	. (n=1007)	Total (n=1021)	Total (n=944)
	CSI	CSI	CSI
This SmartBus service overall	85.9	82.2	86.3
The frequency of buses on weekdays	86.0	80.1	84.4
The frequency of buses on weekends	72.2		
Timetable information at bus stops	86.3	77.4	81.0
Operating hours on weekdays	85.8	78.7	83.4
Operating hours on weekends	73.0		
Real time travel info at selected bus stops	84.3	76.4	80.0
Ease of getting on and off the bus	90.7	80.1	79.6
Use of bus lanes in selected locations	82.3	74.9	79.2
The bus running on time	77.5	81.0	85.0

Annex ID: Upgrading of Pakenham bus services – post market research of users and non-users

ID.1 Introduction

The bus services in the Pakenham area were improved in January 2006, with the introduction of three new routes (927/8/9) and the upgrading of one existing route (826/926).

Market research was conducted in May/June 2006 by Multi-modal Transport Solutions (2006) on behalf of BAV/Metlink. This comprised user and non-users surveys[98], focus groups and analysis of ticket validations.

ID.2 Patronage

- Patronage grew steadily in the period analysed, up to June 2006, but was still 'low'.
- The new routes averaged around three to four boardings per trip on weekdays (around 0.4–0.5/bus km) and one to two boardings per Saturday trip (0.1/bus km). The upgraded route averaged 12 boardings per trip on weekdays (0.9/bus km) and around six boardings per Saturday trip (0.5/bus km).
- Bus services were used by around 11% of the area population. High frequency users (at least two days/week) comprised about 150 people (c.0.7% of the Pakenham population).

ID.3 User survey findings

ID.3.1 Trip purpose

- The dominant trip purpose of bus users was shopping (40%) followed by commuting to/from work (19%) and personal business (17%)[99].

ID.3.2 Previous mode of travel

- 31% of all users (16% of users of the new routes) had previously made the trip by other bus services (primarily route 826) or by bus/train.
- 27% (25% for new routes) had previously made the trip as car driver or car passenger (given a lift by others).
- 35% (49% for new routes) had previously walked or cycled.
- 3% (6% for new routes) would not previously have made the trip.
- 52% reported that they frequently provided lifts to other people in their household and 9% said this had decreased somewhat with the new services.

ID.3.3 Changes in travel behaviour

- 59% of users said they had changed their travel behaviour as a result of the introduction of new and upgraded bus services. Of these:
  - I can get to places when I need to (30%, representing 18% of all users)

[98] The main surveys of users and non-users were by phone (CATI): on-board surveys were also undertaken to recruit users for the subsequent phone surveys.

[99] The survey excluded people aged <14 and only some 3% of those surveyed were in the 14–17 age group.

- I travel more often (28%, 16% of all users)
- I am less reliant on other for lifts (21%, 12% of all users)
- I drive my car less (13%, 8% of all users).

ID.3.4 Service attribute importance and performance

- Users were asked to rate the importance of a number of different attributes of the new/upgraded services they travelled on, using a 1...5 rating scale. They were then asked to rate the performance of the current services on these attributes. A 'quadrant analysis' was then performed.
- Table ID.1 shows the average importance and performance ratings from this research.
- In terms of the ratings of attribute importance, it is evident that the highest rating attributes relate to reliability, service frequency and closeness of services to desired origins and destinations. However, it is also worth noting that the importance scores on most attributes lie within a relatively narrow range.

Table ID.1 Importance and performance rankings (Pakenham)

Attribute	Importance	Performance	Difference (importance-performance)
Runs to timetable	4.7	3.9	0.8
Routes go where I want	4.7	4.2	0.5
Routes are close to home	4.6	4.2	0.4
Frequent service	4.6	3.8	0.8
Good connections to PT	4.5	3.4	1.1
Information – bus service	4.4	3.5	0.8
Bus stops of a high standard	4.3	3.0	1.3
Easy to get on and off the bus	4.2	4.1	0.2
Runs over the weekend	4.1	3.1	1.0
Buses travel quickly	4.0	4.0	0.0
Runs late at night	3.4	2.9	0.5

- In terms of comparisons between performance against an attribute relative to the importance of that attribute, it is notable that in no case did performance against an attribute score higher than its importance. Those attributes with the greatest shortfall of performance against importance were as follows (with rating differences in brackets):
  - Bus stops of high standard (1.3)
  - Good connections to other PT (1.1)
  - Services run at weekends (1.0)
  - Operates to timetable (0.8)
  - Frequent services (0.8)
  - Information on services (0.8)
  - Services go where I want (0.5)
  - Services run late at night (0.5)
  - Routes go close to home (0.4).

ID.4 Social exclusion aspects (executive summary)

- The surveys confirmed that bus users were often drawn from those groups of people more likely to be experiencing social exclusion.
- Much of the increase came from people who had previously achieved mobility in other ways. There was a change from walking, cycling and being driven by someone else, to using the bus. The changes in bus usage had increased mobility, accessibility, self-reliance and choices for some people, with people reporting they were now able to access employment, health services and undertake leisure activities.
- The new bus services were found to increase the opportunities for accessibility and participation and ultimately may facilitate the generation of social capital. The feeling of mobility was said to be important in feeling good about the community in which you live.

ID.5 Non-user survey findings

ID.5.1 Existing travel arrangements

- For non-users, car was the dominant mode for travelling around Pakenham – for about 90% as the car driver, 5% as car passenger. Walking was the dominant mode for a further 5%, with other responses being negligible.

ID.5.2 Awareness of bus service improvements

- Only 50% of non-users were aware of the introduction of the new services.

ID.5.3 Reasons for non-use

- The dominant reason (63%) for non-use of buses was the availability of a car.
- Other reasons given by at least 5% of non-users were 'I don't know where the buses go' (16%), 'buses are not close to my area' (9%), and 'buses are too infrequent' (5%).

ID.5.4 Desired changes to bus services

- In response to the question about changes to the bus service required for non-users to consider using buses in Pakenham, the main changes nominated were:
  - routes closer to home (30% of these nominating any changes)
  - more information (27%)
  - more frequent services (22%)
  - new routes (10%)
  - routes going where I want (10%)
  - better connections (7%).

ID.6 Focus group findings

- The most commonly-supported suggestions (from the focus groups and the surveys) for further improvements to the bus services concerned:
  - the lack of information (and timetables) informing users and non-users about the new services
  - the lack of adequate bus stops (including the need for lighting)
  - more frequent services (many advocating a half-hour service in preference to the hourly service)

- better connections with the train services
- extended services on Saturdays
- new services on Sundays
- new routes or new stops
- smaller buses to better manoeuvre through the residential estates and to operate more efficiently
- attention to customer service
- well-designed bus shelters.

Annex IE: Dandenong and Greensborough new evening bus services: user post market research

IE.1 Introduction

Market research with bus users was conducted by BAV in October 2007, to better understand the impacts on users of the later extension of weekday evening services (the 'safety net' programme). The research targeted the users of these new evening services (on existing routes). It involved face-to-face interviews on a weekday evening (1830–2130) at Dandenong Station and Greensborough Plaza. A total of 101 interviews were conducted (Loader and Stanley 2007; Loader 2008).

IE.2 Respondent profiles

- Just over half the respondents were long-term users of the bus route being used (at other times of day), the remainder were new users since the extended service hours.
- About 60% of respondents were under age 30, and only about 5% over 60.
- The majority (around 70%) of users in all age groups did not have access to a car (some or most of the time); and this proportion did not vary greatly between full fare and concession passengers. Only around 10% of the 10–19 age group had car access, around 30%–40% of the 20–29 age group and 50% of the 30–49 age groups.
- The main trip purposes of the respondents (on their interviewed trip) were: work (39%), social (21%), education (16%), shopping (14%).

IE.3 Previous means of travel

- Those respondents who had previously used the bus route (prior to its extended hours) were asked how they made their trip before the improvements.
- In most cases (52%, 28 ex 54) said they would previously have got a lift.
- Other significant responses were walk 17%, taxi 15%, other PT routes 13%, drove car 11%, travelled less often 7% and did not travel at all 6%.

IE.4 Enhanced accessibility to opportunities

- Those respondents who had been using the bus route prior to the extension of hours were asked what activities were easier to do, given the extended services.

- The main reported impact (63%, 34 ex 54) was greater access to social activities (including seeing friends and family).
- Other significant responses were shopping (24%), work opportunities (22%) and working later (20%).

IE.5 Priorities for further service improvements

- Respondents were asked, if further service upgrades were to be made, whether they would prefer more frequent services or later services:
  - for those with car access, more frequent services were strongly favoured
  - for those without car access, later services were slightly preferred.

  (Of course, these are only the views of existing users, and do not cover current non-users.)

IE.6 Some respondent comments

- 'Lets us do more things ourselves, we have more independence' (age 15)
- 'Can stay out later – have independence. No-one could live without buses' (age 15)
- 'Jobs were hard to get to before' (new use, female, 32)
- 'I'm able to get rid of my car' (new use, age 25)
- 'I'm more confident knowing I'm not catching the last bus'.

Annex IF: Market research on weekend bus services

IF.1 Introduction

In November 2010, BusVic (with support from DoT/Metlink) commissioned a survey of weekend bus users at four major suburban bus interchanges (Loader 2011):

- Broadmeadows Station and Shopping Centre
- Chadstone Shopping Centre
- Dandenong train – bus interchange
- Doncaster Shopping Centre (Westfield).

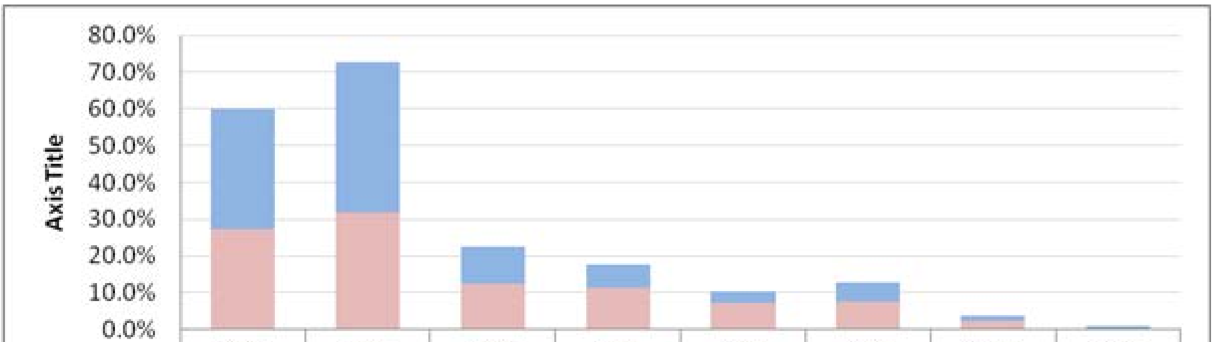
The survey covered 451 bus users over the periods Saturday 1600–2130 and Sunday 1100–2100 (essentially the periods over which services had been extended).

IF.2 Bus user profile (figure IF.1)

Contrary to the common perception of bus users as mainly the young and the elderly, the spread of weekend bus users surveyed over the four activity centres revealed the majority of users (over the age of 15[100]) were aged 20–39, with the most common bracket being 30–39 year old. There were no significant differences in profile of male and female respondents (52% of total respondents were female).

[100] Note that persons under 15 were not interviewed as part of the study, so the data presented only covers users over 15.

Figure IF.1 Age/sex: weekend bus users



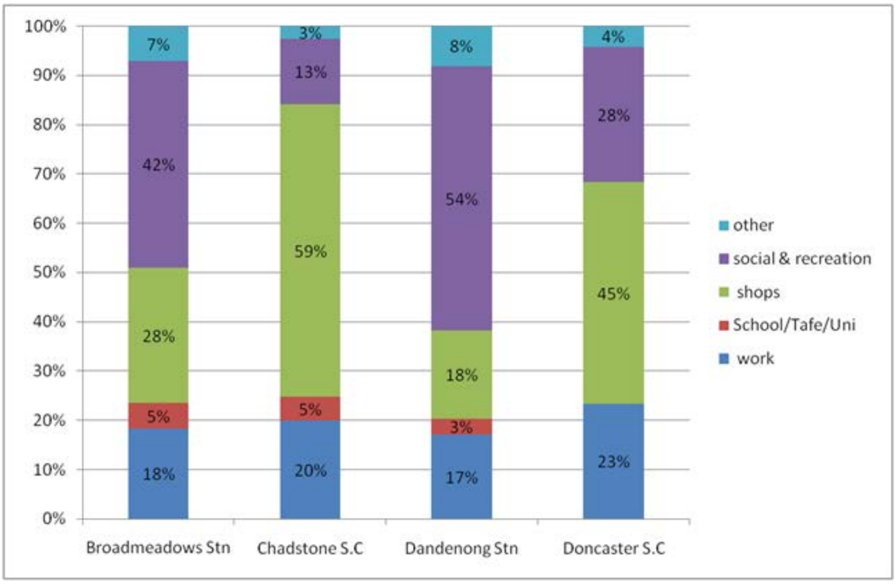
	20's	30's	40's	50's	60's	70's	80's	90's
Male	32.4%	40.9%	10.1%	6.1%	3.2%	5.3%	1.6%	0.4%
Female	27.4%	31.9%	12.2%	11.5%	7.0%	7.4%	2.2%	0.4%

IF.3 Purposes of weekend bus travel (figure IF.2)

Not surprisingly, for those interviewed at Chadstone and Doncaster Shopping Centres, the most commonly stated purpose was shopping. However at Broadmeadows and Dandenong Station, which are not located at shopping centres, social and recreational purposes were the most frequently reported trip purpose.

The next most common trip purpose across the sites was work (17%–23%), showing bus services are important for people to access weekend employment opportunities without relying on a private car.

Figure IF.2 The purpose of travel for weekend bus users



IF.4 Frequency of weekend bus use (figure IF.3)

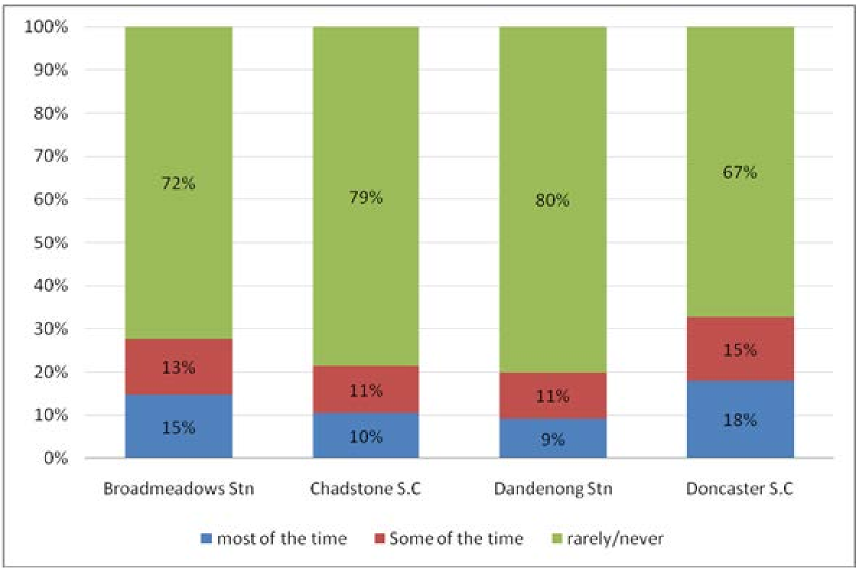
The majority of weekend bus users interviewed were travelling on buses most weekends, with a further significant proportion using buses at least once a month. This suggests that bus services play a large role in accessibility for their users: the increased Sunday services in particular are likely to be providing them with significantly more travel opportunities.

Figure IF.3 How frequently do bus travellers use buses on weekends?

IF.5 Car availability of weekend bus users (figure IF.4)

The lack of access to a car for weekend trips is a significant factor in weekend bus use. Up to 80% (at Dandenong Station) of those surveyed did not have any access to a car for their transport needs: conversely, the level of 'choice' bus travel varied between 20%-33%. Weekend bus users travelling to Doncaster Shopping Centre were the most likely to leave their car at home, with 33% able to access a private car most or some of the time.

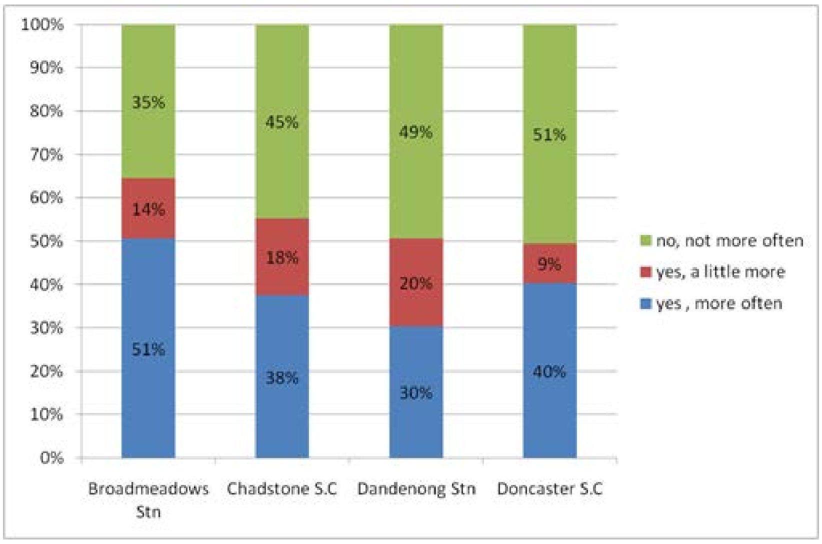
Figure IF.4 Did weekend bus users have access to cars?



IF.6 Impacts of extended services on bus usage (figure IF.5)

Around half of all respondents who were aware of increased weekend bus services stated they were now travelling by bus more often as a result of extra weekend services. This is likely to result in increased levels of social inclusion, and may also represent a small shift away from car travel.

Figure IF.5 Are people who were aware of bus service upgrades using buses more often as a result?

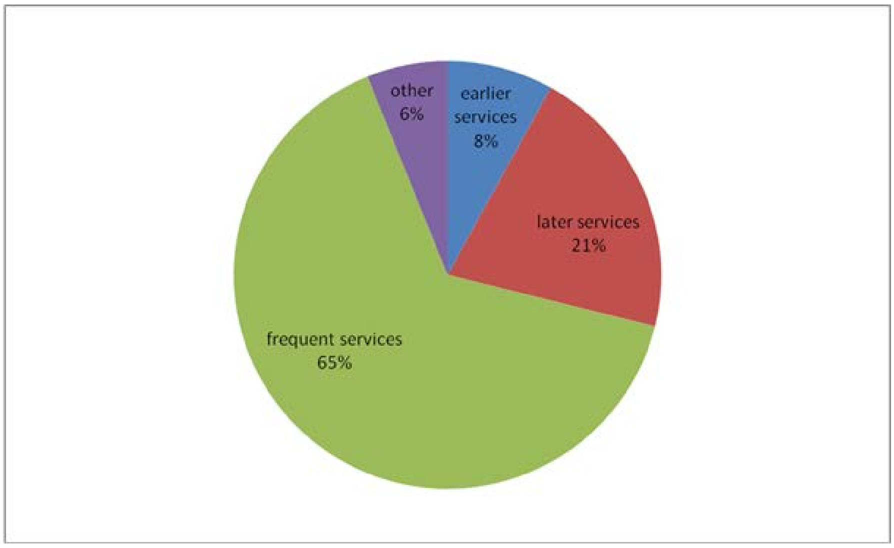


IF.7 Preferences for future service improvements (figure IF.6)

The survey asked whether people would prefer more frequent services or earlier/later services, should there be a future upgrade to service levels. Around two-thirds said they would prefer more frequent services, and there was little difference in this response between users of SmartBus and local routes.

Other comments received revealed a general dissatisfaction with the long waits for buses on a number of routes: 30 minute frequencies were considered too low, whether on SmartBus or other routes.

Figure IF.6 Increased frequency or span of hours? – first preference for future service improvements?



IF.8 Summary

The survey showed that weekend bus services are very important to people with limited transport options, and that increased weekend services are enabling these people to travel more often. This increased travel is very likely to reflect increased levels of social inclusion: in particular, most weekend bus users are travelling every weekend, often to social and recreational activities. There is also a small but significant number of weekend bus users who are choosing the bus over the car.

Annex IG: Metlink bus user surveys

IG.1 Introduction

Metlink has been undertaking an ongoing on-bus user (origin-destination) survey (of users age 15+) since May 2007. The results reported here relate to the period May 2007–September 2008, covering some 33,000 interviews (Loader 2008).

IG.2 Car access

- Respondents were asked if driving a car was an option for the trip in question.
- Overall around 25% of respondents had car access for the trip.
- The averages by fare type were around 30% for full fare travellers, 20% for concession travellers.
- By distance from CBD, the averages in the city area (35%–40%) were substantially higher than those in other (inner/middle/outer) areas (20%–25%).

IG.3 Alternative means of travel

- Respondents were asked how they would make the trip in question if their bus service did not run.
- Overall results were:
  - use other PT service: c.40% average (52% city, 30% outer area)
  - car driver: c.22% average (30% city, 17% outer)
  - car passenger: c.8% average (3% city, 14% outer)
  - walk or cycle: 10% average (5% city, 13% outer)
  - taxi: c.3% average (city 2%, outer 3%-4%)
  - would not make trip: c.15% (city 7%, outer 23%).
- These results also varied systematically by age group, including:
  - car driver was highest in the middle age groups (30–59)
  - car passenger was higher in the younger (up to 19) and older (60+) age groups
  - walk/cycle gradually declined with age, while taxi increased with age
  - ‘would not make trip’ increased with age, from c.14% up to age 29, gradually increasing to about 30% for age 70+.