Experience with value-for-money urban public transport system enhancements

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Abbreviations and acronyms

ARTA	Auckland Regional Transport Authority
ATT	actual travel time
BAH	Booz Allen Hamilton
BCR	benefit–cost ratio
BRT	bus rapid transit
CBD	central business district
CCTV	closed circuit television
dB	decibel
DMU	diesel multiple unit
EMU	electric multiple unit
HOV	high occupancy vehicle lane
LCN	local connector network
M	million
NZTA	New Zealand Transport Agency
QTN	quality transit network
RTN	rapid transit network
RTPI	real-time passenger information
TOD	transit-oriented development
TSP	traffic signal priority
vkm	vehicle kilometre(s)

Contents

Executive summary

This report reviews the value for money of urban public transport enhancements where ‘effectiveness’ in revenue and cost terms is emphasised. Note that some other perspectives on value are also considered and highlighted. The research concerns conventional urban public transport systems, with the main focus on bus-based measures and on incremental service improvements rather than large infrastructure projects. However, consideration is given briefly to other conventional public transport modes and larger projects. The central approach adopted in the research is a review of the research literature and published evidence from public transport practice.

Value is commonly seen in public transport systems from a patronage and revenue growth viewpoint with cost effectiveness referring to profitability of services relative to fare-box revenue. This can be seen as a limited view since most New Zealand (and world) public transport services require subsidy and value is seen to result from congestion and environmental relief and social support value resulting from public transport. Nevertheless fare-box cost recovery has been reducing in New Zealand (although at the time of finalising the report most recent data suggested a slight upturn). The government’s goal is to grow patronage for public transport services, while reducing reliance on public subsidies. While a major focus of national policy in New Zealand is improving the commerciality of services, growing patronage for the subsidy provided and increasing farebox recovery (with a medium-term goal of 50%), it is clear that around half of all costs will continue to be paid as subsidies from various levels of government.

A wide range of improvements to public transport have been considered and evidence of their performance examined. The improvements most likely to be effective are:

- fare increases (which increase revenue but cause a decline in patronage)
- bus priority measures
- bus route simplification (route complexities intended to save money often cost more in other ways and are not conducive to attracting additional passengers).

Several improvement measures are thought to be ‘on the edge’ of profitability including bus route and network restructuring (where the focus is on reducing costs and refocusing resources on more patronage and revenue effective routes and services), new buses, personal safety and security measures (low-cost measures), real-time passenger information measures and branding, promotion and signage measures.

New services including new routes, extended service hours and spatial coverage plus increased frequency are considered to be higher cost items with medium impacts. Increased frequency and reduced fares are identified as measures with medium-to-high patronage and revenue impacts but with high costs. Hence they are likely to be high net cost items requiring subsidy.

None of the measures identified have high patronage/revenue impacts for short-term measures (other things being equal). Arguably, increased frequency and new routes/networks might achieve patronage gains but this would be at a high net cost making such measures less realistic under current (2011) economic conditions.

A range of conditions can add much value to public transport improvements. Off-peak period and central business district (CBD) focused measures may be more effective from a patronage and revenue perspective. CBDs can be effective locations for targeting improvements since they represent areas where most patronage is focused, hence benefits can be spread further. Conversely they are quite small areas spatially and require comparatively smaller operating resources than suburban contexts. From a congestion relief perspective on value, the peak period and CBD bottlenecks are effective targets. From an environmental perspective, the peak period is an important target because of the increased number of single occupancy vehicles. Social perspectives on value target reduced fares, equity in service distribution, and youth and aged markets.

Abstract

This report reviews research literature and published evidence regarding the value for money of urban public transport enhancements. The improvements most likely to be of value are peak period fare increases (which increase revenue but cause a decline in patronage), bus priority measures, rationalising peak network and service design (reducing vehicle and crew requirements) and bus route (and network) simplification.

Several improvement measures are thought to be ‘on the edge’ of profitability including bus route and network restructuring (where the focus is on reducing costs and refocusing resources on more patronage and revenue effective routes and services), new buses, personal safety and security measures (low-cost measures), real-time passenger information measures and branding, promotion and signage measures.

New services including new routes, extended service hours and spatial coverage plus increased frequency are considered to be higher cost items with medium impacts. Increased frequency and reduced fares are identified as measures with medium-to-high patronage and revenue impacts but with high costs. Hence these are likely to be high net cost items requiring subsidy. Understanding customer needs in each market is important to target improvements and maximise value to existing and potential customers.

1 Introduction

1.1 Overview

This report presents the findings of a research study undertaken from 2006 to 2011 for the Land Transport New Zealand 2005/06 Research Programme. It reviews the alternative approaches to urban public transport system enhancement, and provides guidance as to the best value-for-money enhancements, to provide better information to those concerned with the improvement of urban public transport systems in New Zealand.

1.2 Approach and scope

Regional councils (including Auckland Transport) in New Zealand are required to procure public transport services through procedures which 'obtain best value for money' (section 25 (1) of the Land Transport Management Act 2003). However, 'value for money' is not defined in this legislation.

The terms of reference for the research project defined value for money as being achieved when:

> *Decision-making processes result in optimal project selection, leading to an integrated, safe, responsive and sustainable land transport system; and*
>
> *Projects are delivered in an efficient and cost-effective manner.*
>
> (Tyrinopoulos and Aifadopoulou 2008)

This project therefore assessed value for money in terms of 'effectiveness' and 'cost effectiveness', while also considering other perspectives on value.

Although the research concerned conventional urban public transport systems, the central focus was on bus-based measures, and on incremental service improvements rather than large infrastructure projects. This was due to bus being the dominant public transport mode in New Zealand (relevant to the widest number of stakeholders) and incremental improvements less likely to be put through large-scale rigorous business case processes. However, some consideration was given briefly to other conventional public transport modes and larger projects.

The central approach adopted in the research was a review of the research literature and published evidence from public transport practice.

1.2.1 Comparison of cost evidence in other currencies

This report provides cost evidence in local currencies for a range of measures. Table 1.1 sets out purchasing power parities to allow the reader to interpret this evidence.

Purchasing power parity is the rate that equalises the purchasing power of different currencies by eliminating the differences in price levels between countries. It provides a price relativity that overcomes the fluctuations that are inherent in exchange rates and allows comparison of prices in different currencies.

The table shows the relative value of one New Zealand dollar to the Australian dollar, British pound and United States dollar for the nine years up to the date of publication of this report, along with an average for each currency over that period.

Table 1.1 Relative value of one New Zealand dollar

	Australia	Great Britain	United States
2003	0.90	0.43	0.67
2004	0.90	0.42	0.66
2005	0.90	0.41	0.65
2006	0.95	0.42	0.67
2007	0.95	0.43	0.66
2008	0.99	0.44	0.67
2009	0.99	0.45	0.69
2010	1.00	0.45	0.67
2011	1.01	0.46	0.68
Average	0.95	0.43	0.67

Source: OECD web site at www.oecd.org/std/prices-ppp/. Accessed 19 April 2013.

1.3 Report structure

The remainder of this report is structured as follows:

Chapter 2 - Understanding value in public transport improvements – discusses alternative objectives for managing public transport systems and how value can be attributed to these.

Chapter 3 – Understanding costs in public transport improvements – overviews issues in examining the cost elements of the 'cost effectiveness' factor including types of costs, factors influencing their scale and how these impact on the cost effectiveness of improvements.

Chapter 4 – Public transport improvement measures – explores a range of types of improvements which can be made to public transport, including short-range and long-range measures.

Chapter 5 – Impacts of short-range measures – presents a review of evidence from studies of the impacts of short-range public transport improvement measures.

Chapter 6 – Impacts of long-range measures – presents a review of evidence from studies of the impacts of long-range public transport improvement measures.

Chapter 7 – Evidence of wider 'value' impacts – presents a review of evidence from studies examining the wider benefits resulting from public transport enhancements.

Chapter 8 – A synthesis of value-for-money effectiveness – summarises evidence on the relative effectiveness of public transport improvements.

Chapter 9 – The conclusions contain a summary of the key study findings

Chapter 10 – Recommendations are made for future research and practice in this field.

2 Understanding value in public transport improvements

In exploring value for money in public transport enhancements it is necessary to first understand what 'value' is. This section discusses alternative objectives for managing public transport systems and how value can be attributed to these.

2.1 Objectives and value in public transport

In modern western society, value is most commonly associated with money and the financial return resulting from an investment. In relation to public transport enhancements, value can also be considered as a financial return since it is common practice to charge a fare for use. This fare is most commonly paid (or partly paid) by the passenger.

Hence the financial return from fare-box revenue might be seen as a way of assessing value. Using this perspective, an enhancement to public transport might increase patronage or passenger trip lengths thus acting to increase fare-box revenue. This viewpoint can also be seen as a commercial perspective since a financial return is sought on a financial investment, (such as enhancing public transport). A commercial perspective seeks profit through financial returns that more than cover financial investments. Here the objective of any enhancement to public transport might be to make a profit, or to reduce the scale of subsidies (if fare revenues do not cover costs).

International perspectives on commercial and financial 'value' are reasonably rare in relation to public transport, particularly in circumstances relevant to New Zealand where the profitability of public transport is low. In 2008/9, fare-box revenue was estimated to cover 46% of costs and has fallen from 58% in 2001/2 (El-Geneidy 2010). The government's overall goal is to grow patronage for public transport services, while reducing reliance on public subsidies. It is clear that around half of all costs are paid as subsidies from various levels of government. Subsidies of this kind are common in urban public transport systems worldwide and are justified in terms of wider definitions of economic 'value' than direct financial fare box revenue. These are also associated with wider objectives in providing public transport rather than profit.

> *…high quality public transport', 'best practice' and 'success examples' can only be meaningful in relation to a defined purpose. Objectives vary between cities and often change over time. The institutional setting reflects the types of objectives in focus and the institutional context influences which goals different planners will consider* (Nielsen et al 2005)

There are many objectives driving public transport planning. These objectives often conflict and change over time. This makes defining 'success' or 'failure' in planning a very objective led pursuit. It also affects how 'value' is seen to relate to public transport improvements. Larwin (1999) defines a range of benefits associated with urban public transport systems. The major ones are associated with:

- Congestion relief benefits – public transport reduces the numbers of vehicles on streets and highways, especially in high travel demand corridors, and into high-activity centres.
- Environmental benefits – public transport makes contributions to reductions in air pollution and in reducing greenhouse gas emissions.

- Social benefits – public transport acts as a 'safety net' for individuals who cannot afford an automobile, who are handicapped or who are too young or old to drive (Larwin 1999).

Table 2.1 presents a summary of the wider objectives of providing urban public transport systems and relates these to economic values which have been estimated from local and international research.

Table 2.1 Definitions of 'value' from urban public transport systems

Objective and 'value' area	Benefits	Estimates of scale
Congestion relief	• Reduced traffic congestion delays, crash costs and environmental costs due to car drivers deciding to use public transport	• New Zealand value of mode shift to public transport (per car passenger vkm avoided) - Auckland = NZ$1.19 - Wellington = NZ$0.911 (Land Transport NZ 2005) • Australia - Sydney CityRail – congestion relieved by rail services in Sydney - A$740.5M (2007) (Currie and Mesbah 2011) • USA - Value of savings in congestion costs resulting from provision of urban public transport in 85 urban centres: - US$18.2 billion (2005) (Kittleson & Associates 2003)
Environmental relief	• Per passenger km urban public transport is more efficient than cars in terms of greenhouse gas and other pollution emissions	• New Zealand - Air pollution benefits valued at NZ$0.0089/vkm mode shift to public transport - Greenhouse gas emissions valued at 4% of vehicle operating costs - Reduced noise impact is NZ$410/db/household pa (NZTA 2010)
Social relief	• Provision of basic travel options for people in society who have no alternative for travel	• The average social value of a trip has been valued at A$20/trip based on research in Victoria, Australia. This value increases with lower income and reduces for higher income due to variation in trip rates by income. (Stanley et al 2011) • Value of unmet social trips supressed due to lack of transport alternatives in Victoria, Australia is A$2.4B pa (Fu and Xu 2001)

This suggests that value in terms of public transport enhancement might have very different meanings according to the perspective and objective taken.

2.2 Public transport enhancements and value

Improvements to public transport aim to address service objectives and hence provide value in relation to these objectives and roles. Nielsen et al (2005) have suggested that public transport systems worldwide tend to be designed around three different goals according to the context and priorities of the cities where these goals apply. These are presented in table 2.2 below.

Table 2.2 Typical public transport design goals – impact on system design and 'value' definition

Design goal	Service design features	Definition of value
Relieve roads of congestion from car traffic	• Public transport replaces congested car corridors but only in the peak • Focus on peak emphasising high capacity on major large volume corridors • High car user charges, parking and taxes to encourage public transport (peak only) • Some traffic restrictions justified where public transport is more volume efficient • High capacity, frequent and reliable services operating at high speed	• Reliable capacity, fast frequent service • Encouraging car drivers to use public transport in the peak
Mobility for all members of society	• Public transport complements the car as a means of access • A minimum basic service is provided as a 'social safety net' for those without options • Low/free fares to assist travel by low income groups • Services are dispersed in time and space, typically operating at slow speed to help older passengers board • Low frequency slow stopping services at night/off peak	• Equity of access for all members of society • New trips for transport disadvantaged people
Replace car travel in order to create a sustainable city	• Public transport, walk and cycle replaces the car • High car user charges, parking and taxes to discourage car use • Public transport is available to all locations at high frequency (at all times) and at low cost • A network of high frequency services given priority over all car-based travel	• Increasing public transport patronage • Reductions in car travel

Source: Booz & Company analysis based on Nielsen et al (2005).

The three different perspectives in table 2.2 suggest very different public transport systems with very different meanings for value in improving them. It is interesting to contrast these with the financial concept of value which in public transport relates to fare-box cost recovery:

- For systems designed around relieving traffic congestion, fares can be relatively high since parking and road-use/congestion price are also high. However, public transport is designed around peak times where the costs of public transport provision are also relatively high (see chapter 3). This puts public transport productivity and the cost effectiveness of any improvements under pressure. Cost recovery is typically better in morning peak periods (when vehicles have higher utilisation and more full fares are purchased).

- For systems designed around providing mobility for all members of society, a major concern is the provision of cheap low fares and fare concessions to ensure affordable services for low income groups. In addition, services are often provided in dispersed areas and at times when usage is low (nights/weekends). These contexts have very low financial 'cost effectiveness' but clearly provide value in terms of social benefits.
- For systems where public transport replaces the car, cost recovery can be very good because almost everyone uses the services on a frequent basis (Kimpel and Strathman 2004). These contexts typically have higher urban densities which justify both higher service levels and good utilisation of services typical of smaller, higher density European cities and towns. A major challenge to planners is replicating these conditions in New Zealand's lower density sprawling cities.

Overall therefore 'value' in providing value-for-money public transport improvements can have very different meanings depending on the objectives and perspectives taken in planning and policy.

2.3 'Value' in the context of this research

Two perspectives on value are emphasised in this report:

- Financial value – based on fare-box cost recovery. Although this may seem to be a limited perspective in relation to the wider goals of urban public transport systems, it is a highly important aspect of the management of quality and prudent public transport systems. The New Zealand government's goal is to grow patronage for public transport services, while reducing reliance on public subsidies.
- Patronage effectiveness – here the value of improvements is based on their effectiveness in increasing public transport patronage. This aim can be indirectly associated with a range of wider benefits from improving public transport systems.

In addition to the perspectives above, the analysis also considers value and effectiveness in relation to the relief of congestion, and environmental and social benefits.

2.4 'Value' and regulatory perspectives

Financial value might be seen as a commercial perspective common to private taxi companies or airlines where fares are the only income source. In public transport this can be the case where services are run entirely commercially, such as in a fully deregulated environment; however, these contexts are relatively rare worldwide and even in New Zealand fare-box revenue covers less than half of costs.

Regulatory environments are an important consideration when examining value since it is how public transport is provided or procured that often determines how value is perceived and managed by public transport providers. Table 2.3 summarises some regulatory regimes and their impact on value.

Table 2.3 Regulatory perspectives on value in public transport improvements

Regulatory regime	Framework	Impact on value
Deregulation	• No direct government interest in funding/regulating services • Private sector funds services from fares alone • Eg United Kingdom outside London	• Financial income from fares essential to understanding how value is perceived by the operator • Increasing revenue and reducing costs a major driver of service planning • Fare-box revenue is above costs to ensure a profit
Contracting/franchising – net cost contracts	• Government supports and manages contracts but fares are retained by private operators • Can include 'shadow' fares or fare supplements to encourage patronage growth, eg Australian bus companies, rail operators in Melbourne, UK operations in London	• Financial income from fares important to understanding how value is perceived by the operator • Often most income comes from government hence operators/ franchisees also concerned about wider service design and subsidies supporting them • Fare-box revenue as a share of costs is low/medium
Contracting/franchising – gross cost contracts	• Government supports services and retains revenue, eg bus services in Melbourne • Operators run services prescribed by government and are paid for service provided, eg on a per bus km basis	• Operators have less concern about financial revenue hence value is seen in terms of keeping government clients happy or increasing services to enhance contract size • Fare-box revenue as a share of costs is low/medium
Government run services	• Government subsidises services directly and runs public transport as the operator • Can include corporatised models), eg government bus and rail services in Sydney	• Operators often more focused on wider government objectives than direct fare-box revenues • Fare-box revenue is typically a very low share of costs

Source: Booz & Company analysis.

Overall commercial financial value for public transport is an essential ingredient for deregulated contexts where low costs are also a major concern. Improved fare-box cost recovery is also important in other regulatory environments but to a lesser degree. In net-cost contracting or franchising conditions fare-box cost recovery is maintained as an incentive to encourage operators to grow and maintain patronage while subsidies are still provided by government. Interestingly, revenue in these models is often not directly related to actual fares and involves a shadow fare or an estimate of fare revenue share between companies when integrated ticketing systems mean that revenue must be distributed between public transport providers. In government-run models, fare-box revenue is still of value; however, wider government objectives are also important and can dominate perceptions of value.

Regulatory perspectives often act to explain why perspectives on value in public transport improvements vary between different contexts.

Finally it is worth mentioning how value in public transport improvements relates to regulatory and contracting models where a major public transport infrastructure development project is being commissioned by the government to the private sector, eg public private partnerships or build own operator transfer models. These models often integrate infrastructure construction, vehicle procurement and public transport operations into a single contract. In these cases value in terms of improvements to public transport can be seen in many ways depending on the nature of the specific contract. For example contract payments can provide incentives to complete and operate projects earlier. Hence financial revenue streams as well as payments for completed infrastructure are both seen as a value to the contractor. Value for money in this context therefore has a subtly different connotation for both operators and regulators.

3 Understanding costs of public transport improvements

This chapter explains the cost elements of public transport improvements, the types of costs, factors influencing their scale and how these impact on the cost effectiveness of improvements.

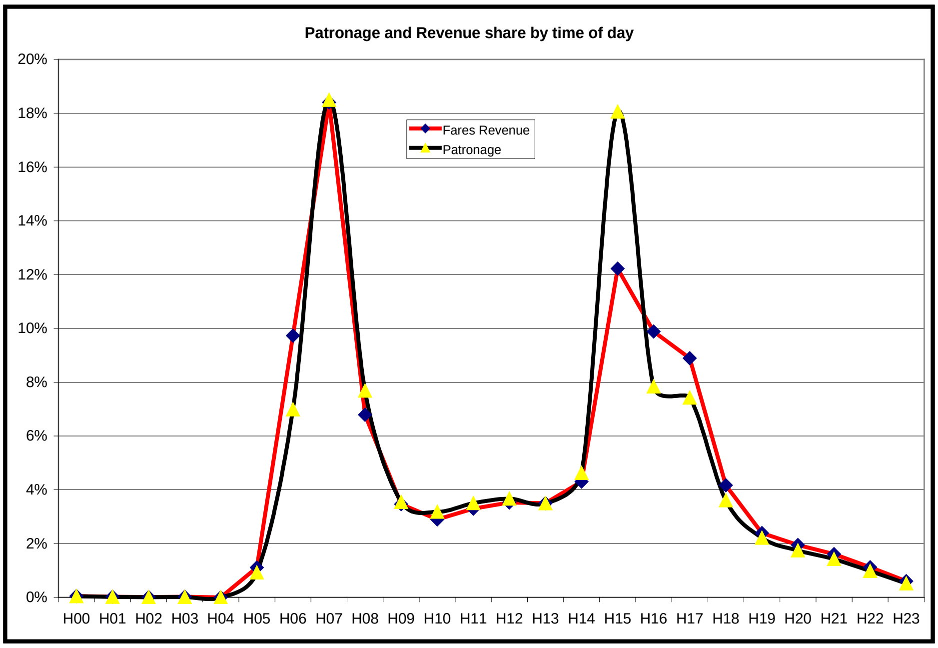
3.1 Short-range perspectives

Short-range perspectives on public transport costs require an understanding of:

- how marginal changes in services affect costs
- the 'whole of life' cost impacts of changing services.

A major driver of marginal short-range changes in costs is the issue of the peak vehicle requirement and how this impacts the cost of providing service. Figure 3.1 illustrates this issue through an analysis of demand (and revenue) in Auckland.

Figure 3.1 Patronage and revenue share by time of day



Source: Auckland Transport

In figure 3.1 the proportion of daily demand in each hour typically matches the revenue, except in the afternoon peak when a larger proportion of concession travellers (school students) and daily ticket holders make their second journey for the day.

A key efficiency concern for public transport operators is that all operating resources (crew, vehicles) are designed to cater for the peak of the peak capacity. In figure 3.1 this is the point between 7am and 8am when most demand occurs. The problem is that the fleet and crew resources required for this time are not fully used during the rest of the day (or weekends). Because of this, peak resources are the most expensive to provide because they represent a net increase in the total scale of overall system costs. Conversely, providing new services in the off-peak can often be undertaken using fleet and crew resources which are already available since they are not required during off-peak periods and are hence available as a marginal (rather than a full) cost.

Table 3.1 shows some of the typical short-range operating costs which apply to improvements in services.

Table 3.1 Typical public transport marginal operating costs (A$, 2005/6)

Cost category	Units	Bus	Tram	Train
a On vehicle crew costs	$ per hour of service	33.00	60.00	220.00
b Direct vehicle operating costs	$ per km of service	0.90	1.50	2.80
c Infrastructure maintenance costs	$000 per track km pa	-	65	115
d Overhead	% on total costs	21.0	17.5	14.0
e Profit margin	% on total costs	6.0	4.0	4.0

Source: Australian Transport Council 2006

A common method for deriving appropriate marginal costs for service changes is the 'fully allocated cost model' (Fielding 1987). Based on these principles any new services operating in the peak period would incur costs in all the above categories (a to e) including capital costs for purchasing and renewing vehicles (see below). In off-peak periods, only costs associated with b 'Direct vehicle operating costs', are thought to apply. As noted, this makes peak resources very expensive to provide.

Table 3.2 Typical public transport capital costs (A$, 2005/6, $000)

Vehicle	Purchase cost	Expected life (years)	Annualised equivalent cost of capital
Bus rigid	380	20	37.0
Bus articulated	600	20	58.4
Light rail articulated	4500	35	350.2
Train – EMU 3-car set	8000	35	627.0
Train – DMU 3-car set	8800	35	689.7

Source: Australian Transport Council 2006

Table 3.2 shows some typical capital costs for purchasing public transport vehicles. Improvements which require new vehicles must include costs for purchasing new vehicles of this order. However, they will only be required if provided in peak periods; typically no capital costs apply for vehicles which are already available, such as those used in off-peak periods. In addition, although rail vehicle capital appears relatively expensive it also has higher capacity and hence high costs against higher demand (and revenue). In addition rail vehicles last longer than buses. A 30-year time frame for a project evaluation might require purchase of two new buses while a rail vehicle might only require refurbishment during this period.

The implication of the above discussion on the value-for-money aspects of the cost of public transport enhancement is that:

- Peak services are expensive and require full allocations of new vehicle and crew costs for a new peak service. For the off-peak period, only additional operating costs (eg fuel, maintenance costs) apply to new services because staff and vehicle purchase costs have been covered by the peak services. Hence off-peak services are important and relatively low cost to provide.

- One of the most cost-effective means of saving on costs is to reduce peak services because this is when costs are highest. Clearly this needs to be done sensitively since patronage and revenue might also be reduced.
- Efficiency measures, such as saving peak vehicles/crew without affecting demand and revenue, represent some of the most cost-effective measures available.

3.2 Long-range perspectives

A critical concern for long-range planning is the infrastructure work associated with building new lines. Table 3.3 shows some typical cost values associated with major infrastructure projects in public transport.

Table 3.3 Example capital infrastructure unit costs (A$M, 2006)

Construction costs per route km	
Dedicated right of way	**A$M/route km**
Rail tunnels dual track twin bore	100–150
Rail dual track surface	20–50
Light rail dual track	10–30
Dedicated bus lanes	3–10

Source: Based on Australian Transport Council (2006)

As indicated, rail infrastructure is expensive to provide. Tunnelling is notably expensive, although it has a major operating cost and route penetration benefit. Bus-based infrastructure is relatively cheap for right of way compared with rail. This is part of the reason for the expansion of bus rapid transit (BRT) infrastructure (Currie and Delbosc 2010). Relative infrastructure cost advantages for bus-based versus rail-based infrastructure have been noted in a number of studies (US General Accounting Office 2001; UK Commission for Integrated Transport 2005).

Another major concern is the accuracy and reliability of costs associated with infrastructure work. Considerable variation between forecast project costs and actual costs has been experienced with substantial contingencies now being adopted for new projects to allow for such inaccuracies. Inaccuracies are embarrassing to project promoters and the government and critically influence perceived performance of the project.

Overall major concerns for project value for long-term public transport improvements concern the correct and appropriate estimation of capital costs usually derived from engineering studies. Correct accounting and valuation can affect how the overall project value is perceived.

It is also clear that rail infrastructure is more expensive to provide and hence requires substantive associated project benefits, patronage and revenue to offset high costs in creating net value.

4 Public transport improvement measures

A key aspect of value-for-money public transport enhancements is the improvements themselves. This section explores the range and types of enhancement which can be made. It identifies a framework for short-term and long-term measures.

4.1 Internal and external public transport improvements

Changes in value-for-money aspects of public transport including revenue and patronage can be affected by a range of wider influences including:

1. **Exogenous (or external) factors** – including changes in factors outside the direct control of public transport regulators, planners and government. This can include changes in population levels, travel behaviours, technology or socio-economic conditions (eg fuel prices and the economy).

2. **Endogenous (or internal) factors – wider government policy** – here government policy creates a change in services. For example road pricing or provision of direct funding for service expansion and/or bus priority.

3. **Endogenous (or internal) factors – direct control of regional council and operator** – as they have direct control of a service change, eg changes in schedules, fares, frequencies, route alignment and network design.

There is often much blurring of the boundaries between the above factors. For example where the government is also the operator of services, factors 2 and 3 are not necessarily different. In London, the provision of the congestion charging scheme by government policy (item 2 above) acted to require many improvements in services (item 3 above). Also it could be argued that exogenous factors (item 1 above) such as changes in economic conditions are influenced by direct government policy (item 2).

Regardless of these issues, the focus of public transport improvements in this research is on item 3. However, some consideration will be given to improvements associated with item 2. This does not mean to suggest that exogenous (or external) influences (item 1 above) cannot improve public transport. Rather the focus of the research is on factors we can 'pro-actively' address rather than factors that are 'reactively' responded to in transport planning.

4.2 Direct public transport improvements

There are two major types of planning for public transport; short- and long-range planning (Vuchic 2005):

- **Short-range planning** – encompasses projects and measures that can be implemented in three to five years that do not involve major investments and infrastructure construction. Scheduling, purchase of new vehicles, modification of existing lines and networks are involved (Wilson et al 1984). This is very dependent on existing conditions.

- **Long-range planning** – with horizons as long as 10 to 25 years where major infrastructure including new lines, modes (eg light rail), networks and facilities are constructed. The focus of planning is strategic with modelling of the market, investment and urban planning impacts of these measures. Typically long-range plans are updated every five years.

Improvements to public transport can also take a short- and long-term perspective with important impacts on creating value both in terms of financial and patronage contexts. There are also important implications for who makes and decides on improvements. Short-range planning, the major focus of this research, tends to be in the remit of the public transport operator (in their internal control; item 3 above) while long-range planning requires much involvement of wider planning agencies including government (item 2 above).

4.3 Short-range planning initiatives

The following types of public transport improvements are the main focus of this research. They represent short-range planning measures which are under the direct control of operators, such as:

- route and network planning measures, including:
  - route design: the nature of route alignments and operating patterns
  - route spatial coverage: the geographic reach (or spread) of services
  - route temporal coverage: the span of hours when services are provided
  - network design: the design and function of service networks including network density, coordination, presentation and connectivity
- service frequency measures: initiatives which improve the number of services provided in a given period
- reliability, speed and traffic priority measures: providing priority for buses over other traffic to improve speed or reliability
- vehicle types and feature measures: features of the vehicles in use or different types of vehicle (minibus, double deck, articulated etc)
- personal safety and security measures: initiatives designed to improve actual or perceived safety for users
- fares and ticketing measures: price, fare structure and ticket system features
- information and marketing measures: examining alternative strategies for the provision of information to users and the selling of services through marketing initiatives
- amenity and 'soft factor' measures: provision of ancillary services and infrastructure which are secondary to the main service itself but which impact on the customer experience of what value is provided.

4.3.1 Route and network design measures

Route design improvements involve adjusting service patterns to add value to alignment and method of operation of public transport routes. There are five major categories of route design (Scheurer and Curtis 2008):

1. Radial routes (or trunk routes) – usually service central business districts (CBD) and tend to have higher frequency and larger demands. For buses they are characterised by frequent stops, short passenger trips and relatively slow-to-average bus speeds.
2. Cross-town routes – non-radial, usually link to major activity centres and intersect with radial lines (where schedules should be coordinated to provide optimal transfer connections).
3. Circulator routes – provide services to specific locations, typically downtown or residential areas. They connect between major public transport nodes or major activity centres to allow passengers to transfer to other routes to gain access to the rest of the network.
4. Feeders or shuttle services – provide a service to access other modes of transportation (air, rail, etc). Routing is generally short and as direct as possible to maximise customer convenience.
5. Regional services – provide cross-regional connections between one major urban area and another major urban area. These are typically long routes with few stops and act as a limited stop or express type of service.

Some bus routes become an amalgam of different route types over time as funding cycles require service adjustments to reflect the funding available. Adjusting these designs to optimise them or adding new designs are the primary means of improving route design. Cross-town or orbital routes are an important addition to the route network in cities. Most transport networks operate on a radial basis with routes radiating out from the CBD. This leaves gaps for the cross-region travel market that does not want to travel via the CBD. The road network, however, may limit the options available, with orbital services not being suitable for Wellington, but suiting Christchurch.

Orbital and cross-town services work best when the transfer from the service to connecting routes does not attract an additional fare. Christchurch's Orbiter works well due to the two-hour transfer system via the Metrocard. Similarly, an integrated smartcard and revised fare structure is being progressively rolled out in Auckland which will facilitate modal transfers and multi-modal public transport trips. Linking residential areas with key points across the region such as hospitals, airports, tertiary institutions and shopping centres using arterial roads can attract significant patronage (Melbourne SmartBus, Christchurch Orbiter).

Cross-town services generally carry fewer passengers than CBD-focused routes but allow a different segment of the market to travel thus broadening the base of customers. Orbital and cross-town services can be added to an existing and well-functioning radial system. A transferrable ticket is also important to their success. Orbital services could have a lower fare structure in the absence of integrated ticketing.

Express and stopping patterns are another major aspect of route design (Wilson et al 1984; Vuchic 2005). Balancing the speed and reduced travel time advantages for passengers against the longer walk access to limited stops is a major facet of good design for these patterns of service.

Stop spacing and the degree of route deviation are also major aspects of route design. Short stop spacing reduces walk access but increases delays for vehicles since stopping occurs more frequently. A balance is needed between these factors to ensure good design (Nielsen et al 2005; Scheurer and Curtis 2008). Bus stop spacing is an important part of the speed vs access trade-off. The frequency of the route is also an important consideration. When services are infrequent there is little point in having bus stops too close together as the walk time component is much shorter than the wait time. Therefore it is better to have wider spacing. A person walking at 6km per hour can travel 100m in a minute. When the wait time is more than five minutes the stop spacing can be 500m or more without resulting in excessive walking distance or a high potential of missing the bus. When stops are too close together 200m–300m or less this makes the bus journey time too slow due to frequent stops.

Depending on historical context, removing bus stops can be one of the most cost-effective ‘improvements’. If stops are relatively underutilised then the cost of retaining (maintaining) the stop is high. This is particularly the case when considering an upgrade of stop infrastructure, to meet disability access, shelter or comfort (such as seating) objectives.

Circuitous public transport routes improve coverage at the cost of slower travel times for those on board. The trade-off is between walking time (for those passengers better served) versus on-board travel time (for those passengers travelling through). A balance between direct services and local services is often needed in order to serve both market segments (through travel and local access) well.

Route spatial coverage concerns how the density of public transport routes can impact on patronage and costs. Most planning authorities specify a route coverage spatial standard. For example in the USA:

- In areas with a density of more than 4000 residents/square mile (about 10,000/square km), the aim is to provide 90% of the population with a public transport stop within ¼ mile (about 400m) walking distance of their residence.
- In areas with a density of between 2000 to 4000 persons/square mile (about 5000 to 10,000 resident/km), the aim is to provide 60% of the population with a public transport stop within ¼ mile (about 400m) walking distance of their residence.

Source: (FTA Introduction to Transit Workshop 1997 from Scheurer and Curtis 2008).

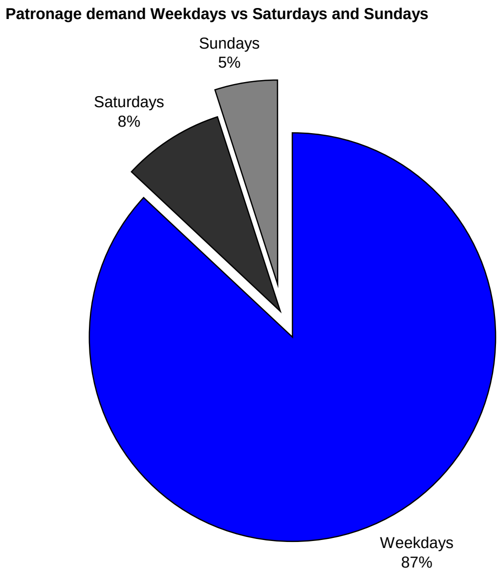
Adjusting spatial coverage of routes can improve walk access coverage and hence patronage, particularly where new trip generators have emerged. It is also possible to trade-off reductions in coverage in poor performing patronage areas to favour areas with better performance. Care needs to be taken to balance geographic coverage improvements with service frequency improvements, as people will usually prefer to walk further to more frequent services.

Route temporal coverage measures typically extend or contract the hours of operation on specific days of the week.

As a general rule, most public transport services and patronage are focused on weekdays and weekday peaks. Figure 4.1 shows a fairly typical patronage profile for day type sources from Auckland Transport.

Patronage demand on Saturday at 8% and Sunday at 5% is low compared with a weekday at 17%. Weekdays generate 87% of patronage and peak patronage represents around 40% of the total daily demand.

Figure 4.1 Auckland demand profile by day type



Source: Auckland Transport.

Adding services on Saturdays and Sundays often uses existing underutilised buses but has a relatively limited customer market compared with weekdays. Drivers, a major element of operational cost may require overtime allowances for weekend work.

The casualisation of the workforce and an increasing acceptance of flexitime have had a significant impact on travel patterns. Public transport providers typically have difficulty identifying how to best serve travellers outside the traditional peaks of 7am–9am and 3.30pm–5.30pm. Many offices are split into two categories of workers, the early starters who finish early and the late starters who finish late. The peak shoulders of 6am–7am and from 5.30pm–6:30pm have seen significant patronage growth in recent years. In addition weekend travel has also increased, particularly in areas with strong retail or hospitality sectors.

Congestion on the road network has also spread to encompass those times, as trying to beat the traffic has led to early and later start and finish times.

In Auckland the southern line rail inbound time table from Papakura begins at 5am and the western line at 5.30am. Early services allow shift workers to get to their 7am shifts on time. Hospitals, airports and other 12-hour shift-based employers require services that align to shift changes. Evening services enable afternoon shift workers to get home.

Several cities have introduced late night services which are relatively expensive due to higher security requirements, late shifts and staff penalty rates of pay and relatively low patronage. Many such services are provided on a flexi-route system and service a particular area with some flexibility. A higher flat fare is often charged but can be competitive with taxi fares. Night buses usually have additional equipment (such as CCTV) for the safety of the driver and customers. Some night operations employ additional staff (on board or at busy stops) as a safety measure.

Night services provide flexible service over a wide area. They are popular with local communities, police and safety organisations due to the lowering of drink-driving rates and providing travel alternatives that reduce crowding on other services (such as at taxi ranks). They provide a similar function to taxi services but require subsidy unlike taxi services funded by passengers. Night services are not cost effective without significantly higher than usual fares but may meet other social, safety objectives. Some systems run on a commercial basis with high fares, eg the London night bus network.

Network design and performance is a critical factor influencing the quality of the public transport offering on a city wide basis:

> *It is widely recognised today that the most effective way of building a 'transit metropolis' is to tightly integrate dense, mixed-use development around stops on a fixed-route transit network, thus maximising walk-up patronage and multiple trip making.* (Source: Kenworthy 2003)

The Auckland Passenger Transport Network Plan (2006–2016) is an example of a network enhancement strategy seeking to better structure the network as a means of improving public transport. It creates a four-level public transport system.

1. The primary level is the rapid transit network (RTN). This is the spine of the network. The goal is high frequency, high-quality services that are not affected by road traffic congestion. This is made up of the rail network and the busway.
2. The next level is the quality transit network (QTN). This is the main bus corridor and will feature branded services, high-quality infrastructure and real-time information.
3. The third level is the local connector network (LCN). This provides local services and connects to the RTN or QTN.
4. Targeted services are services such as total mobility or school bus services.

Segmenting the services into a clearly defined level of service framework assists the public in knowing what they can expect from the route they are about to board. RTN, QTN and LCN design tends to be a long-term rather than a short-term planning issue; however; short-term planning can involve micro adjustments to the network. Matching the network development to changes in population and activity generators is also important.

Adding new routes and route restructuring are ways of adjusting network design. This can reallocate existing bus and driver resources to more productive patronage/revenue areas and hence does not necessarily involve additional cost. Removing services from one area and adding them to another can be difficult from a political perspective since it creates inequality in service provision between areas.

Concentration of service on corridors is another network design improvement measure:

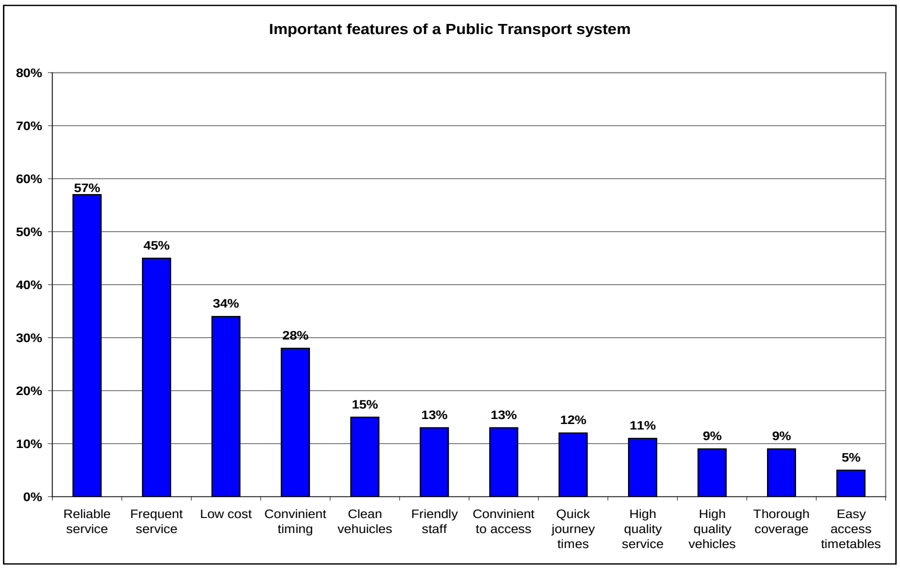
> *Growing patronage requires identifying and servicing specific corridors where one can focus on a high quality service in terms of frequency, reliability, travel time, visibility and security. (*Hensher 2004)

Network restructuring combining adjacent routes, removing under-performing services, and increasing frequency on popular routes can act effectively to both gain patronage and reduce costs. This is different from route simplification in that multiple routes may cease to exist (being combined) and there is a lag time (up to two years) for the public (existing and future) to fully understand the new network.

4.3.2 Service frequency measures

Insufficient service frequency is one of the most commonly identified issues cited by public transport users regarding service quality (figure 4.2). However, frequency of service also drives service cost since bus and crew resources are directly driven by the headway provided (Vuchic 2005).

Figure 4.2 User views on important features of a good public transport system



Source: Annual public transport satisfaction monitor (GWRC 2008)

Adding frequency off peak can be a low-cost option if bus and crew resources are available. However, these are not high-demand periods so a balance between cost and patronage/revenue is needed.

High-frequency services (headways shorter than 10 minutes) are very popular with passengers and have been related to the term 'forget the timetable' services, because no specific schedule time for departures is required; users just turn up and go on routes (Nielsen et al 2005).

A 15-minute frequency route suits 'clock face' timetabling. Services that leave at quarter past the hour, half past the hour, quarter to the hour and on the hour are simple to remember. This enables passengers to arrive at the stop closer to the departure time reducing wait times and thus improving the customer experience. It is also easy to add a peak service so that peak frequency is 10 minutes and off peak 15 minutes. These timetables are easy to remember; make good marketing tools as customers turn up at the stop without referring to a printed timetable. Smaller cities can use a single 15-minute route as their main street service linking the shopping centre to the primary arterial of the city. This can reduce parking demand on the main shopping street.

Examples of more frequent services in New Zealand include:

- LINK in Auckland (flat fare) – (around 2 million annual boardings)
- City circuit in Auckland (free) (around 1 million annual boardings)
- Orbiter in Christchurch (flat fare)
- Orbiter Hamilton (two-hour transfer) (550,000 annual boardings)

- Onboard shuttle in Hamilton (free) (153,000 annual boardings).

The importance of frequency has been identified as a reason why people switched from infrequent steam trains to frequent electric trams in New Zealand the 1890s.

> *The first benefit was single fares. Then came more frequent cars. People will leave a steam line and use cable or electric cars, because there is no time-table to remember, and if they miss one car, they know another will soon follow.* (Source: *Rapid transit in cities* (Clarke 1892))

A trade off exists between customers wait time at high-frequency periods and operator efficiency. As routes become more frequent they become increasingly costly to operate. There is a critical point between a one bus operation and a two bus operation and so on depending on the length of the route and the frequency. As frequency increases it becomes more important to have bus priority in place and eventually an exclusive right of way becomes necessary. A headway less than 10 minutes is best delivered on a busway system with segregated rights of way as it becomes increasingly difficult to avoid bunching of buses at choke points such as intersections and lane convergence. Peak congestion also makes reliable services more difficult to maintain without an exclusive right of way.

Hourly services represent the minimal service level that can be expected to generate patronage interest and are often defined as the minimum acceptable service to provide in urban contexts (Currie et al 2003). Service levels below this are not attractive due to the risk to the customer of having to wait for a long time if they miss the bus they were trying to catch. These services only appeal to captive customers (those without access to a car).

Frequencies of between one bus per hour and four per hour are common in sub-urban contexts and are a necessary compromise between cost, revenue and patronage. Cities like Rotorua and Tauranga operate most of their services with 30-minute headways. Tauranga has some 20-minute headways in the peak on its higher patronage routes. Based on the highest patronage service in these cities frequency could in theory be increased to three per hour (20-minute headway) during the peak first, and if successful then through the 7am to 6pm period.

Services with a headway longer than 60 minutes will generally be poorly patronised. These services are typified by even the highest patronised trip carrying less than 10 passengers and the remaining trips of the day carrying one or two passengers with vehicles often running empty. Services that run on only a few days a week (such as Tuesdays and Thursdays) often exist for reasons other than demand (such as social needs). The cost per passenger of these services is high. These services may exist for historical reasons or due to political necessity that continues despite not attracting many people. Even if these services were free the patronage would still be low.

A common approach to management of frequency in these cases is the adoption of minimum performance standards which require the resources deployed to be removed and used on more productive routes (eg Toronto Transit Commission 1985). This is a 'lose it or use it' approach which puts the onus on performance with the community. Transparency about the cost per passenger of these services may help in the public/political debate and improve the decision making around these types of services. Establishing minimum patronage thresholds and maximum cost per passenger thresholds may assist in creating clear boundaries and setting public expectations over what is a reasonable level of subsidy.

4.3.3 Reliability, speed and traffic priority measures

Bus travel within CBDs can be the slowest part of bus journeys for users and reduce the productivity of buses and crew utilisation affecting cost, revenue and patronage. By having dedicated bus roads or bus lanes on a few of the CBD streets allows faster journey times for buses. The central public transport corridor in Auckland (currently under construction) will be a good example of a 24-hour bus lane that gives access to the university and hospital and through to Newmarket. These are all important destinations and generate a high volume of traffic. The Lambton Quay bus lane in Wellington is another example where buses have priority thus creating a bus and pedestrian dominated zone. Concentrating buses onto one corridor can reduce congestion for buses in the CBD and provide a frequent service on an uncongested route. Rail-based solutions especially using underground rail or subways are a better long-term solution if significant growth in employment and residential activity are expected over the longer term.

Increasing the speed of operation is another means of improving services. Increasing the speed of service tends to increase patronage and reduces the need for vehicles at any given frequency of service. The effectiveness of grade-separated services such as subways, BRT or bus lanes is the speed gains that they make.

The impact of stopping patterns on travel speed is highlighted by analysis of heavy rail and bus operations in various cities. There is generally an inverse relationship between travel speed and the number of stops on urban and sub-urban public transport services. Reducing the number of stations in Auckland could be a key to improving the speed of services. Underutilised stations within walking distance of more highly patronised stations could be closed. Some stations like Te Mahia and Westfield are no longer linked to a good catchment of employment (1989 Westfield freezing works closed, 1992 Otahuhu rail workshops closed) or residential housing, and these stations could be bypassed (for a net community gain) until redevelopment is significant enough to warrant the stations' reopening.

The speed of operation is a major issue for public transport. In Wellington, price, value for money and accessibility needs predominantly meet customer expectations but competitive journey times do not. For example (Greater Wellington Regional Council 2008):

- Most residents agree there is a bus or train stop close enough to their home to make public transport accessible for them (84%).
- Nearly two-thirds of residents agree the cost charged for each journey, on public transport, is fair (64%).
- More than half of residents agree that journeys on public transport are cheaper than journeys in private cars (59%).
- Few residents believe that journeys on public transport are faster than journeys in private cars (27%).

Ramp signals, by-pass or queue jump lanes and B (bus) phase signals at traffic lights are important time saving features. Active traffic signal priority allowing extended green phase or shorter red phase is also important.

Bus priority measures are designed to improve the speed and reliability of the bus service. By providing bus advance lanes at controlled intersections or by providing stretches of bus lanes the buses can be given parity if not priority over the car. High-occupancy vehicle (HOV) lanes and high-occupancy toll lanes can also be bus priority measures.

Motorway shoulder bus lanes and bus lanes on two lane arterials also improve the speed competitiveness of buses. Bus only lanes on motorways can be an effective allocation of road space based on passenger loadings. These can be on the hard shoulder as in Auckland on some stretches of the motorway network. The motorway express bus using the hard shoulder or a motorway bus lane is an option to be considered especially when lanes are added to motorways or when new stretches are added to minimise effects on other road users. To be implemented safely it is important that the emergency lane is wide enough to facilitate safe operation of the motorway.

Grade separation is another major means of improving public transport. Rail and BRT systems such as busways are fully segregated to provide faster and more reliable running times and to enhance patronage.

Simple fare structures and fast boarding times are essential on frequent services especially in heavily congested traffic areas. Cash handling of complex stage-based fares causes delays if bus drivers manage the sale of tickets. Integrated ticketing, pre-paid boarding and smart card technology all improve travel speeds. Pre-paid boarding is one of the most cost effective, depending on the sophistication and simplicity of the existing ticketing system. In Brisbane and Sydney, pre-paid boarding has been implemented on several high-demand routes, following simple marketing campaigns locally.

4.3.4 Vehicle types and feature measures

Vehicle features such as new modern décor, air conditioning, super low floor access and low emission vehicles can all have an impact in terms of attracting passengers. In a discretionary market, quality becomes increasingly important once frequency and reliability have been addressed. Quality improvements are best added in a package associated with key high-frequency or premium routes or corridors.

Many vehicle improvements can also have cost reducing and operational efficiency benefits such as low floors to reduce dwell-times (the time that a vehicle spends at a stop for passengers to alight or board).

The quality of the vehicle (bus, train, ferry) is not a major barrier to a highly valued trip; however, it can assist patronage levels when trips are discretionary and there is competition for travel. Given the long life of some public transport vehicles, highly refined vehicle procurement processes that lead to the purchase of high-quality (and value-for-money) vehicles can present a very high value-for-money improvement to public transport management.

4.3.5 Personal safety and security measures

As a general rule, public transport passengers expect bus and rail services to be relatively safe from crashes or disasters and hence patronage is not directly influenced by crash rates of services. Concerns regarding issues such as terrorism may have changed this view; however, there is little evidence of this as a direct influence on general patronage.

Personal safety from theft and assault is, however, another matter. Research has illustrated fear of crime and antisocial behaviour as a major barrier to patronage on public transport overseas (Crime Concern 2004) and also in New Zealand (Kennedy 2008).

Measures to address these concerns (in particular to address the perceptions) are therefore another means to improve public transport and can range from increased staffing levels, CCTV surveillance, use of ‘panic buttons’ to better lighting and more open and visible design of areas within vehicles and stations. Value for money regarding these types of improvement is a neglected area of research, although research from Melbourne highlights that perceptions are very different from reality. This highlights that campaigns aimed at increasing awareness of the reality (or changing perceptions) could be more cost effective than mass deployments of technology or security staff.

4.3.6 Fares and ticketing measures

The level of fare paid is a major driver of fare-box revenue; however, there is an inverse link between fare levels and patronage. Hence setting fare levels is an area where value in relation to fare-box revenue conflicts with value in relation to patronage benefits (social and environmental).

Improving public transport can also entail clarifying and simplifying fare structures which have patronage and revenue impacts. This is a key area for value for money, as simple fare structures may (depending on the existing circumstances) be cheaper to administer and attract more passengers, resulting in a net positive value-for-money impact.

As a general rule more 'commercial' fare structures tend to be more complex since they attempt to link user payments more carefully to the amount of travel consumed (travel distance). This increases revenue and more clearly relates revenue to costs. However, more complex fare systems are also less easy to understand and can act as a barrier to patronage. This is why zonal fare structures and flat fares have been adopted; to improve simplicity. Clearly a balance is required between commercially complex fares which maximise revenue and simple fare structures which increase patronage and are easy to administer.

Flat fare systems are easier for users to understand and can reduce costs of ticketing equipment if single coin fares are used. Smaller cities and towns often implement flat fare structures especially if there are few competing operators and routes with similar lengths. Hamilton has a simple flat cash fare of NZ$2.60 (cheaper if using a BUSIT card). Christchurch has a simple cash fare of NZ$2.80 within Zone 1, which covers all of Christchurch city. These two cities have also invested in smart card systems which are able to simplify the customer interaction with complex fare structures but have chosen to keep their flat fare structures.

Simplifying fare structures can be seen as a means of improving public transport but can reduce the link between costs and revenue of services thus reducing revenue yield. Both Hamilton and Christchurch have simplified fares and significant patronage growth has been linked to this.

Another fare product that can have wide appeal is fare discounting to encourage increased use such as the multi-trip ticket. Clearly this requires careful consideration in terms of revenue impacts. International research highlights a low negative elasticity between fares and patronage meaning that lower fares do not tend to increase patronage to the same extent that the fare has been lowered. Research suggests that low fares are most suitable for shifting non-essential travel into the off-peak period (ie mainly affecting existing users travel time choices).

Concessionary fare schemes such as the 'super gold card' and 'free' transport for seniors have obvious roles in social policy and in increasing patronage but they erode revenue. The value for money of these schemes clearly lies on the social or environmental side of the value equation and would be quantified differently in each community (depending mainly on local social need).

Integrated ticketing allows easy transfers between modes/competing operators within the same journey/price and has been shown to increase patronage. Fears of revenue loss by operators are an obvious concern and careful management of fare and revenue sharing is required to make these schemes effective. Christchurch used a two-part process with a simplified gold coin flat fare introduced first and then followed by an electronic card that had a discounted rate. Simplifying the fare structure first makes revenue allocation easier and reduces complications in fare calculations.

The adoption of smart cards has presented an opportunity to operate more complex (and hence commercial) fare structures in a relatively easy to use manner. Introducing these systems is not without challenges since they cost considerable sums to procure and require interoperability agreements between operators, banks, credit card companies and the ticketing machine manufacturers. Smart card systems that avoid cash transactions provide a range of operational benefits including reducing waiting time at stops. Electronic ticketing and gated systems at stations also realise operational benefits.

Smart card technology also makes it possible to introduce more complex pricing systems such as fares based on service frequency or to vary fares by time period.

Periodical tickets, such as annual passes are common in other parts of the world but not in New Zealand. Canada allows a 15% tax credit based on monthly or annual public transport pass costs. In the USA up to US$115 per month of pre-tax-income to buy public transport passes is available as a tax credit thus lowering taxable income. A heavily discounted annual pass is notably absent from New Zealand's public transport fares system. They are common when linked to employer-subsidised schemes or universal access schemes at universities to reduce administration costs. Overseas work place travel plans and travel demand management policies often include use of annual passes, especially if linked to parking restraint occurring after office relocation. Annual passes typically cost 20% less than purchasing 12 separate monthly passes (equivalent to the cost of 10 monthly passes). However, the value for money of implementing these ticket types is unclear (untested).

Periodical tickets can be considered as a simple 'loyalty scheme' which rewards long-term customers. More complex loyalty schemes exist in the public transport sector (most notably in the aviation sector) and many provide a positive return on commercial investment. A loyalty scheme for public transport would need to find its own place in the plethora of such schemes but could be a value-for-money improvement to customer service.

University students represent a concentrated market of travellers who are dependent on public transport or at least highly sensitive to transport costs (willing to try cheap alternatives). Over the last few decades U-pass (or universal access) ticketing schemes where student fees are rolled into an annual fare payment scheme have proven to be successful in increasing patronage of public transport systems. These schemes are often priced in consultation with operators and all students, including those not using public transport. This is because the U-pass is provided (and costs are passed through) to all students as a core component of their enrolment regardless of whether they intend to use public transport. The resulting shift to public transport benefits all students as even those who still choose to drive encounter less congestion and can find parking more easily.

A negotiated ticket price tends to ensure revenue productivity although increased usage often requires increased service provision and higher costs. Massey University at Palmerston North now operates such a scheme which provides discounted public transport included in the enrolment ID card of the university. The university pays the regional council to allow free travel on the bus services in return for funding sourced from student fees and car parking charges at the university campus.

A similar scheme in the USA is an ECO pass, which is a public transport pass paid for by employers. Employers pay bus companies a significantly discounted rate and are provided with a specific number of passes for their employees. The advantage to the operator is that they receive a payment up front for the year ahead and also not every pass will be used. Fringe benefit tax rules would need to be changed for this to work in New Zealand.

4.3.7 Information, marketing measures

Information and marketing strategies can be effective at increasing patronage but it is often difficult to separate the marketing from a new service that has been launched. Most marketing campaigns are aligned to something new that is being provided be it services, fares, or other changes to the transport system. The requirement to explain changes in services and fares requires a marketing approach and it makes sense to combine changes and new services with marketing. Marketing is a very wide field for public transport improvement hence only a select few initiatives are discussed here. However, it is clear that advertising presents value for money in its own right in the correct circumstances. Many public transport systems (particularly those with franchised operators) engage in advertising of the network or specific modes.

Journey planning systems using the internet and mobile phone technology are increasingly becoming standard practice for larger urban areas worldwide. Making coverage of these services comprehensive to all public transport modes and operators is a challenge in some regulatory environments. A failure to address integrated information provision issues such as this has been cited as a major problem with deregulated services in the UK outside of London and a major success in the centralised planning and contracted network within London (White 2002).

Journey planning software is well established now so development costs are not as high and there is a choice of experienced providers. The use of call centre staff is the most expensive (and perhaps least value-for-money) element of these systems.

Traditional printed timetables are being supplemented and in some cases substituted by electronic timetable information in the form of online timetables and information. This includes mobile phone applications which could store the entire set of public transport timetables in New Zealand if required. These 'app' systems have been developed by third parties and are typically available for all public transport systems in New Zealand, but are not branded or coordinated by public transport management agencies. An example where third-party 'app' software has been purchased, branded and managed by the public transport management authority exists in Melbourne with the 'MetLink App'. No research has concluded the extent to which this action is considered value for money.

Alternatively, electronic signs can provide real-time information at stations and stops or via SMS to mobile phones. The cost of implementing this technology has been falling while users find much value in the information provided. Visual aids using GPS that show how a bus or train is progressing along a route can also provide customer confidence that a bus/train is on its way.

Branding is another means of marketing services and also provides simple indications of service expectations. Airport buses are a good example of a route that lends itself to bus branding and design features. Examples include Wellington's Airport Flyer Route 91 and Auckland's Airbus. Bus priority measures can be added to airport services to improve the quality offered. The Auckland MAX bus brand and its association with the Northern Busway is another good example. Branding costs can be high over a large network, but are consistently viewed as being value for money.

4.3.8 Amenities and 'soft variable' measures

Amenities and 'soft variables' cover a range of ancillary improvements to services which are not directly operations or service quantity related but improve the passenger experience of quality associated with the main service offering. They can include roadside and station infrastructure such as shelters and seating, quality of facilities including cleanliness, on vehicle facilities including seating and issues such as ride quality experience. There is some overlap here with information and ticketing infrastructure since these also contribute to passenger perceptions of service.

4.4 Long-range planning initiatives

Improving value for money with long-range public transport improvements requires more careful planning processes to ensure strategic investments and land-use policies achieve better outcomes.

While plans for wider distribution of short-term planning measures can be included in long-range planning they also tend to include consideration of major infrastructure investments such as new major lines and new public transport modes. In Auckland the redevelopment of the Britomart terminal, refurbishment and modernisation of urban rail services and the development of the Northern Busway are all examples of long-range planning initiatives of this type.

Developing new light rail systems is another example of major long-range investment. The Gold Coast Light Rail system being developed in Australia is an example. Light rail transit seeks to provide heavy rail type quality to enhance urban development and reduce car usage in urban areas. Light rail schemes have been strongly associated with enhancing urban renewal and in acting to increase urban densities (Steer Davis and Gleave 2005) making cities more liveable (Vuchic 1999).

Although considered cheaper to construct than equivalent heavy rail systems, the development of BRT has been increasing because of its cost effectiveness compared with light rail (US General Accounting Office 2001; UK Commission for Integrated Transport 2005; Currie and Delbosc 2010). These systems aim to provide rail type quality using buses and have often been termed 'rubber tired rail' (Levinson et al 2003). Key features are exclusive rights of way, higher service levels and frequency, quality station like stops and the use of off vehicle ticketing and quality passenger information.

An issue arising with such systems (particularly serving CBD locations) is that the number of vehicles can congest areas unless vehicle priority, stops and layover areas are designed appropriately. A further emerging impact of BRT is pollution caused by large numbers of diesel-operated vehicles. This can be overcome by using propulsion systems that generate less vehicle pollution.

In addition to infrastructure investments to improve public transport, long-range measures can consider wider measures such as changes in land use and transport pricing structures. Transit-oriented development (TOD) is a good example of a measure in this area (Cervero et al 2002). This seeks to increase urban densities and the mix of development design and quality around major public transport nodes to reduce car usage, increase walk, cycling and public transport use. These measures are best enacted in long-range plans in conjunction with supportive major public transport investments (Dittmar and Ohland 2003). While these measures have most commonly been associated with rail and particularly light rail development (Dittmar and Ohland 2003) there are examples of BRT and bus-based TOD (Currie 2006a; Currie 2006b).

5 Short-range measure impacts

This chapter presents a review of evidence of the value-for-money impacts for short-range public transport improvements from studies that have measured the direct impacts of these measures. It covers general findings on public transport improvement sources from elasticity research, evidence from 'meta studies' of performance of planning measures (these are comparative studies of all types of public transport enhancements with a view to isolating better performing measures), and a review of evidence on impacts of individual short-term improvement measures.

5.1 General elasticity evidence

This section provides an overview of elasticity evidence and what it tells us about the value for money of public transport improvements. The focus of this section is generalisable values of elasticities for public transport as a whole rather than specific values for specific service enhancement measures. More specific elasticity value evidence is presented in the next sub-section examining individual short-term service enhancement measure performance.

5.1.1 Understanding elasticity in simple terms

In simple terms the elasticity of demand is a ratio of change in demand given a change in a variable of interest (such as fare). Demand elasticities are derived from studies which measure how demand changes in various contexts. Elasticity is very relevant to understanding value for money because it explains how patronage is influenced by changes in public transport service attributes such as fare, frequency and travel time.

As a ratio, a positive elasticity, eg +0.5, implies patronage will increase if the public transport service variable also increases. For example a typical service quantity (or frequency) elasticity might be +0.5. It implies that an increase in service provided (buses per hour say) will increase patronage by half (0.5) as much as the increased number of buses. Hence increasing the number of buses an hour from four to five is an increase of 25%. With an elasticity of +0.5 demand will broadly increase by 12.5% (+25% * +0.5).

The higher the elasticity, the higher the demand increase will be. A value above 1.0 implies demand will increase more than the percentage change in services.

Negative elasticities, eg-0.3 mean that demand will change in the opposite direction to the change in the service variable. A good example is fares. A 10% increase in fares will reduce demand. A typical fare elasticity is -0.3. Thus demand will decrease by 3% if fares are increased by 10% (+10% * -0.3).

In technical terminology the discussion above relates to what is termed the 'shrinkage ratio'. While this is a simplistic way of examining demand it also the easiest way to understand it. A good source which discusses these issues in more depth is Wallis (2004). This report summarises elasticity values for public transport improvements and is a major source for the discussion below.

5.1.2 Public transport elasticities and the patronage value of enhancement

Table 5.1 shows recommended values for general elasticities of public transport service attributes relevant to New Zealand conditions. These values are sourced from a review of New Zealand and international evidence.

Table 5.1 Sample elasticity values for public transport service changes – short run

Variable	Bus		Rail	
	Average	Typical range	Average	Typical range
Fares	-0.40	-0.20 to -0.60	-0.30	-0.20 to 0.50
Service levels[(a)]	0.35	0.20 to 0.50	0.35	0.20 to 0.50
In-vehicle time	-0.30	-0.10 to -0.50	-0.50	-0.30 to -0.70

Source: Wallis (2004); Wallis and Schmidt (2003).

Note: [(a)] For medium-frequency services (20–30 min frequencies).

The elasticities shown in table 5.1 suggest the following about value in terms of patronage growth that would take place if public transport improvements of the following occurred:

For bus services:

- A fare reduction of -10% would increase patronage by 4% on average. However, this can vary between 2% and 6% depending on circumstances.
- If the frequency of service (buses per hour) is increased from two buses an hour to three (an increase of +50%). On average, demand might be expected to increase by 17.5% (with a range between 10% and 25%).
- If in-vehicle travel time on buses is reduced by 10%, patronage might be expected to increase by on average 3% (with a typical range of between 1% and 5%).

Average elasticity values for rail fares are lower compared with bus. This is because peak elasticities are generally smaller and off peak larger. Rail generally has more peak travel than bus in New Zealand.

Average rail elasticity values are larger than for bus in relation to in-vehicle travel time. This is because they tend to be larger (or more sensitive) if the variable being measured is a larger part of travel. In this case in-vehicle travel times are a larger part of a rail journey than they are of a bus journey because travel distances tend to be longer by rail.

Another important observation regarding elasticities is that they tend to work in exactly the opposite way if services are being reduced compared with being improved. Hence a fare decrease of -10% has a patronage growth effect of +3% (for rail). If fares are increased by +10% patronage will fall by -3%.

Table 5.2 presents a synthesis of elasticity evidence for bus services and what they imply for the range of likely patronage impacts that are possible for different conditions (based on Currie and Wallis 2008).

Table 5.2 Synthesis of elasticity evidence and implications for patronage impact in various contexts – urban bus service changes

	Fares	Service levels[a]	In-vehicle time
Typical short-run elasticities			
Average	-0.40	0.35	-0.30
Maximum possible improvement	-100% fare reduction	Over 100%+	-50% travel time reduction
Maximum possible demand growth	+40%	Very high (200% plus)	+15%
Factors influencing elasticity values			
Time horizon	Long run typically double (range 1.5 to 3.0) short run.	Long run typically about double short run.	Very limited evidence: indicates long run 1.5 to 2.0 times short run.
Trip purpose/time period	Off-peak/non-work typically twice peak/work; weekend most elastic.	Off-peak/non-work typically c. twice peak /work; weekend most elastic (may be partly frequency differences).	Inconclusive re relative elasticities; although most evidence is that off-peak is more elastic than peak.
Trip distance	Highest at very short distances (walk alternative); lowest at short/medium distances; then some increase and then decrease for longest distances (beyond urban area).	Highest at short distances (walk alternative).	Limited evidence – longest trips more elastic than short/medium distance trips.
City size	Lower in larger cities (over 1 million population) – USA evidence.	Higher in larger cities – EU evidence.	No evidence.
Base level of variable	Elasticities broadly proportional to the base fare level (based on recent UK study – otherwise limited evidence).	Elasticities increase with headways (broadly proportional up to c.60 mins headway).	No firm evidence – although expect elasticities to increase with proportion of total trip (generalised costs) spent in vehicle.
Magnitude of change	No significant variation in elasticities with magnitude of change (majority of studies).	No evidence	No evidence
Direction of change	No significant differences for fare increases and decreases (majority of studies)	No evidence	No evidence

Source: Currie and Wallis (2008), synthesised from the following meta studies: (Wallis 2004; Wallis and Schmidt 2003; Balcombe et al 2004).

Note: [a] Based on medium-frequency services (20–30 min frequencies). Service levels are typically measured by bus kilometres operated, or service frequency.

Table 5.2 suggests that the ‘effectiveness’ of bus improvements in patronage terms is driven by the degree to which improvements can act to reduce fares, increase service levels and reduce bus travel time.

Table 5.2 shows that in the longer term (over 5 to 10 years), the impacts of bus improvements on patronage are almost double the short-run (6 to 12 months) impacts. Off-peak market effects are larger than peak market and commuter impacts. Market impacts of improvements for shorter distance trips (for which walking or cycling may be competitive alternatives) are larger than for long distance trips. In larger cities (>1 million population) fare elasticities are lower, while service level elasticities tend to be higher. However, it should be noted that evidence also indicates that market effects are dependent on the initial level of service provided: the service frequency elasticity for example tends to reduce as the base frequency improves.

5.1.3 Public transport elasticities and the revenue value of enhancements

Patronage elasticities also explain much about how fare-box revenue changes. As a general rule, assuming fares charged are the same for new as they are for existing riders, an increase in patronage will also match increases in fare-box revenue[1].

This rule does not apply to changes in the level of fares. Take for example the following simple example:

- Fares decline by 10%.
- Bus patronage increases by 4% (elasticity is 0.4: +4%= -10% * -0.4).
- This implies that 104% of riders now pay 10% less fare.
- This means that total fare-box revenue is only 93.6% of previous levels before the fare change (ie 104% of patronage pays only 90% of previous fare levels: 104% * 0.9%).

The above fact is an important rule which is consistent in public transport systems throughout the world; fare reductions do not result in enough patronage increase to make up for lost fare-box revenue. In this case patronage increases by 4% but total revenue declines by 6.4%. The cause is the low value of the elasticity: -0.4. This identifies a 'diminishing return' for a given level of change in service variables. This 'diminishing return' is also true of service level and travel time elasticities, ie they are all well below 1.0. In other words you have to improve public transport services by a large amount to get big increases in patronage.

Another unfortunate implication of the above rule is that fare increases will typically increase total fare-box revenue despite patronage losses. Take the following example:

- Fares increase by 10%.
- Bus patronage decreases by -4% (elasticity is 0.4; -4%= +10% * -0.4).
- This implies that 96% of riders now pay 10% more fare.
- This means that total fare-box revenue is now 105.6% of previous levels before the fare change (ie 96% of patronage pays 110% of the previous fare levels; 96% * 1.1).

This fact explains why authorities who need to increase value for money in terms of service cost effectiveness and who are not too worried about declining patronage levels (or the political implications of this) tend to increase fares. It is a simple and easy way to increase cost recovery. Reductions in demand

[1] Note that for some tickets, such as periodical tickets, increased patronage does not always act to increase revenue. This is because additional trips can be made on the same ticket for the same original amount of fare paid.

can also have a secondary influence on requiring less service and thus fare increases can also have a secondary impact in reducing costs. These observations act to explain why entirely commercially based public transport services running in deregulated areas of the UK outside London have had considerably increased fares and declined patronage in the three decades since they were introduced (Sharp and Sharp 1997). However, if value for money is measured in terms of increased patronage or the impacts which public transport can have on congestion, social or environmental issues, then increasing fares is not a means of 'enhancing' public transport at all.

A balanced approach would seek to optimise fare-box revenue, on the basis that additional revenue will fund more services (or other improvements) that in elasticity terms attempt to offset the reduction in patronage.

It is also worth noting that in the 'real world' the elasticity for an individual is based on their perception of reality, not necessarily reality itself. Thus the marketing of service improvements or changes is a significant factor that influences the impact of changes on patronage.

5.2 Meta studies of improvement performance

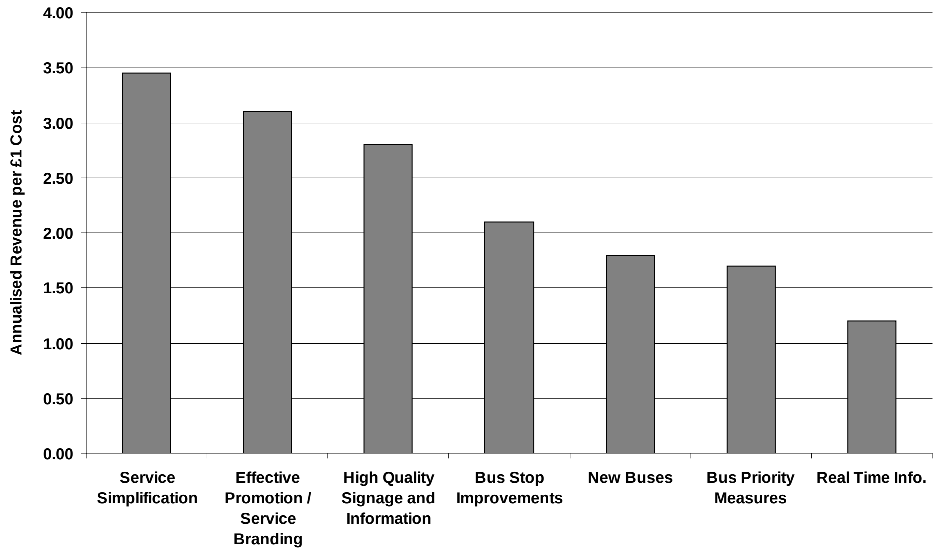
This section examines the relative value for money provided for short-range public transport improvement measures by examining evidence from meta studies. These studies compare the performance of a range of types of public transport improvements with a view to identifying those which are better performing. Evidence reviewed includes:

- UK evidence of most financially viable bus improvements
- European evidence on best bus improvement measures
- a summary of studies on bus and rail route patronage drivers.

5.2.1 UK review of most financially viable bus improvements

In 2002, a survey of outcomes of bus enhancements was undertaken of private bus companies in the UK (outside London) running commercial bus companies on a profit-making basis (TAS Partnership 2002). This assembled evidence on the relative financial value of bus improvements by comparing direct fare-box revenue gain against the relative cost of providing each measure. Figure 5.1 shows the key findings of the review and includes the most effective measures ranked by revenue ratio as a share of costs.

Figure 5.1 Synthesis of relative financial value of urban bus service changes – UK outside London



Source: TAS Partnership (2002).

Route simplification was identified as the most effective value-for-money bus improvement covering almost 3.5 times the financial return compared with costs. Route simplification has a wide range of reasons for performing well:

1 Users often find bus networks confusing. Simplification clearly aids user comprehension of the product on offer.

2 Simpler routes tend to be straighter and more direct which can reduce passenger delays.

3 In addition many route simplification processes also involved concentrating route resources on a single corridor. This effectively created high frequency services in major corridors; a feature common with much advice about improving patronage.

4 Simpler direct routes are easier to operate and can be a means of focusing efforts to improvements such as traffic priority.

5 There can be operating cost savings from concentrating services into single corridors compared with spreading them thinly; for example less roadside furniture is needed.

6 Some cases of route simplification (particularly those affecting peak period services) could reduce overall fleet and driver requirements.

Promotion and branding was identified as the second most successful commercial measure covering just over three times the costs. Making users aware of services has both an information and awareness function. Branding is clearly important in a competitive market but also helps users recognise a specific product or service.

Signage/information was ranked third covering 2.8 times costs. Again a user awareness measure, this shares a feature with many of the top ranked measures: market impact at relatively modest cost. Some of the most effective measures, such as route simplification, new buses and bus priority, can also save operating and maintenance costs while generating patronage; a ‘win win’ scenario.

What is also significant about the results presented in figure 5.1 is the improvement measures which are not identified as having value; notably higher frequency services, new routes and improved spatial or temporal coverage. The direct cost and revenue implications of these measures clearly make them unwarranted on a profitability basis.

5.2.2 European evidence on best bus improvement measures

Table 5.3 shows a summary of the key results from a series of European studies of bus improvements with a focus mainly on patronage growth. As a general rule it is hard to isolate performance of specific individual measures because the programmes reported involved packaging measures into groups. Also overall performance is wide ranging and mixed. However, overall patronage growth ranged between 2% and 53%. The highest growth was for a bus/HOV lane in Madrid. Larger passenger growth initiatives are at the top of the table and in general tend to be a mix of many measures combined into a strategy.

Provision of real-time passenger information is one of the few reported as single initiatives in Brussels and Southampton. Here a remarkably consistent patronage growth of 5% to 6% is reported with a financial payback period of four to six years.

The share of new riders who previously used cars is an indication of project ‘value’ in terms of congestion relief. Mode shift from car varies between 2% and 35% confirming evidence presented earlier that short-range initiatives rarely attract large shares of auto users and typically mostly attract existing riders onto new services. Most of auto mode shift values quoted are for values at or below 10%; higher values are quoted for larger packaged measures involving many forms of bus improvements.

Table 5.3 also quotes financial payback periods for bus improvements which range from three months, for a traffic signal priority scheme in Turin, to six years. This data confirms some of the UK commercial evidence presented above that:

- bus priority initiatives (lanes and signal priority) tend to be cost effective notably where bus travel time savings, and hence improved bus utilisation and cost efficiency, is large
- real-time passenger information appears both patronage and revenue effective.

In general the results in table 5.3 are also supportive of the view that packaging of multiple improvements generates large net gains.

Table 5.3 EU project experience in bus improvement initiatives

Location	Country	Guided busway	Increase bus frequency	Bus signal priority	Bus/HOV lanes	Branding/marketing	Low floor buses	High -quality bus stops	Real -time passenger info.	Public access terminals	Website	Smartcards	Park and ride	Journey time decrease	Patronage increase	Mode shift	Payback period (years)
Projects with patronage growth reported																	
Ipswich	UK	*	*		*		*		*		*		*	-4 to 5 mins	+43%	25% ex car	-
Leeds	UK	*	*	*	*	*	*	*	*					-33%	+40%	11% ex car	2
Madrid	Spain				*										+53%		
Nottingham	UK		*		*								*		+38%		
Birmingham	UK		*			*	*	*	*					-1% to 5%	+31%	10% ex car	
London Route 220	UK			*	*				*					-14 to 23%	+6% to +15%	Small decrease in car use	
Manchester	UK				*		*	*						Large	+10% to +12%		
Liverpool	UK		*	*	*	*	*	*	*						+7%	35% ex car	6
Brussels	Belgium								*						+6%		4
Southampton	UK								*						+5%		6
Bilbao	Spain			*			*		*	*					+2%	Small decrease in car use	3

Location	Country	Guided busway	Increase bus frequency	Bus signal priority	Bus/HOV lanes	Branding/marketing	Low floor buses	High -quality bus stops	Real -time passenger info.	Public access terminals	Website	Smartcards	Park and ride	Journey time decrease	Patronage increase	Mode shift	Payback period (years)
Projects with patronage growth unreported																	
Aalborg	Denmark			*			*	*						-7%	N.A.	8% ex car	2
Hertfordshire	UK											*					
Patra	Greece		*	*					*							2% ex car	2
Skane	Sweden		*											-10%			
Turin	Italy			*													3 months

Source: JUPITER, CAPTURE and OPIUM projects, as reported in Booz Allen Hamilton (2002).

5.2.3 Summary of studies on bus and rail route patronage drivers.

Although not specifically focusing on public transport enhancements, many studies have examined factors influencing patronage on public transport routes in general by analysing factors which might cause patronage to be higher on one route compared with another. The following is a summary of research in this field for bus and rail, mainly light rail, services.

5.2.3.1 Bus systems

Table 5.4 presents a summary of research evidence from a variety of sources showing factors that influence higher patronage on bus services. These have been restructured into endogenous influences (factors that funding agencies, managers and operators can control) and exogenous influences (wider socio-economic factors).

Table 5.4 Previously identified route level public transport patronage drivers – previous aggregate research

Identified patronage driver	Research source
Exogenous factors	
High-density residential development	Johnson (2003) Seskin and Cervero (1996) Babalik-Sutcliffe (2002) Kain and Liu (1999) Kuby et al (2004)
Low car ownership	Babalik-Sutcliffe (2002) Mackett and Babalik-Sutcliffe (2003)
Endogenous factors	
High service levels	Stopher (1992) FitzRoy and Smith (1998) Currie and Wallis (2008) Mackett and Babalik-Sutcliffe (2003) Kain and Liu (1999)
Low fares	Mackett and Babalik-Sutcliffe (2003) Kain and Liu (1999)
Modal integration	Mackett and Babalik-Sutcliffe (2003) Kuby et al (2004)
Ticket integration	Mackett and Babalik-Sutcliffe (2003)
Reliable service	Mackett and Babalik-Sutcliffe (2003)

Source: Babalik-Sutcliffe (2002); Cregan et al (2002); Johnson (2003); Mackett and Babalik-Sutcliffe (2003); Kuby et al (2004); Hirsch et al (2005); Parker (2005); Gopinath (2006); Currie and Wallis (2008).

Higher frequency services appear to be the most significant factor influencing higher patronage on bus services, all other things being equal. Low fares, integrated fares and intermodal integration are also significant as well as more reliable services.

A recent study of some 77 bus routes in Australia modelled the individual factors acting to increase patronage (ABS 2000). This established that the frequency of service provided was the single most important influence on patronage levels on bus routes. Slower speeds were also shown to influence patronage, but this is because buses are slower in areas with slower speeds, such as inner cities where density/activity (and hence patronage) is also high. Bus routes operating in a segregated right of way, such as a bus lane, also carried higher patronage while bus fleets with more modern buses, often those with wheelchair access, were also more popular.

5.2.3.2 Light rail systems

Table 5.5 shows a summary of factors which previous research has associated with higher patronage on light rail services. These have been restructured into endogenous influences (factors funding agencies, managers or operators can control) and exogenous influences.

Table 5.5 Light rail patronage drivers – previous aggregate research

Identified patronage driver	Research source
Exogenous factors	
High-density residential development	Hass-Klau and Crampton (2002) Johnson (2003) Seskin and Cervero (1996) Kuby et al (2004) Babalik-Sutcliffe (2002) Kain and Liu (1999)
Public transport network effect	Babalik-Sutcliffe (2002) Mackett and Babalik-Sutcliffe (2003) Denant Boemont and Mills (1999)
Low car ownership	Babalik-Sutcliffe (2002) Mackett and Babalik-Sutcliffe (2003)
Strong economic conditions	Babalik-Sutcliffe (2002)
High employment	Kain and Liu (1999)
Strong policy support	Knowles (2007)
Endogenous factors	
High service levels/frequent service	Kain and Liu (1999) Mackett and Babalik-Sutcliffe (2003)
Low fares	Kain and Liu (1999) Mackett and Babalik-Sutcliffe (2003)
Modal integration	Babalik-Sutcliffe (2002) Kuby et al (2004)
Ticket integration	Crampton (2002) Hass-Klau and Crampton (2002) Mackett and Babalik-Sutcliffe (2003)
Pedestrianisation	Hass-Klau and Crampton (2002)
Reliable service	Mackett and Babalik-Sutcliffe (2003)
High speed	Hass-Klau and Crampton (2002) Crampton (2002)

Identified patronage driver	Research source
Stop distance	Hass-Klau and Crampton (2002) Crampton (2002)
Light rail network density	Hass-Klau and Crampton (2002) Crampton (2002)
Easy station access	Kuby et al (2004)

Source: Crampton (2002); Hass-Klau and Crampton (2002); Riley (2003); Kuby et al (2004); Knowles (2007).

Of the factors operators can control, frequent services, low integrated fares with good modal integration were those recommended for increased patronage. Integrating route and interchange design into pedestrian areas and easy access including short stop distances were also critical influences.

In a recent study of factors affecting patronage on 57 light rail services in Europe, North America and Australia (Riley 2003), the frequency of service provided was identified as the single most significant factor influencing patronage (β = .74). Integrated ticketing (β = .24) was the only other significant factor which operators might control while employment density was another major external influence. The frequency of service was also shown to influence patronage per vkm offered on light rail routes (ie higher frequency has higher patronage after accounting for a given level of frequency); however, integrated ticketing and the degree of track segregation from traffic were also important.

The results for studies of bus and light rail route patronage above provide some interesting similarities and contrasts between effects and mode. For both, patronage is most heavily influenced by the service level offered while the degree of segregated right of way was also significant in each case. Light rail patronage, however, is heavily influenced by a need for better integration of fares and network design since it critically relies on its ability to attract patronage from feeder services.

5.3 Studies of specific improvement measures

This section summarises findings from studies examining the performance of specific service improvement measures.

5.3.1 Route and network design measures

Although reports on bus network changes in the USA vary considerably (Pratt and Evans 2004), short-term elasticity of demand for increased service (vkm) on area wide networks (average 0.7–0.8) is consistently higher than for service expansion on individual routes (average 0.5). The implication is that there are increasing returns for packaging service expansions on multiple routes. This could be the result of a ‘network effect’ whereby increases on multiple services lead to significantly reduced waiting times for journeys involving an interchange to a second route. The same source reports a high service level elasticity for express bus services (0.9) but notes the complex overlap between travel time and fare impacts on these services.

Table 5.6 summarises major findings from before and after studies of route and network redesign measures on bus services in New Zealand and Australia. A major feature of the new route and route design measure performance is the larger scale of performance of new CBD circulator routes. While many of these mix free fare and new route service initiatives they illustrate an important aspect of good performance; CBD-based measures are clearly a fruitful area for the focus of service improvements because base patronage and public transport dependence are high in these locations, hence patronage impact of improvements can be large. At the same time CBDs are not large areas compared with suburban and fringe regions and the costs of new services are often not high in relative terms.

New orbital bus routes are the other major patronage growth measures in terms of overall scale. In each of the cities where service performance is quoted, these routes have become a central part of overall patronage often within only a few years of development.

Table 5.6 Route and network design initiatives – key impacts

Project	Cost	Patronage impact	Other impact
New orbital bus routes			
Christchurch Orbiter 10 min frequency branded loop service, 1999	NZ$2.5M	600,000 boardings 2008 Regional effects: 1999 9.2M +3.2% 2000 10.0M +8.6% 2001 11.7M+17% 2002 14.0M +20%	Carries 12% of Christchurch patronage
Hamilton Orbiter, 2006	NZ$3M	800,000 in 2009 Regional effects: 2003 1.3M 2006 2M +54% 2007 2.9M +45% 2008 3.6M +26%	17% of total network wide boardings
Perth (WA) Circle Bus Route, 1998–99	Unknown	15%–20% corridor patronage growth	
New bus services			
The LINK 10 min frequency branded loop service with a flat fare, 1996	Predominantly commercially operated. ARTA contract covers off peak	2.5M annual boardings	Around 5.8% of Auckland bus patronage
Hamilton CBD shuttle 10 min frequency branded loop service, 2006	NZ$400,000	400,000 boardings Regional effects: 2003 1.3M 2006 2M +54% 2007 2.9M +45% 2008 3.6M +26%	2009 10% of total boardings
Crosstown Route 007, Auckland (Nov 96)	Unknown	Weekday +4.5 times in first 3 months, 6 times after 1 year and 10 times after 4 years.	Now carrying over 0.5M new passengers pa.
Perth City (free) CAT Service, 1996 (Western Australia)	Unknown	214%	
Brisbane CBD (free) bus, 1993 (Queensland)	Unknown	New service 58% free fares 50%	

Project	Cost	Patronage impact	Other impact
Marion Access Shopper Service, 1998 (South Australia)	Unknown	40%	66% of new passengers were ex car users
Rowville Telebus – demand responsive service (Victoria)	Unknown	10%	
New bus network restructuring			
North-east area restructure, Christchurch (Nov 2000)	Unknown – vehicle trips increased c.20%, service km by more.	+16% weekday, +60% Saturday and +25% Sunday.	
Campus Connection, Wellington (Feb 99)	Unknown	+4% to +7% within 1 – 2 years	
Perth, 1997–99 (Western Australia)	Unknown	Midland area 20%–25% Canning 20%–30%	
National Bus Company, 1994–95 (Victoria)	Unknown	10%–20%	
New express/limited stop bus routes			
Terry Hills–Sydney CBD 1992 (New South Wales)	Unknown	15%	
Adelaide Transit Link 1992–1994 (South Australia)	Unknown	Balanced 19% pk, 29% off pk Overlay 34%	Some 4%–10% of patronage previously drove a car

Sources: Environment Canterbury (2007); Environment Waikato; NZ Bus; Currie & Wallis (2008).

Only limited financial data is available and this focuses on costs rather than fare-box revenue. Data suggests that route and network improvements cost between NZ$400,000 and NZ$3 million and have generated patronage gains between 5% and 15% – note that patronage growth is from a very different base level in each context. Orbital or loop services with high frequency (over four buses per hour) again show up in these figures. Orbital services have a network-wide implication on impact while loop services are often very localised. CBD shuttles that often have low or no fares are also effective at gaining patronage; however, their financial performance is clearly limited since fare-box revenue is low or zero.

In a review of published experience of bus network restructuring in Australia (Booz Allen Hamilton 2002) the following conclusions were drawn on likely performance:

- Major new trunk bus routes can be relatively successful in terms of patronage levels, new public transport trips and financial performance. However, the success of non-radial routes is very situation-specific. Success is likely to be dependent on the route connecting to a number of major generators of potential bus trips, eg regional shopping centres, schools and tertiary education institutions, hospitals, railway stations etc.
- In general, comprehensive network redesign on an area/sub-region basis is likely to be an effective means of increasing patronage. As part of network redesign, service increases focused outside peak periods are likely to be relatively cost-effective and to improve the fare-box cost recovery percentage for the services as a whole. However, in general where fare-box cost recovery is relatively low such service increases are likely to increase the total subsidy requirement. The greater part of the

patronage response to major service change occurs within six months of the change. However, the more-or-less full response may take up to three to four years to recur.

- Regarding express and limited stop services the review found that a two-tier service pattern in any corridor (ie express/limited stop service as well as local/all stops service) is only likely to be warranted in situations where demand is sufficient to justify quite high overall frequencies (eg six trips/hour total in corridor, peak direction) and where time savings on the express service are substantial (minimum 5–10 minutes, which applies only on longer routes typically 8km or more). A two-tier service pattern should be designed in a 'balanced' way, so that all peak period/peak direction buses are more-or-less full at their maximum load point. Desirably the design would be such that the additional demand created by the faster service could be accommodated without any increase in peak vehicle requirements (but with faster round trip times and enhanced overall frequencies).

In the USA, patronage experience of bus routing and spatial coverage initiatives have been summarised by the Transportation Research Board in chapter 10 of its Transit Cooperative Research Program (TCRP) report 95 (Pratt and Evans 2004). Key points from their analysis are that:

1 Completely new area-wide bus transit systems if successful achieve three to five boardings per capita per annum or 0.8 to 1.2 boardings per bus mile (1.3 to 1.9 boardings per bus km). University towns or services focusing around public transport hubs such as metro stations are generally more successful

2 Bus network restructuring experience has had very mixed results. Designs which fit well with land use and have clearer well-defined structures (like hub and spoke networks) have a slight edge in performance over other systems notably grid networks. Network restructuring which aims to reduce costs as well as achieve patronage growth, ie to better target resources to more productive patronage has the following key features.

   a emphasis on high service level core routes (concentrating frequency)

   b consistency in scheduling

   c enhancement of direct travel

   d ease in transferring between routes

   e quantitative analysis in design based on travel patterns

   f ambient economic conditions.

3 Irrespective of bus route design, routes servicing multiple functions/activities tend to fare best.

4 New bus routes take one to three years to mature to full patronage levels.

5 Most patronage comes from homes within walking distance of stops. Most patronage (60% to 94%) tends to come from passengers who are already using public transport.

Very little of the evidence reported above discusses the financial value for money of improvements; however, some useful comments on this issue are made in the US review (Pratt and Evans 2004):

- Compared with major rail-based improvements to services, the costs of restructuring bus services are comparatively low.

- A major financial performance concern is that it normally takes one to three years for full patronage to build on new services/networks implying an upfront financial commitment and early loss.
- Virtually no North American mass public transport system meets costs with fare-box revenue.
- In one case (New Jersey Transit) new cost recovery standards were imposed for new route services suggesting 15%, 20% and 25% cost recovery per month in the first three consecutive years of operation. Extensions and enhancement to existing networks in general met a slightly higher standard of 20%, 25% and 30%.

In terms of enhancement in route temporal coverage, a range of research makes it quite clear that off-peak service level elasticities are almost double those in the peak period and are generally higher than all day elasticities (Balcombe et al 2004; Evans 2004). The implication is that extending temporal coverage of bus services into the evening and weekend is generally more effective at increasing patronage than it is per unit input in the peak period. Table 5.7 illustrates some values quoted for expansion of services into off-peak periods. This suggests that weekend day (notably Sunday) and weekday evenings are particularly fruitful times to increase services, notably in the long term (particularly for evening services).

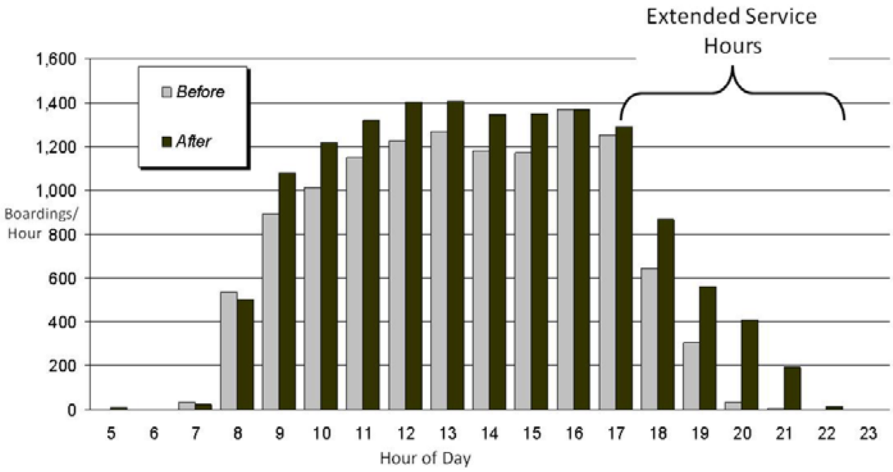
A study of the introduction of later evening services in Melbourne (NRMA 2006) illustrated why evening services had particularly higher all day elasticity effects than specific effects on evening demand. Daytime patronage was shown to be increasing in addition to the night-time service despite no change in daytime frequencies. The cause was that new evening services meant passengers could make return trips, ie both an outbound daytime trip and a return evening trip (figure 5.2).

Table 5.7 Service level elasticity evidence by off-peak time period – urban bus service changes UK

Time period	Short run	Long run
Weekday		
Early morning pre-peak	0.38	0.58
Interpeak	0.17	0.30
Evening	0.35	1.95
Weekend		
Saturday	0.52	0.67
Sunday	1.05	1.61

Source: Preston (1998).

Figure 5.2 Increase in Sunday daytime demand due to evening only increases in service frequency/temporal coverage



Source: NRMA (2006).

There is very little evidence of demand impacts from comprehensive network redesign, mainly due to the limited number of such enhancements and also their complexity since they tend to incorporate multiple types of service enhancements as a package. However, evidence reported earlier suggested that, overall, the patronage impact of enhancing services over a wide area tends to be larger (proportionally) than the impact of improving one single route. This is suggestive of 'network effects' – higher patronage growth from network-wide improvements rather than localised ones.

Network integration – the better fitting of routes and schedules between services (often termed network synchronisation) to make transferring between services easier – is a related aspect of improved network design. Few studies have measured the scale of patronage impacts from integration effects mainly because they are a complex area; fare increases are often combined with service and schedule integration. One of the few studies to try and separate these effects examined the combined influence of fare, ticketing information and marketing integration (Honnery and Moriarty 2004). It estimated that 11.6% of growth had occurred but of this 8.1% was directly explainable by integration effects. The implication is around 3.5% of growth was from other effects.

Another study of intermodal schedule coordination (Abelson and Baker 1982) estimated that in Melbourne adjusting schemes to synchronise bus-rail timetables at all locations could generate bus patronage growth of between 3.5% and 8.5%. However, it was considered unlikely that network-wide coordination of this scale was possible in all locations so overall impacts were likely to be below this.

5.3.2 Service frequency measures

Table 5.8 shows a summary of evidence from studies of elasticity of demand in relation to bus and rail service frequency changes.

Table 5.8 Service level elasticity evidence by time period – urban bus service changes Australasia

Time period	Values					
Typical short-run elasticity recommendations						
Average	**0.35 Bus/rail**					
By time period	Off peak/ non-work typically double peak/work					
Long run	Long run typically double short run					
Recent evidence from bus services – Australasia						
	Melbourne SmartBus frequency [(a)]	**Melbourne service spans [(a)]**	**Adelaide frequency**	**Brisbane frequency**	**Auckland Mt Eden Road**	**Dunedin**
Weekday						
• Overall	0.39	-	-	-	-	-
• Evening	0.77	0.65	0.55	.59	-	-
• Interpeak	0.37	-	0.46	-	0.45	-
• Peak	0.27	-	-	-	-	-
Saturday/Sunday						
• Overall	.57	-	0.61	0.73	0.50	0.50
• Evening	-	0.95	-	-	-	-

Note: [(a)] Melbourne values suggest weekend ~50% higher than weekday

Source: Wallis (2004); Orbital Engine Company (2004).

Typical recommended average short-run elasticity values with respect to service level or frequency for New Zealand are 0.35 for both bus and rail. Off-peak values vary by time period and city; however, they are broadly double peak values. Evidence suggests Saturday and Sunday values are higher than weekday values. Evening values are higher than interpeak. In summary, the recent results from the Australiasia off-peak service frequency review (Orbital Engine Company 2004) found that:

- There are clear differences between weekday/weekend peak and interpeak/evening elasticities.
- There is little evidence of differences in elasticity given the starting point of initial service frequency.
- Evidence suggests no significant difference in elasticity given the relative scale of change. There is also no evidence that impacts of decreases vs increases are significantly different.
- Results are surprisingly consistent between cities and routes and types of service.
- A ramp-up period of about 12 months from initial change in service to full increase in demand is required.

5.3.3 Reliability speed and traffic priority

High amongst public transport improvements which have concerned reliability and speed has been the introduction of traffic priority measures for on-road public transport including mainly bus but also trams and streetcars. This has included measures to improve traffic signal performance at intersections and roadspace measures such as bus lanes.

Traffic signal priority (TSP) is now a major means of improving bus services worldwide. It includes 'passive' measures, adjusting the timing of existing lights to bias green time for buses/trams and 'active' measures, which use technology to sense when the bus is coming and only change light phases when buses/trams can benefit from them (Smith et al 2005). Much evidence suggests that 'active' priority enables public transport to benefit while at the same time reducing the impact on other road users.

Table 5.9 summarises the impacts of TSP measures on public transport from an operational perspective. This suggests that impacts can include:

- Reduction in travel time: TSP reduces transit delay at intersections and thus improves transit travel time over a corridor. Intersection travel time reductions vary from 6% to 80% in some cases. This results in a travel time saving of 2% to 18% (depending on the number of intersections with TSP, TSP strategy, traffic congestion level and bus operation conditions).
- Reliability: Reliability improvement can be significant, eg Seattle, Washington State (USA), experienced a 35% improvement in travel time variability.
- Adverse general traffic impacts: TSP may cause some negative traffic impacts especially on the crossing flow roads, notably minor roads. However, the overwhelming view of most studies is that delay impacts on general traffic are negligible.

This analysis implies that TSP patronage and revenue impacts are likely to be positive while the improved efficiency of bus/tram operations is likely to reduce costs suggesting a possibly financially positive net outcome. Indeed as quoted earlier (table 5.3) bus signal priority was identified as one of several measures to have a short payback period (less than two years in several cases). In one case (Turin) bus signal priority was shown to pay back costs of installation within three months (Booz Allen Hamilton 2002).

Table 5.9 Summary of benefits and impacts – traffic signal priority (TSP)

Location	Public transport	Intersections	TSP strategy	Impacts
Portland, Oregon, USA: Tualatin Valley Hwy	Bus	10	Early green, green extension	Bus travel time savings = 1.4%–6.4%. Average bus signal delay reduction = 20%.
Portland, Oregon, USA: Powell Blvd	Bus	4	Early green, green extension, queue jump	5%–8% bus travel time reduction. Bus person delay generally decreased. Inconclusive impacts of TSP on traffic.
Seattle, USA: Rainier Ave at Genesee	Bus	1	Early green, green extension	For prioritised buses: • 50% reduction of signal-related stops • 57% reduction in average signal delay. 13.5% decrease in intersection average person delay. Average intersection delay did not change for traffic. 35% reduction in bus travel time variability. Side-street effects insignificant.
Seattle, USA: Rainier Ave (mid-day)	Bus	3	Early green, green extension	For TSP-eligible buses: • 24% average reduction in stops for eligible buses

Location	Public transport	Intersections	TSP strategy	Impacts
				• 34% reduction in average intersection delay. 8% reduction in travel times. Side-street drivers do not miss green signal when TSP is granted to bus.
Europe	Bus	5 study sites	Various	10 seconds/intersection average signal delay reduction. 40%–80% potential reduction in public transport signal delay. Public transport travel times in England and France reduced 6%–42%. 0.3%–2.5% increase in automobile travel times. 1- to 2-year payback period for installation of TSP.
Sapporo City, Japan: Rt 36	Bus	Unknown	Unknown	6.1% reduction in bus travel time. 9.9% increase in patronage.
Toronto, Canada	Streetcar	36	Early green, green extension	15%–49% reduction in public transport signal delay. One streetcar removed from service.
Chicago, USA: Cermak Rd	Bus	15	Early green, green extension	7%–20% reduction in public transport travel time. Public transport schedule reliability improved. Reduced number of buses needed to operate the service. Passenger satisfaction level increased. 1.5 seconds/vehicle average decrease in vehicle delay. 8.2 seconds/vehicle average increase in cross-street delay.
San Francisco, USA	Light rail transit and trolley	16	Early green, green extension	6%–25% reduction in public transport signal delay.
Minneapolis, USA: Louisiana Ave	Bus	3	Early green, green extension, actuated public transport phase	0%–38% reduction in bus travel times depending on TSP strategy. 23% (4.4 seconds/vehicle) increase in traffic delay. Skipping signal phases caused some driver frustration.
Los Angeles, USA: Wilshire and Ventura Blvds	Bus	211	Early green, green extension, actuated public transport phase	7.5% reduction in average running time. 35% decrease in bus delay at signalised intersections.

Source: Baker et al (2002).

The wider benefits of public transport priority measures were theorised in a model developed as part of the BRT system planning in the USA; figure 5.3 (Levinson et al 2003).

Figure 5.3 Wider impacts of public transport priority measures – a theoretical model

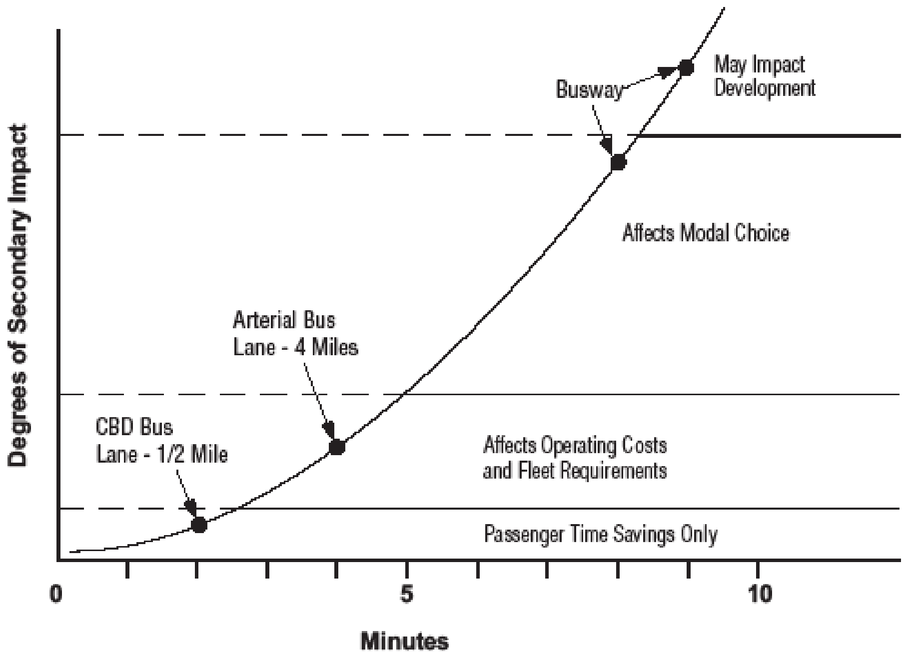


Figure 5.3 above shows a theoretical model to highlight the travel time savings necessary to achieve various impacts. The patronage and operational impacts of bus priority lanes were benchmarked in Australasia and worldwide in an Australian study (Kain and Liu 1999).

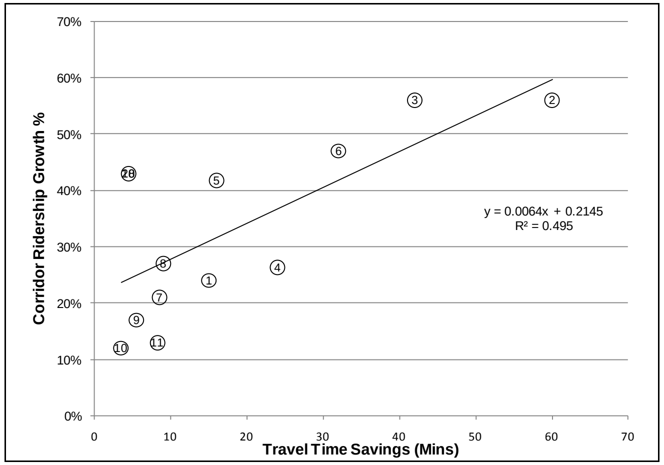
This model suggests that when schemes achieve travel time savings of only a few minutes, the main benefits are passenger travel time savings. However, if travel time savings exceed three minutes then benefits in fleet operating cost and resource savings are also theorised. Above five minutes of travel time savings there are impacts on modal choice, notably reduced use of roads by car drivers. Wider longer-term land-use impacts are theorised to lie beyond savings of eight minutes.

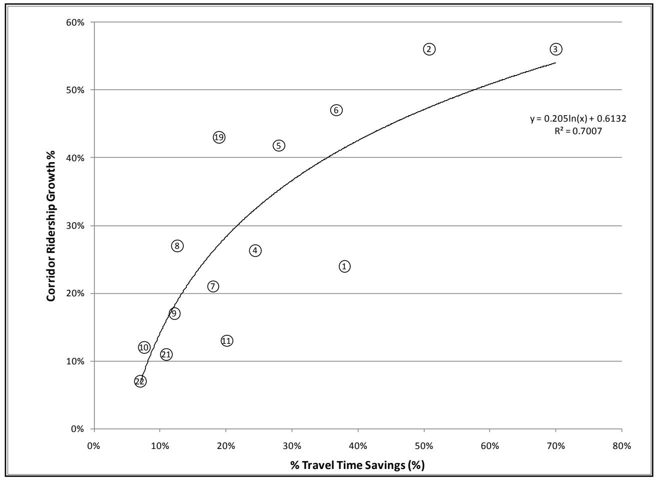
To test this theoretical model a review of the performance of public transport priority impacts on patronage and mode share was undertaken in Australia (Kain and Liu 1999). Figure 5.4 shows the impact of the schemes on patronage and then car driver mode reduction as a result of travel time savings resulting from priority initiatives.

Results show a strong link between corridor patronage growth and both the absolute and percentage reduction in public transport travel time. Even small reductions in travel time resulted in mode shift from car drivers. The impact increased with travel time reductions notably in percentage terms. Overall, however, there is much scatter in the data.

Figure 5.4 Impact of priority initiatives on patronage – absolute and proportion of travel time savings (Currie and Sarvi 2012)

Impact on patronage

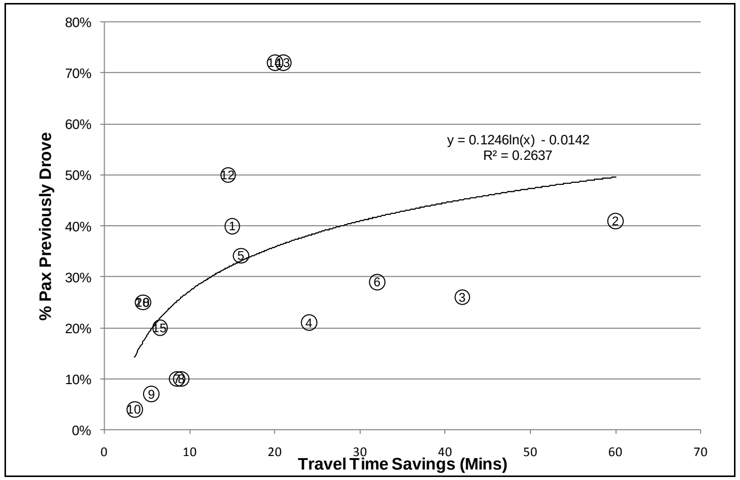


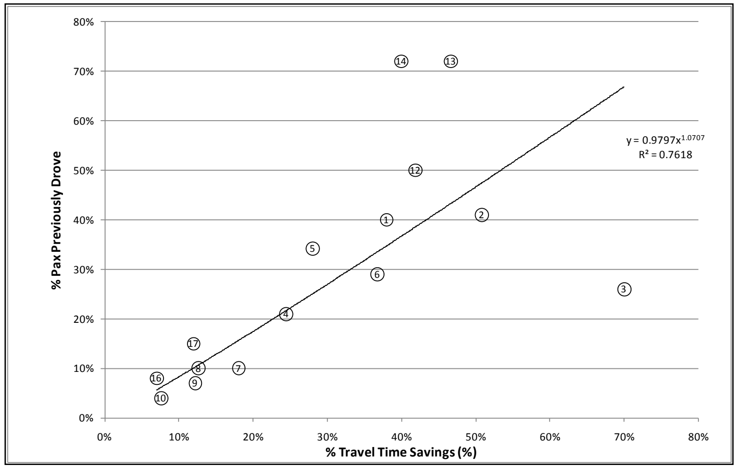


Key

1	Adelaide North East Busway
2	Sydney Liverpool Parramatta Transitway
3	Brisbane SE Busway
4	SmartBus Route 903
5	SmartBus Route 901
6	SmartBus Route 902
7	Transit Link 2 West Lakes
8	Transit Link 3 Elizabeth
9	Transit Link 4 Port Road
10	Transit Link 5 Grange Adelaide
11	Euclid Avenue Cleveland USA
12	Hartford USA
13	HOV System 1, Huston USA
14	HOV System 2, Huston USA
15	Vancouver Broadway B Line,
16	Aalborg, Demark
17	Florence, Italy
18	Ipswich, UK
19	London Rte 220, UK
20	Ipswich, UK
21	Helsinki, Finland
22	Los Angeles, USA

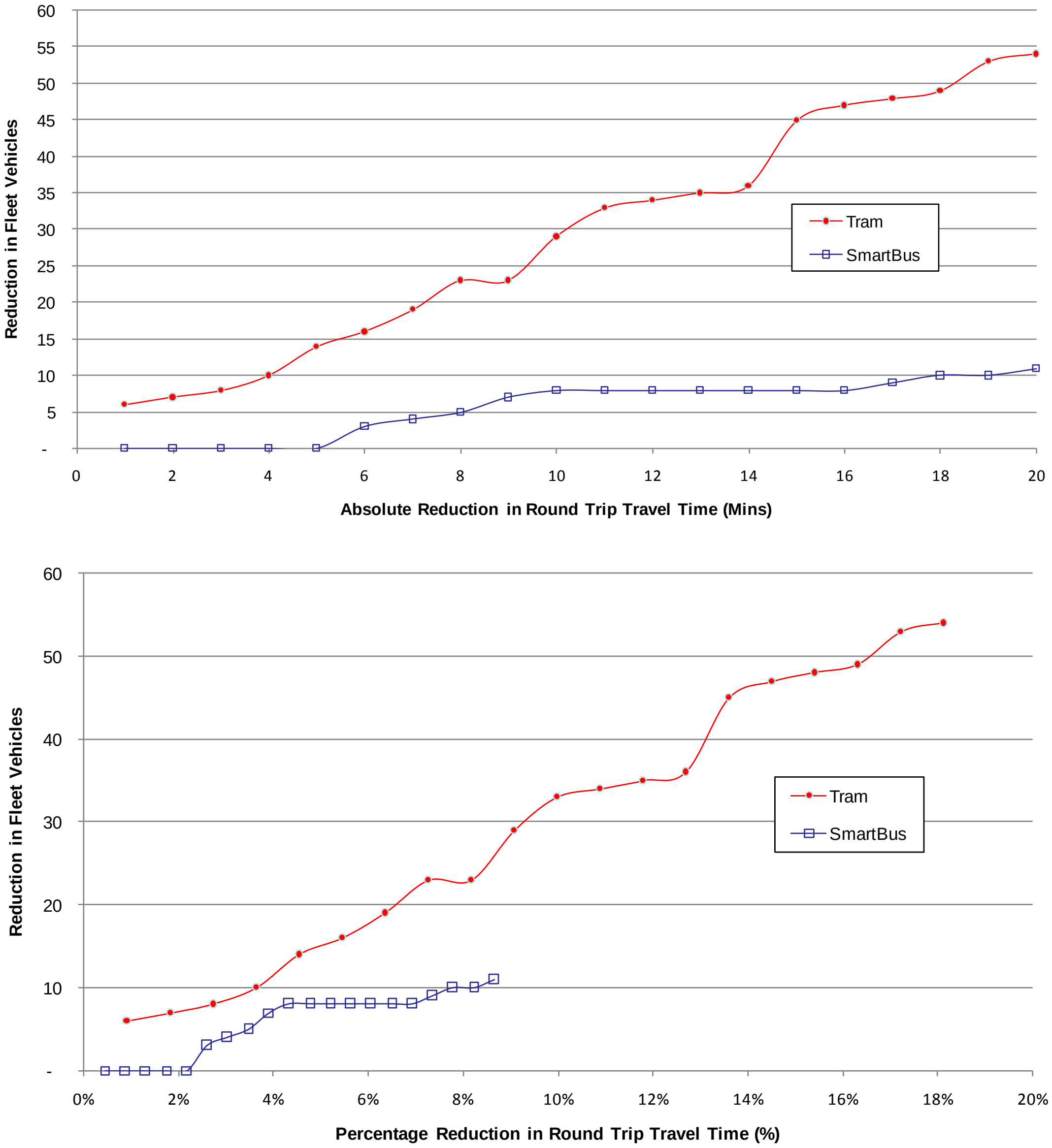
Impact on car driver share





The same study sought to benchmark likely impacts of travel time reduction resulting from public transport priority initiatives on bus and tram fleet resources in Melbourne (Kain and Liu 1999). Figure 5.5 shows how absolute and share of travel time reductions act to impact on tram and bus resources.

Figure 5.5 Impact of priority initiatives on bus and tram resources – Melbourne (Currie and Sarvi 2012)



This suggests that saving even one minute of travel time (or 1% of travel time) on tram routes might reduce the tram fleet by five vehicles. This would save a considerable amount of money (capital costs for trams are about A$6M each to purchase, with operating costs in the order of some A$500,000 pa per vehicle). For the SmartBus network; larger savings in travel time are needed because services are less frequent than trams and cover longer route lengths. Overall it is clear that there is considerable scope to improve the financial as well as patronage and congestion reduction value of public transport using public transport priority initiatives.

Table 5.10 shows some of the more recent data on the performance of bus priority initiatives in New Zealand.

Table 5.10 Bus lane costs and associated elasticity and patronage growth – New Zealand

Project	Cost (local currency)	Date	Elasticity or patronage impact	Sources
Auckland bus lanes Onewa Rd Dominion Rd Mt Eden Rd Sandringham Rd	Re-allocation of existing lanes Onewa Rd Dominion Rd Mt Eden Rd Sandringham Rd	 1982 1998 1999 1999	Onewa public transport lane 25% Carries twice as many commuters as the single occupant lane One year after opening: 9% increase in bus patronage 36% increase in carpool vehicles 18% decrease in other traffic Dominion Rd 70% BCR 4.4 -7 Mt Eden Rd 40% BCR 4.7 -5.6 Sandringham Rd	BAH 2006
Wellington bus lanes Lambton Quay Thorndon Quay Chaytor St Adelaide Rd Kaiwharawhara Rd	Karori bus lane NZ$95,000 Lambton Quay NZ$394,000 Thorndon Quay NZ$6500 Chaytor St Adelaide Rd NZ$8500 Kaiwharawhara Rd NZ$18,000	2002	Lambton Quay Thorndon Quay BCR 11 Chaytor St 2003 5.4% 2004 15.2% Adelaide Rd BCR 67 2003 9.3% 2004 4.8% Kaiwharawhara Rd BCR 40 2003 7.8% 2004 4.8%	WCC bus priority lanes monitoring report 2004
Sydney harbour bridge to Gore hill bus priority	Re-allocation of existing road space	1992	23% on routes using priority. The bus lane carries more people between 7.45am–8.45am than all five lanes combined.	

This indicates that:

- generally speaking the costs of priority schemes are relatively low ;ranging from NZ$6500 to NZ$394,000
- patronage growth rates on the corridor in the New Zealand experience range from 5.4% to as high as 70%
- there is a cost per % gain in patronage of NZ$1204 to NZ$5628.

Bus lanes and bus priority measures have widely varying costs depending on whether they are a reallocation of existing road space, extra lanes added, or bus advance lanes added at intersections. All bus lane projects quoted have had high positive benefit cost ratios (BCRs) and have provided long-term benefits especially if maintained over long periods, eg the Onewa Road, Dominion Road and Mt Eden, Sandringham Road lanes. Bus lanes typically carry more people in fewer vehicles than surrounding lanes. The Lambton Quay lane in Wellington also acts to increase pedestrianisation. High-frequency services, express buses and larger capacity buses may be required due to the resulting patronage growth.

5.3.4 Vehicle types and features

New vehicles with specific features such as air-conditioning and low floors improve service to the public. Table 5.11 shows some of the impacts from evidence of improvements in relation to vehicle types in Australasia.

Table 5.11 New buses and their associated elasticity's and patronage impact

Project	Cost	Date	Patronage impact	Sources
New buses STA Sydney	A$250M (505 SLF, aircon, Euro 4 and 5 buses - A$595,000 per bus)	2007	Low floor 0.17% Aircon 1.7% New buses patronage +2%-6%	Auditor general STA annual report Currie and Wallis 2008
New buses STA Sydney	A$115M (150 SLF, aircon, Euro 4 and 5 articulated buses - A$767,000 per bus)	2007	Low floor 0.17% Aircon 1.7% New buses patronage +2%-6%	Auditor general STA annual report Currie and Wallis 2008
First Group UK	£71M (431 low-emission buses - £164,733 per bus)	2008	New buses patronage +2%-6%	First Group UK Currie and Wallis 2008
NZ Bus	NZ$7M (20 Euro 5 buses - NZ$350,000 per bus)	2008	Low floor 0.17% Aircon 1.7% New buses patronage +2%-6%	NZ Bus press release Currie and Wallis 2008

New buses cost between NZ$350,000 and NZ$767,000 with the lower emissions and articulated buses costing more than the smaller standard diesel buses. The patronage impact is difficult to establish accurately but has been suggested at 2%-6%. This equates to between NZ$128,000 and NZ$175,000 per % gain. A regular fleet replacement programme would provide a smoother capital investment profile. Adding new buses in association with extra peak services and adding capacity to already heavily loaded routes is a better option as it adds capacity and quality at the same time. The style and branding of buses is also very important (see later).

Low-floor buses aid passengers with mobility impairments which can include mothers with prams as well as older passengers and those with physical impairments. Evidence suggests patronage impacts of low-floor buses are low (less than 1%). Air conditioning, however, has been shown to increase patronage by up to 1.7%; however, impacts of these measures are clearly more significant in cities with warmer weather. Impacts in New Zealand are not expected to be as high.

Although the overall patronage growth impacts of low-floor buses are not large in comparative terms they can act to substantially increase patronage of those who find access to buses problematic. Hence there is also social 'value' in low-floor bus improvements. This was found in a UK review of the impacts of low-floor bus designs (TAS Partnership 2002):

- The Birmingham Showcase quality bus route resulted in a 91% increase in passengers described as ‘encumbered’, a 71% increase in mobility impaired passengers, and a 146% increase in children under five, compared with the overall average increase of 31%.
- In Manchester, loadings along the bus priority demonstration corridor were 10% to 12% higher on the low-floor buses than on other buses using the same route, and passengers with pushchairs were 2.5 times more likely to use a low-floor bus than a conventional one.
- 88% of users of low-floor buses in Bilbao thought there was a significant improvement in service quality.
- Low-floor buses were a major part of the package scheme in Florence, where patronage on the affected routes increased by 15%.
- A high percentage of passengers using the SMART low-floor buses in Liverpool felt that they were much more accessible in all aspects than other buses in the city.
- The positive influence of low-floor buses is supported by the JUPITER and CAPTURE EU projects (see table 5.3).

Table 5.12 shows a summary of passenger valuation of the importance of in-vehicle ‘soft variable’ attributes of buses and trains resulting from ‘willingness to pay’ studies. These are expressed as values in equivalent ‘in vehicle’ minutes and could be used to make a forecast of patronage impacts by applying an in vehicle travel time elasticity to the relative impacts on travel time such measures might imply.

Table 5.12 Passenger valuation of in-vehicle public transport attributes

Mode	Attribute	Valuation – in-vehicle minute equivalent
Train	Train environment	0.3–1.5
	Train facilities	0.4–1.5
	Customer information	0.3–1.1
	Train staff and security	1.6–2.0
Bus	Driving quality and customer service attributes	0.3–0.7
	Seating	0.2–0.4
	Customer information	0.7
	Bus environment[(a)]	-1.5–0.5

[(a)] Negative values reflect attributes such as a dirty bus and poor ventilation

Source: Vincent (2000)

The results imply that trained staff providing security on railways would have the highest patronage impact. However, this would be unlikely to be significant (less than 1%). Train facilities (eg seating) and environment (eg cleanliness) appear to have a larger impact than customer information on rail. On buses, driver customer service and drive quality are major on-vehicle issues as well as customer information (which is relatively more significant than for trains).

5.3.5 Personal safety and security

Concerns about crime on public transport have been widely seen as a barrier to public transport use (Crime Concern 2002; Kennedy 2008). UK research, for example, has identified that an additional 10.5% of rail trips would be generated if people felt more secure when travelling and waiting at stations (Crime Concern 2002). A majority of car drivers in inner Los Angeles claimed they would use public transport if public buses were perceived as safe and clean (Loukaitou-Sideris 1999). It would therefore seem reasonable to assume that initiatives to improve both perceptions of safety and actual safety on public transport might also increase patronage and potentially revenue. This proposition was supported by a major survey of personal safety concerns of New Zealanders reporting in 2003 (BAH 2003a). This suggested that:

> *…security measures are going to be more effective if they are targeted towards increasing the frequency of use of existing patrons. Security measures are going to be less effective at persuading non-users of public transport to become users.*

For bus services, the survey established significant customer support for improvements such as:

- lighting at bus stops
- emergency alarms or 'panic buttons' at bus stops to alert guards
- security cameras at bus stops.

It is unlikely these measures will act to substantially improve patronage or revenue; however, the implementation costs of these measures are also relatively low.

For rail which was considered a greater concern from a security viewpoint, key improvement measures included:

- random security guard patrols at stations during less busy times
- emergency alarms or 'panic buttons' at stations to alert guards
- open café/kiosks at stations
- security cameras at stations.

Security guards and staff are a common priority for passengers seeking reassurance about safety concerns. Unfortunately this is also a high-cost measure. Cost saving by reducing staffing at stations has seen an increase in concern for personal safety on railways. Hence additional staff is difficult to justify financially. Roving guards are a common solution, ie spreading out available staff over many locations to increase their overall impact.

5.3.6 Fares and ticketing information

Earlier discussion (table 5.1) has summarised major issues associated with the level of fares. In summary short-term fare elasticities are of the order of -0.3 to -0.4 with values off peak typically doubling peak values. The implication of this is that increasing peak fares tend to increase revenue more and reduce patronage less than off peak because workers often have few choices but to use public transport in the peak period. However, such a strategy can be detrimental to the congestion relief objectives of public transport.

Table 5.13 summarises the limited data available on the patronage and cost impacts of new ticketing schemes in New Zealand.

Table 5.13 Fares and their associated elasticities, patronage impact and BCR

Project	Cost	Date	Patronage impact	Sources
Christchurch gold coin fares	NZ$2 gold coin fares and simplified fares	2000	2000 9,967,097 +8.6% 2001 11,668,191 +17% 2002 14,014,821 +20% 2003 14,789,985 +5.5%	Environment Canterbury 2007
Christchurch Metrocard (Smart card ticketing)	NZ$1M ERG contract	2003	2003 14,789,985 +5.5% 2004 14,675,592 -0.8% 2005 15,743,911 +7.3% 2006 15,487,890 -1.6% 2007 16,078,761 +3.8% 55,000 cards 2004 143,000 cards 2007 70% of boardings Reduced use of cash fares from 61% to 38% and 70% reduction loading time.	Environment Canterbury 2007
ARTA tertiary discount from 20% up to 40%		2008	186% increase in tertiary ticket sales	Auckland Transport 2011
SuperGold Card Free off-peak travel for +65 October 2008	ARTA expenditure $4.1m first 6 months	2008	In Auckland – 277% increase in SuperGold Card trips.	Auckland Transport 2011

The introduction of a simplified fare structure in Christchurch with a single zone and gold coin had a significant patronage impact. The Orbiter and the new interchange were introduced at the same time so the individual patronage impacts are difficult to isolate but they show the benefit of a package of approaches. The gold coin fares represented a fare increase but due to the introduction of a single zone and patronage gains, revenues increased. Patronage increased by 52.7% between 1999 and 2002 linked to the Orbiter and single zone gold coin fares; there was a cost percentage gain of NZ$47,438. This increased by 8.7% between 2003 and 2007 with the introduction of integrated ticketing and a cost percentage gain of NZ$114,942 resulted. Exogenous factors also had an impact on patronage during the same period.

Value for money is perhaps more important than the fare price itself. If the service is highly valued then a higher fare can arguably be justified. A high-speed high-quality journey can command a higher price. A focus on making the journey highly valuable is more important than a focus on fare price. Patronage demand is a good way to establish the value of the service fare. Price variation may be used to shift demand on to off-peak services to charge a higher fare for express rail or bus services using grade separated infrastructure.

5.3.7 Information and marketing

It is rare to find specific data collected on patronage and revenue performance of marketing or information improvements. However, willingness to pay research has considered how passengers value information improvements (see table 5.14).

Table 5.14 Passenger valuation of public transport attributes

Mode	Attribute	Valuation – in-vehicle minute equivalent	Estimated patronage impact[(a)]
Train (general measures)			
In vehicle	Customer information	0.3–1.1	0.5%–1.9%
Off vehicle	Customer information and ticketing	0.1–0.4	0.2%–0.7%
Bus (general measures)			
In vehicle	Customer information	0.7	1.2%
Off vehicle	Customer information (at home)	0.4–1.0	0.7%–1.7%
	Customer information (at bus stop)	1.5–1.7	2.5%–2.9%
Bus (specific measures)			
External	Large route number and destination sign front, side and rear plus line diagram on side vs small signs	0.2	0.3%
Interior	Easy to read route no. and diagram compared to none	0.2	0.3%
Info of next stop	Electronic next stop sign and announcements vs no information	0.2	0.3%

Source: Vincent (2000); Australian Transport Council (2006).

[(a)] Assumes a 20-minute bus journey with 5-minute access/egress walk, 5-minute wait, a A$1.50 fare and a value of time of $A10.00/hr (2006). This makes a weighted generalised cost of 59 mins. Forecasts are made by applying a generalised cost elasticity of -1.0 to the change each soft factor has on this base generalised time. These assumptions are based on Australian Transport Council (2006).

This analysis suggests that information improvements are only likely to achieve patronage growth of less than 3%. If sustained, it is possible that revenue growth may cover costs since information measures can be inexpensive compared with many other costs associated with public transport provision. This hypothesis is supported by the review of financially effective measures on UK bus services (TAS Partnership 2002, figure 5.1). This review showed that information and signage measures were one of the most effective bus improvements in commercial bus services; on average covering more than 2.5 times costs.

Table 5.14 suggests that customer information at bus stops would be valued most highly and would achieve the highest patronage impacts if provided. Rail passengers tend to place higher values on information provided inside the vehicle. This is likely to be influenced by the current standard of information provided for each mode (and the differences between the quality (and importance) of information provided at stops/stations and inside vehicles).

The UK survey of effective bus improvements (TAS Partnership 2002, figure 5.1) also suggested introducing real-time passenger information (RTPI) would be of value (covering on average 1.6 times costs from the UK evidence). European meta study evidence (table 5.3) also suggested positive results, including short payback periods ranging from between four to six years for the specific studies where only these measures were introduced. What is interesting is that the costs of providing RTPI have fallen considerably since these studies because more systems are being introduced worldwide. This popularity also suggests very positive outcomes for RTPI-based measures.

Table 5.15 summarises the evidence of patronage impacts from introducing RTPI. This shows that:

- Bus stop based RTPI measures have generated patronage growth of between 0% and 10% with a median value of 5.8%. This value is double the highest impact suggested earlier in relation to static information.
- Non-stop based measures, mainly using the internet and mobile communications, have increased patronage by between 1% and 6% with an outlier of 64% for a scheme in Germany. These measures are not as effective at increasing patronage as bus stop based RTPI; however, the implementation costs tend to be lower.

The implications of the above analysis are that RTPI and general information provision are likely to represent good value for money from many perspectives and can be effective if carefully targeted and managed.

Table 5.15 Patronage growth evidence associated with real-time passenger information

Source reference	Location	System	Patronage growth
RTPI at bus stops			
(ABS (Australian Bureau of Statistics) 2005)	London, UK	Countdown	0
(Currie and Phung 2006)	London, UK	Countdown	+1.5%
(DETR/PTEG 2001)	Southampton, UK	'Stopwatch'– 1 corridor	+5%
(DETR/PTEG 2001)	Liverpool, UK	Timechecker	+2%–5%
(DOI 2006)	Brussels, Belgium	Phoebus	+6%
(Currie 2006b)	Bournemouth, UK	Super Route 17	+5.6%
(Taylor and D'Este 1996)	Helsinki, Finland		+10%
(Goeddel 2000)	Assumptions for advanced traveller info system impacts on patronage and revenue		+1%–3%
Non-stop based RTPI			
(Benson 2005)	Gothenburg, Sweden	SMS/WAP	+2%
(HORSCOTRS 2002)	Ipswich UK	Internet	+3.9% (est)
(Sayeg and Charles 2005)	Hesse Germany	WAP	Share of trips by public transport increased from 11%–18% in field sample (a growth of 64% in public transport usage)
(Dunphy 2004)	Yokohama Japan	Internet	+6% reported (but unclear if this was the only influence)
(Goeddel 2000)	Assumptions for advanced traveller info system impacts on patronage and revenue		+1%–3%

There is surprisingly little information on the effectiveness of marketing measures in creating value in public transport. This is partly because marketing efforts are often mixed in with information measures and hence impacts are confused, or are undertaken when new services are introduced and impacts are again confused, or are part of general day-to-day system management and impacts are difficult to distinguish from day-to-day changes in patronage caused by socio-economic impacts.

Table 5.16 shows a summary of selected evidence collated on marketing measures in Australasian studies where evidence was available. This suggests that general marketing campaigns can result in patronage impacts of 6% to 7%; however, it is unclear how long these impact last. This is a major concern about overall cost effectiveness. A high local impact for the Perth Travelsmart program is noted (17% growth). This is an individualised marketing programme which involved 'coaching' users in how to change travel habits. Although programmes such as these are considered expensive to provide, they can have high patronage impacts. However, questions remain as to the long-term sustainability of the patronage growth levels.

Table 5.16 Australasian major bus marketing improvements and market impacts

Project	Corridor patronage growth	Scale of impacts	Mode shift impacts
South Perth Travel Smart 1997 (Western Australia)	17%	Local area	PT mode share increased from 6.0% to 7.1%
Met Bus Information and Marketing Campaign (Victoria)	6%	Network	
Melbourne Tram and Info Marketing Campaign 1997 (Victoria)	7%	Network	

5.3.8 Amenities, 'soft variable' and stop/station measures

A range of amenity and 'soft variable' related issues have already been considered in relation to vehicle, information, security and marketing measures. 'Soft' variables concern service improvements relating to service quality aspects such as cleanliness, security, amenities and comfort. A number of studies of this type have been undertaken, normally involving stated preference surveys (eg Steer Davies and Gleave 1990; London Transport 1997) to estimate the values that bus users might place on these factors. Outputs from some such studies have been drawn together in table 5.17, where the effects of improvements to bus vehicle factors have been expressed in terms of their equivalent in-vehicle time savings.

This analysis suggests that bus improvements associated with 'soft' variables are not likely to increase patronage by more than a few percent. The evidence presented suggests air conditioning, CCTV and a smoother ride are the highest patronage impact improvements; however, these together are likely to increase patronage by only around 3% or 4%. A critical issue in estimating demand impacts is how far existing amenities meet needs; demand impacts identified in table 5.17 are only relevant if amenities were not provided at all prior to improvement.

Table 5.17 suggests that for buses, amenities with the largest effects would be air conditioning, CCTV (for security) and ride quality. Cleanliness (notably windows and litter), and driver attitude are not as significant as the above in terms of patronage impacts but are more important than most of the other measures identified. Step design and seating layouts do not seem to have much relative value.

Table 5.17 Soft factors improvements for buses – value and estimate of patronage impact

'Soft' bus improvement		Valuation (in vehicle min equivalent)	Notes	Patronage impact[(a)]
Boarding	No step	0.1	Difference between 2 and no steps	0.17[(b)]
	No pass show	0.1	Two stream boarding, no show pass vs single file past driver	0.17
Driver	Attitude	0.4	Very polite helpful cheerful well presented vs businesslike and not very helpful	0.68
	Ride	0.6	Very smooth compared to jerky	1.02
Cleanliness	Litter	0.4	No litter compared to lots of litter	0.68
	Windows	0.3	Clean windows, no etchings compared with dirty windows and etchings	0.51
	Graffiti	0.2	No graffiti compared with a significant amount of graffiti	0.34
	Exterior	0.1	Completely very clean compared with some very dirty areas	0.17
	Interior	0.3		0.51
Facilities	Clock	0.1	Clearly visible digital clock with correct time vs no clock	0.17
	CCTV	0.7	CCTV, recorded, visible to driver plus driver panic alarm compared to no CCTV	1.19
Information	External	0.2	Large route number and destination sign front, side and rear plus line diagram on side vs small signs	0.34
	Interior	0.2	Easy to read route no. and diagram compared to none	0.34
	Info of next stop	0.2	Electronic next stop sign and announcements vs no information	0.34
Seating	Type/layout	0.1	Individual shaped seats with headrests all facing forward vs basic double bench some backwards	0.17
	Tip-up	0.1	Tip-up seats in standing/wheelchair area compared with all standing area in central aisle	0.17
Comfort	Legroom	0.2	Space for small luggage vs restricted legroom and no space for small luggage	0.34
	Ventilation	0.1	Push-open windows giving more ventilation vs slide-opening windows	0.17
		1.0	Air conditioning	1.70

Source: Based on Australian Transport Council (2006).

[(a)] Assumes a 20-minute bus journey with 5-minute access/egress walk, 5-minute wait, A$1.50 fare and a value of time of $A10.00/hr (2006). This makes a weighted generalised cost of 59 minutes. Forecasts are made by applying a generalised cost elasticity of -1.0 to the change each soft factor has on this base generalised time. These assumptions are based on Vincent (2000); Australian Transport Council (2006).

[(b)] The 0.17% impact of a 'no-step' bus is small compared with estimates of the impact of low-floor vehicles (Balcombe et al (2004) = 5%; and TAS Partnership (2002) = 3% to 9%). We conclude that this is a 'low' estimate or that it concerns only the implementation of a step and not the provision of an entirely new low-floor vehicle.

Table 5.18 shows a similar analysis of soft factors in relation to rail service amenity issues.

Table 5.18 Passenger valuation of rail soft factor amenities

Context	Attribute	Valuation – in-vehicle minute equivalent
Off vehicle	Station environment	0.2–0.5
	Station access	0.1–0.2
	Station facilities	0.1–0.4
	Platform features	0.1–0.4
	Customer information and ticketing	0.1–0.4
	Station staff and security	0.2–0.7
On vehicle	Train environment	0.3–1.5
	Train facilities	0.4–1.5
	Customer information	0.3–1.1
	Train staff and security	1.6–2.0

Note: Negative values reflect attributes such as a dirty bus and poor ventilation

Source: Vincent (2000).

The highest valuations and hence patronage impacts are related to provision of staff (for security). Clearly this is also a higher cost measure. On-vehicle facilities and the general quality of the on-train environment are also major features valued by passengers. Off-vehicle station staff generate significant 'benefit' for passengers as does the quality of the station environment.

Some limited research has been undertaken in New Zealand on the relative cost and patronage impacts of amenities, notably roadside infrastructure for bus services.

Bus shelters can sometimes be provided at no cost in association with advertising companies or can cost between NZ$2300 and NZ$6782 per shelter. The patronage gains of improved bus shelters are estimated to provide 2% to 6% gain in patronage. This equates to a cost of NZ$1130 to NZ$1150 per % gain. Bus shelters have a relatively low patronage impact compared with other service-related interventions. The ongoing maintenance costs especially of glass shelters have become problematic in Auckland and elsewhere with metal mesh now replacing glass due to vandalism. The number of bus shelters provided needs to align with demand and careful analysis of use should be completed prior to providing the shelters. Demand for shelter is often focused on the inbound passenger on commuter routes. Wider spacing between stops becomes more appropriate as frequency increases. Tradeoffs between walk time and wait time allow for high-frequency routes to have faster running times with wider spaces between stops.

6 Long-range measure impacts

This section presents a review of evidence from studies of the impacts of long-range public transport improvement measures.

Although this report focuses on short-range measures it is worth briefly considering how value for money may be viewed for long-range projects. Surprisingly little evidence is available. This may be due to the difficulty monitoring large projects over long periods of time (without bias) as numerous wider factors can influence patronage, revenues and costs. This section provides a brief review of what is known about relative value for major public transport projects.

6.1 Before/after experience

Table 6.1 presents a review of the impacts of major long-run public transport improvement projects on value in terms of market effects.

Table 6.1 Major public transport improvements – patronage impacts

Long-range improvement	Proportion of market by previous mode used							
	Car driver	Car psngr	Did not travel	Walk/ cycle	Other	New market	Existing market	Overall
Australia								
North-east busway, Adelaide	13	6	9	-	4	33	67	100
	40	*17*	*27*	-	*15*	*100*		
Perth northern suburbs railway	23	1	10	-	1	35	65	100
	66	*3*	*29*	-	*3*	*100*		
Bundoora Melb tram extension	16		11	5	-	32	68	100
	49		*36*	*15*	-	*100*		
UK heavy/light rail schemes								
Birmingham cross city rail	11		26	-	-	37	63	100
	30		*70*	-	-	*100*		
Merseyside link/loop rail	20		24	-	-	44	56	100
	45		*55*	-	-	*100*		
West Yorkshire new rail stations	16		13	-	2	31	69	100
	52		*42*	-	*16*	*100*		
Manchester Metrolink	14		15	-	-	29	71	100
	48		*52*	-	-	*100*		
Glasgow cross-city rail	15		15	-	-	30	70	100
	50		*50*	-	-	*100*		
London Underground	20		19	-	-	39	61	100
	51		*49*	-	-	*100*		

Long-range improvement	Proportion of market by previous mode used							
	Car driver	Car psngr	Did not travel	Walk/ cycle	Other	New market	Existing market	Overall
European light rail								
Grenoble light rail transit	5	4	3	-	12	88	100	
	42	*33*	*25*	-	*100*			
Nantes light rail transit	10	16	-	7	33	67	100	
	30	*48*	-	*21*	*100*			
Nieweigein light rail transit	8	15	-	-	23	77	100	
	35	*65*	-	-	*100*			
US rail								
San Diego Trolley	30	-	-	4	44	56	100	
	68	-	-	*9*	*100*			

Source: Australian Transport Council (2006)

This indicates that:

- even for large projects, the majority of users of improved public transport projects are existing users
- new users to public transport represent between 12% and 44% of patronage of improved services
- the share of new riders who previously drove a car tends to be between 40% and 66%.

Table 6.2 shows some evidence from busway projects in Australasia including consideration of scheme costs.

Table 6.2 Busways and transitways costs and patronage impacts

Project	Cost	Date	Elasticity or patronage impact	Sources
Adelaide O-bahn	A$98M	1989	50% growth on corridor	Adelaide Metro, Currie & Wallis 2008
Ottawa Transitway	C$440M	1996	PT carries 75% of all peak trips to downtown area	Currie 2006b
Brisbane, SE Busway	A$400M	2001	60%–70% core routes 7% non-core routes	Currie & Wallis 2008
Northern Busway, Auckland	NZ$300M	2005	Northern express route + 85% 2008 North Shore region + 4.8% 2007; + 4.5% 2008	ARTA annual reports
Liverpool-Parramatta Transitway, Sydney	A$346M Projected 2.8M annual boardings	2003	56% growth on corridor 2004 962,485 2005 1,547,718 +61% 2006 2,033,000 +31% 2007 2,297,000 +13% 2008 2,522,000 +11%	Currie & Wallis 2008, Auditor General report, STA annual reports
North-west Transitway, Sydney	A$524M	2007	Growth from 100,000 per month to 150,000 in first 4 months; 100% growth in first year	NSW Treasury report

Generally speaking the following can be summarised from the above table:

- Costs are typically between A$300M and A$500M and patronage growth ranges between 50% and 110% on the corridor, and 7% and 9% for regions.
- It costs A$4.5M to A$6M per % gain at a local corridor level.
- It costs between A$42M and $55M per % gain at a regional level.

6.2 Mode amenity valuation

Research has also established the relative value of public transport modes to passengers using ‘willingness to pay’ research methods. These establish the specific facets of public transport modes which users find attractive after considering the relative service level differences between modes. Table 6.3 presents a summary of this evidence including some estimates of the relative patronage differences this might make if new services were introduced.

Table 6.3 Recommended mode-specific values[1] and market impacts – long-run mode conversion from on-street bus

Mode	Right of way	Mode-specific factor (mins)[(a)]	Notes	Market effect compared with on-street bus[(b)]
Bus	On-street	0	Reference case	0%
	Busway	-4	Better quality of stop, in vehicle reliability and bus quality	+6.8%
	Guided busway	-5	Slightly better ride quality than busways otherwise same quality as busway	+8.5%
Tram/light rail	Tram on street	-3	Same in-vehicle ride quality as busway but stops not as high quality	+5.1%
	Light rail – segregated right of way	-5	Station quality and in vehicle ride quality similar to busway	+8.5%
Heavy rail	Old DMU/EMU vehicles	-3	Older station facilities and vehicles. Ride quality similar to tram	+5.1%
	Refurbished DMU/EMU	-6	Improved station facilities and in-vehicle experience	+10.2%
	New modern DMU/EMU	-8	Best quality station and in-vehicle experience	+13.6%

Source: Australian Transport Council (2006).

(a) Assumes a 20-minute average in-vehicle time journey

(b) Assumes effect of converting an on-street bus to the other modes identified with exactly the same service frequency, walk access/egress, service frequency etc. Forecast is based on the generalised cost elasticity and example given in table 6.2 above.

This analysis suggests that all other things being equal, light rail in a segregated right of way should represent an overall 8.5% higher patronage impact compared with on-street bus. New modern EMU/DMU can increase patronage relatively by 13.6%.

While these values are high, and revenue might be expected to increase by similar amounts, the relative cost differences between modes is also considerable.

6.3 Long-term land-use and value improvements

Long-term public transport improvements must also consider how public transport might be expected to affect land-use and travel patterns. Many improvement schemes are now integrated into urban development plans and improvements such as light rail are specifically targeted at new development sites (Steer Davis and Gleave 2005). Transit-oriented development is a specific planning approach which targets the development of higher density and car-free development near public transport stops (Dittmar and Ohland 2004). These schemes can have a fundamental impact on value in terms of reduced environmental emissions, increased liveability and increased patronage for public transport (Vuchic 1999).

Interestingly there are few evaluations which have considered the long-term impacts of transit-oriented development on patronage and value in terms of fare-box revenue. Research does suggest that the value of developments designed as ‘transit-oriented’ can create wider benefits in terms of patronage.

In Hong Kong and some other parts of south-east Asia, the value capture of development around public transport nodes is a key funding stream for railway operators. The Hong Kong railway (MTR) annual report shows that 60% of revenue comes from commercial leases and residential land sales (MTR 2011). This highlights that access to development rights around public transport routes can provide significant financial benefit to operators (greater than the cost recovery from fares).

7 Evidence of wider value impacts

This chapter presents a review of evidence from studies examining the wider benefits resulting from public transport enhancements. Three major areas are examined:

- congestion relief impacts
- social relief impacts
- environmental value.

7.1 Congestion relief value and effectiveness

As noted in chapter 2, a common rationale for subsidising public transport systems is the positive effect they have on congestion at peak times.

Table 7.1 shows some of values used in the NZTA's (2010) *Economic evaluation manual* related to increasing patronage on public transport services which demonstrate the scale of this value.

Table 7.1 Average benefits from additional passengers ($/additional passenger boarding – 2008)

Urban area	Mode	Average trip length (km)	Road traffic reduction benefits (NZ$)		Public transport user benefits (NZ$)	
			Peak	Off-peak	Peak	Off-peak
Auckland	All	7.70	12.61	0.86	8.59	5.73
	Rail	16.50	17.27	1.65	13.18	8.78
	Bus/ferry	6.60	11.73	0.76	8.02	5.35
Wellington	All	12.14	13.25	1.25	10.90	7.27
	Rail	22.76	17.70	1.99	16.44	10.96
	Bus/ferry	6.97	11.97	0.89	8.21	5.48
Christchurch	All	8.05	2.71	1.24	8.78	5.85
Other	All	7.86	2.06	1.00	8.68	5.78

Source: NZTA (2010b)

This suggests that road traffic reduction benefits can be applied to improvement projects with a value per additional passenger generated by the project of between NZ$2.06 and NZ$17.70 in the peak period and $0.76 and 1.99 off-peak. The biggest value occurs for peak periods and larger cities notably for rail-based projects into busy city centres. Typically the value of these congestion relief-based measures for peak periods is higher than the user benefits resulting from these projects.

A number of studies have also estimated how much value public transport systems generate as a result of congestion relief:

- In Australia, an evaluation of Sydney's metropolitan railway suggested the railway relieved the city of congestion travel time delays amounting to A$740.5M (2007) per annum (Currie and Mesbah 2011).

- In the USA, the value of savings in congestion costs resulting from provision of urban public transport in 85 urban centres was estimated at US$18.2 billion (2005) per annum (Kittleson & Associates 2003).

Mode shift evidence presented in table 6.1 supports the view that larger public transport improvements reduce car use. Between 40% and 66% of new riders on major public transport projects used to drive a car.

Although public transport is considered to reduce congestion in cities, very little research has been undertaken to understand how public transport improvements might act to increase these effects. A rare exception is a research programme undertaken in Melbourne exploring links between congestion and public transport use (Yarra Trams 2010). This established a range of useful indications regarding the relative effectiveness of public transport in relation to traffic congestion:

- From evidence of public transport strikes, on average some 28.6% of public transport users drove a car as an alternative mode while 29.6% got a lift.
- Overall and accounting for differences between strikes and more on-going longer term concerns, the study estimates that on average 21.4% of public transport users would drive without public transport and 11% would get a lift.

Modelling of the effects of these trips on the Melbourne Road network established:

- When all public transport was removed:
  - more than 1000 links became congested
  - the length of Melbourne's congested roads increased by about 30%
  - vehicle kilometres travelled increased by 1.4 million while vehicle hours increased by about 100,000
  - total network delay increased by over 150%
  - average travel speeds fell from 41.64km/h to 35.20km/h (ie -15.5%)
  - actual travel time per km increased by about 18% from 1.44 to 1.70 minutes per km.
- When separate modes (rail, tram, or suburban bus) were removed:
  - when rail was removed the average road network speed dropped from 41.64km/h to 36.71km/h
  - rail, bus and tram contributed to decreasing congestion in 1014, 555 and 416 road links respectively (considering the effect of each public transport mode separately)
  - rail decreased the delay in the road network by about 66,000 vehicle hours while bus and tram each decreased delay about 20,000 vehicle hours
  - actual travel time (ATT) per km improved 13.9% due to the presence of rail. Similarly, bus and tram improved ATT by 7.1% and 6.9%
  - overall rail had the highest effect, bus had the second highest and tram had the least amount of effect in relieving traffic congestion.

In analysing the spatial distribution of congestion relief associated with public transport:

- Heavy rail manifested the greatest effects in relieving road traffic congestion across all the suburbs (inner, middle and outer) in terms of all measures of congestion.

- Bus had the second most significant role in relieving traffic congestion in middle and outer Melbourne. Its effect was similar to the removal of rail in outer Melbourne.
- Tram had a very small role in relieving congestion in the outer suburbs. But its effect was very strong in inner Melbourne. It manifested the second highest impact after rail in inner areas.
- The greatest percentage changes in vehicle hours and delay were observed in inner Melbourne (traditionally the most congested area of the city) due to the removal of any type of public transport mode. However, the increase in absolute vehicle hours and delay were substantially higher in middle and outer Melbourne due to significantly bigger spatial coverage of these areas in comparison with inner Melbourne.
- A separate analysis of congestion relief related to the CBD only bound trips established that these contributed to about 40% of the congestion relief provided by all public transport. Considering the greater CBD (an area including the CBD and adjacent inner Melbourne suburbs), the contribution of public transport rose to about 53%. The implication of this is that buses contribute to a significant share of congestion relief and this is focused on the middle and outer suburbs.

So what does the above suggest about achieving value for money with public transport improvements in relation to congestion relief?

1 Congestion relief requires a focus on peak services where costs are high. This means improvements related to congestion relief will be relatively expensive to implement (unless increased costs are offset by efficiency improvements such as those made possible using road priority).

2 Reducing road usage with increased public transport has higher benefits in peak periods.

3 Higher capacity mass transit systems which compete well with peak car travel (eg segregated rights of way and high frequency) will have higher impacts on congestion relief.

4 While congestion is focused on the CBD and inner areas, public transport can also be effective at relieving congestion in suburban lower density contexts.

7.2 Environmental value-for-money effectiveness

A wide range of research suggests that public transport improvements can be effective at reducing the environmental effects of noise and pollutant emissions compared with private car use. NZTA (2010a) recognises this by valuing:

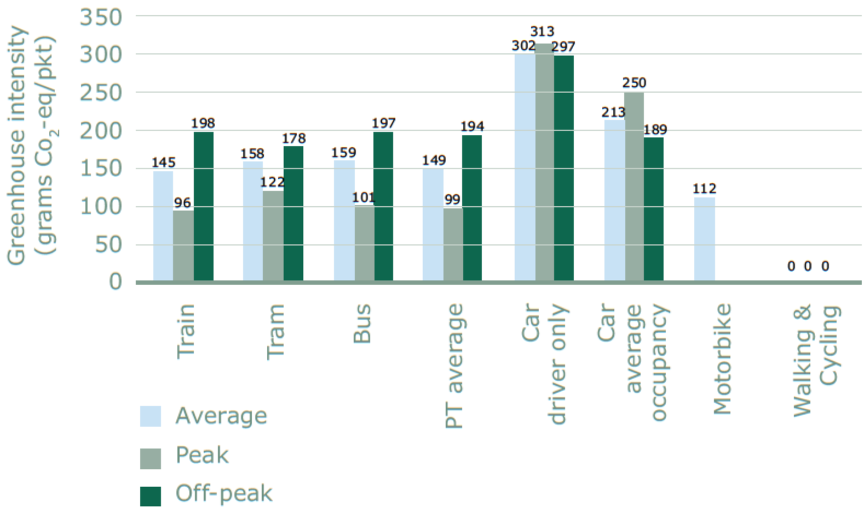
- air pollution reduction benefits at NZ$40 per year per person exposed to μg change in pollution
- greenhouse gas emissions at 4% of vehicle operating costs or $40/tonne CO_2
- the reduced noise impact at NZ$410/dB change/household pa.

There is relatively little research exploring the effectiveness of different public transport improvements in providing environmental benefits. However, NZTA (2010a; 2010b) provides a guide for determining environmental benefits, based on reducing private vehicle use.

A study of the relative impacts of public transport on greenhouse gas emissions in Melbourne (City of Melbourne 2011) established that:

- While public transport is generally believed to be a 'good thing' for the environment, it does have its own environmental impacts, including the emission of greenhouse gases.
- However, in the absence of public transport, many more journeys would be taken by private car which has higher general emissions per trip than all public transport modes (figure 7.1).

Figure 7.1 Relative greenhouse gas emissions per passenger kilometre



Source: City of Melbourne (2011).

Furthermore:

- On average, public transport emits 149 grams of CO_{2e} per person kilometre compared with 213 grams for private cars. That is, on average, public transport emits 30% fewer emissions than cars per person kilometre.
- In peak times the difference is much greater – 99 grams as opposed to 250 grams. This reflects higher public transport occupancy, low car occupancy rates and more road congestion. In peak times, public transport emits 60% fewer emissions overall than cars per person kilometre.
- Given a specific number of public transport services to be operated, emissions per person kilometre can be reduced to under 100 grams (even in off-peak times) if they are fully loaded.
- In general, rail-based modes are considered to be more efficient at catering for travel in an environmentally sustainable manner compared with both cars and diesel-fuelled buses. However, in Victoria trains and trams are powered by electricity that is generated primarily through the combustion of brown coal, the most emission-intensive method of electricity generation in Australia. This implies that the nature of the electricity source is critical to the relative environmental efficiency of public transport modes.

Overall the above findings suggest that:

- Public transport improvements can provide substantial value for money in environmental value terms by reducing car usage and their relatively inefficient emission profile (on a per passenger and passenger km basis).

- In general, public transport improvements in peak periods are more effective because single car occupancy is common in peak periods and is very inefficient from an environmental perspective.
- Public transport improvements on electricity-based systems (EMU rail, light rail or trolley buses) should generally be more effective at reducing emissions on a per passenger kilometre basis than diesel-based services (buses and DMUs). However, much depends on the environmental impacts of the energy sources used to generate electricity.
- In addition, the loading performance of public transport is critical to its effectiveness on an environmental value performance perspective. Empty buses and trains generate emissions for no purpose. Highly utilised services are very efficient from an environmental perspective because the emissions they generate are shared amongst many users.

7.3 Social value-for-money effectiveness

It is widely recognised that public transport systems have an important role in providing a social safety net for passengers who otherwise would not have mobility options. However, there is very little research available on how to enhance social 'value' through public transport improvements.

Section 5.3.4 quoted a range of evidence from the UK that more accessible bus services in the UK substantially increased patronage of people who would otherwise be unable to travel. This included a high number of elderly people and those with disabilities. From this perspective, measures that make public transport accessible to all increase social value.

Another common barrier to access to public transport is fares which are considered too high for low income groups and those without income, eg young people (Currie 2007). Concessionary fare schemes which reduce the level of fares to selected user groups who have difficulty affording them would therefore appear to enhance social value.

As noted in section 2.2, providing public transport for all members of society implies wide coverage of routes in lower density rural and suburban contexts to provide a minimum service and social safety net. These services are not well patronised and have low cost recovery levels. In these contexts 'social value' is hard to justify in the face of clear financial deficits. Social value appears very 'intangible' against the hard facts of financial losses.

A recent study in Australia has estimated the social value of trips that would have not been made if public transport were not available (Stanley et al 2011). The average social value of a trip has been valued at A$20/trip. This value increases with lower income and reduces for higher income due to variation in trip rates by income. The implication is that if public transport enables an additional trip which a person who cannot currently make, the social value will be on average A$20. This value was used to benchmark the likely value of unmet trips in the state of Victoria, Australia. The total value of unmet social trips suppressed due to lack of transport alternatives in Victoria was estimated at A$2.4B per annum (Fu and Xu 2001).

Given the social distribution of trips in Australasian cities it is likely that public transport services based on social value will be focused on remote urban fringe communities. More recent research has also suggested that older people are particularly vulnerable to social exclusion when travel is limited (Delbosc and Currie 2010). This would suggest targeting public transport improvements in areas with an ageing population would add most value from this perspective.

8 A synthesis of value-for-money effectiveness

This chapter summarises evidence on the relative effectiveness of public transport improvements drawing on the findings from the research.

8.1 General value-for-money effectiveness

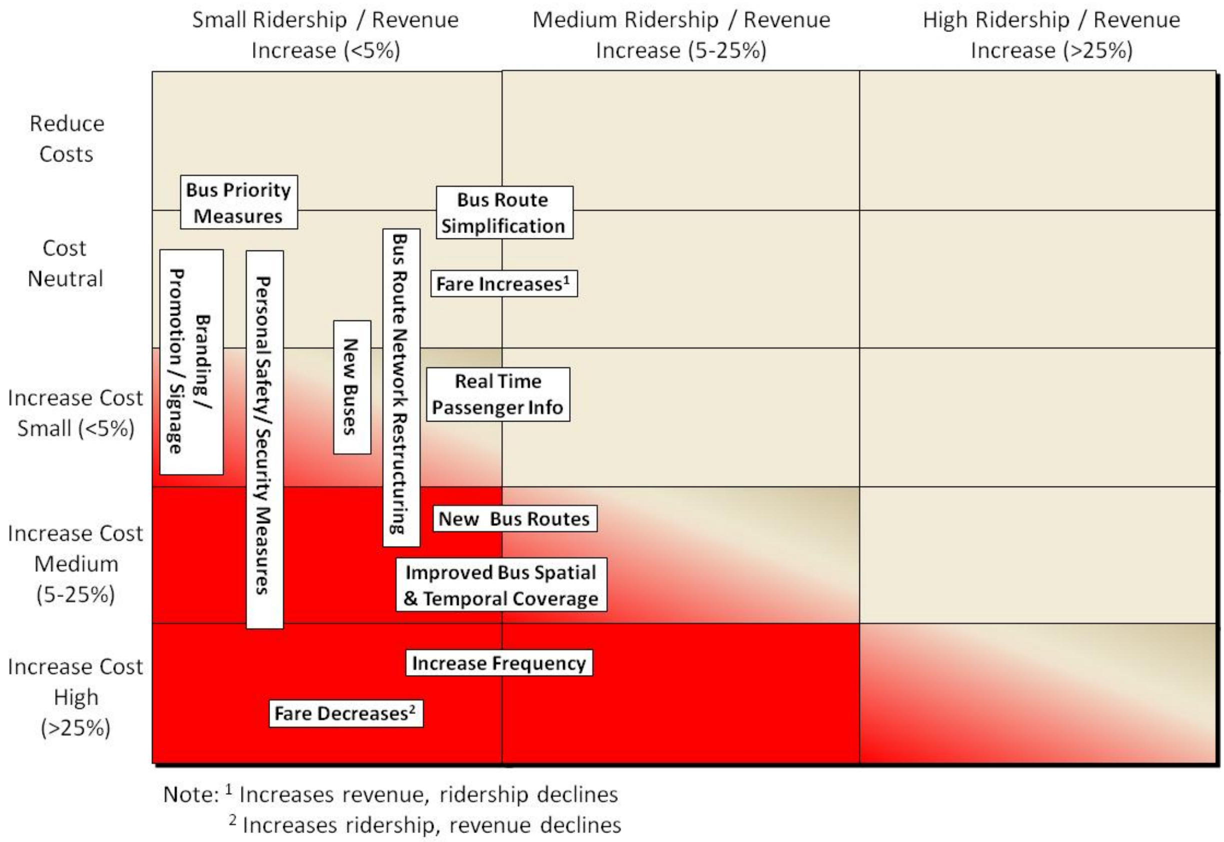
Figure 8.1 gives a synthesis of the evidence presented in chapter 5 regarding the relative effectiveness of short-term public transport improvement measures relating to patronage and revenue growth and the impacts on overall costs. The shading indicates the relative cost effectiveness from the most valuable (top right) to least valuable (bottom left). A number of assumptions are made to complete this analysis:

- It is relevant to prevailing New Zealand conditions.
- It assumes improvement measures are well designed.
- It concerns only the impact of the measures identified exclusive of packaging effects and all other things being equal.

This analysis suggests that:

- The improvements most likely to be of value are: fare increases, information provision, bus priority measures, bus route simplification. However, for each there is a range of possible outcomes for costs and revenues. Much depends on the individual project design and context.
- Several measures are illustrated as being on the edge of profitability but much depends on how they are implemented in practice. These include:
  - bus network restructuring (which can be implemented to save or increase costs)
  - new buses (which can involve small cost changes from planned bus replacement programmes and hence not cost significantly more than originally envisaged)
  - personal safety and security measures (again with a wide range of design options; those involving the presence of staff are effective for passengers but costly)
  - real-time information measures
  - branding, promotion and signage measures.
- New services including new routes, extended service hours and spatial coverage plus increased frequency are considered to be higher cost items with medium impacts.
- Increased frequency and reduced fares are identified as measures with medium-to-high patronage and revenue impacts but with high costs. Hence they are likely to be financially high net cost items requiring subsidy.
- None of the measures in figure 8.1 have high patronage/revenue impacts for short-term measures (other things being equal). Arguably increased frequency and new routes/networks might achieve patronage gains above 25% but this would be at high net cost making such measures less realistic under present economic conditions.

Figure 8.1 Relative patronage and revenue cost effectiveness of short-term public transport improvement measures



Much of the analysis in figure 8.1 depends on the conditions and context in which improvements are undertaken. For example in a growing market influenced by social economic (or exogenous) factors, patronage growth might expect to be higher while in a declining market it could be lower.

Table 8.1 presents a summary of conditions where the value-for-money aspects of public transport improvements might be enhanced. This suggests that:

- Off-peak and CBD-focused measures may be more effective from a patronage and revenue perspective.
- CBDs can be effective locations for targeting effective improvements since they represent areas where most patronage is focused and benefits can be spread further. They are quite small areas spatially and hence require comparatively smaller operating resources than suburban areas. The high-density nature of CBD activity tends to result in traffic congestion which means CBD-focused improvements will deliver greater value for money.
- From a congestion relief perspective on value, peak periods and CBD bottlenecks should be targeted. Road space reallocation measures also advantage public transport while disbenefiting cars (a double and reinforcing effect). As noted above, public transport priority measures may provide operational benefits and savings that cover their cost.
- From an environmental perspective on value, the peak period is an important target because of the increased number of single occupancy vehicles.

- Social perspectives on value target reduced fares. Equity in service distribution and youth and aged markets are also important.

As can be seen from the analysis in table 8.1, perceived value varies according to the objective and there can be conflict between different perspectives. In selecting public transport improvements much depends on how social, environmental and patronage objectives are valued relative to the cost of the improvements.

Table 8.1 also notes that prevailing socio-economic conditions influence effectiveness. This tends to affect value for all perspectives (congestion relief, environmental and social) but some socio-economic conditions can act to increase the importance of some perspectives, such as a social perspective, when fuel prices increase.

Table 8.1 General conditions where value-for-money public transport enhancements might be improved

Circumstances increasing value	Notes
General patronage and revenue value	
Off-peak periods	• Lower costs of increasing service • Higher elasticity of demand, ie demand/revenue increases relatively larger than the peak
City centres	• Impacts on more riders and hence tends to generate bigger demand effects • CBDs are generally smaller spatially than suburban regions, hence costs of improvements can be relatively lower • Car access to CBDs is poor and parking costs high; a good competitive market for public transport to do well in
Promising socio-economic conditions: • growth/population growth areas • increasing fuel prices	• Increases future patronage potential and can be promising financially (as long as capacity does not have to be increased substantially) • Car competitiveness decreases making public transport more competitive – note this can increase costs of operations, eg increasing diesel costs
Congestion relief value	
Peak periods/areas	• Target changes to roads which are congested; usually during commuter peaks
City centres	• Main congested areas – public transport improvements in CBDs target peak commuting by car
Conversion of roadspace/ time to public transport	• Converting traffic lanes to bus lanes and transferring green time at signals to public transport is both a ‘carrot’ and ‘stick’ approach; it is justified for the efficiency improvements which can occur for total travel and can have commercial benefits for road freight
Environment relief value	
Peak periods/areas	• Target single occupancy cars and times where mass transit achieves highest environmental efficiency due to high loadings
Target reducing (peak) car use)	• As above
Do not encourage walk/bike mode shift to public transport	• Bike/walk more environmentally efficient than public transport. Encouraging bike/walk trips is not positive from this view
Rail vs bus-based measures	• Rail/electric powered public transport is notionally more environmentally effective than diesel bus.

Circumstances increasing value	Notes
Social value	
Low fare	• Concessions improve social value of projects
Wide spatial and temporal coverage	• Good social outcomes usually at higher cost
Targeting young/older passengers	• These groups tend to have larger unmet needs which public transport can cater for

8.2 Sequencing and synergy

Sequencing interventions and packaging supportive improvements together enable efficiency gains and improve effectiveness. When making infrastructure improvements it is especially important to consider project staging and sequencing of maintenance or renewal projects and other infrastructure upgrades. Utility upgrades may align with roading upgrades and allow some cost sharing between interested parties. It is not unusual to see brand new roads dug up for electricity, telecommunications, water or other utilities upgrades which is a poor overall use of community resources.

There is a strong link between integrated fares and service measures and major public transport improvements associated with line haul and rail-based modes. Network designs that rely on transfers require a user-friendly transferrable ticket at a reasonable price. Bus services linked to rail services perform best without an extra fare for the transfer.

Increasing the frequency and capacity of rail services can be negated by track speed restrictions and signal failures. Likewise with rail infrastructure if double tracking had been completed when the rail network was first laid in Auckland it would have cost much less than retrofitting additional tracks today. This may mean installing high-quality base infrastructure and larger stations, platforms and bus interchanges than is needed at first. This would result in a short-term over-supply of infrastructure but would allow for some future growth. A successful example of this is the introduction of the European Train Control System (ETCS level 1) in Auckland. This signalling system has a clearly defined suite of upgrades available and upgrading to level 2 in the future will add significant capacity benefits. While it may incur the capital costs of radio block control centres, it will decrease the need for signal maintenance due to the abolishment of wayside signals. The introduction of ETCS L1 in Auckland means that signalling can be progressively upgraded and it is unlikely there will need to be a full replacement for many years. Frequency has also been increased on the busway after it was completed because the infrastructure was able to support higher frequency and capacity demands. Similar rationales have been used to justify building BRT infrastructure, such as busways, to enable easier future upgrade to rail if needed. The Brisbane busway network, for example, has included investment in bridges and tunnels which are suitable for use by light rail vehicles if needed in the future (Currie and Delbosc 2010).

Interventions can be linked such as new bus stops and shelters with new routes or service upgrades. Launching new routes with new branded buses, revised fare structures and marketing campaigns is an effective way of achieving greater impact. The non-tangible aspects of bus design and route branding have significant image benefits for bus services and are not easily measurable in a traditional cost–benefit analysis. New buses increase patronage a small amount relative to other interventions but new buses are essential parts of the maintenance of the fleet quality. CCTV at park and ride facilities does not increase patronage by much but if theft from and of vehicles becomes a problem it can undermine the investment. Graffiti removal is another example of a relatively high cost relative to the patronage benefit. An efficiency based approach does not address issues like landscaping, gardens, public art and other important aesthetic aspects.

Highly visible upgrades of infrastructure can enable a successful re-launch of services using the infrastructure. Even if service levels are not increased new customers can be attracted by marketing the service alongside the opening of a new bus interchange, ferry wharf, or train station. CBD car parking charge increases will generate more public transport patronage growth if bus frequencies are improved at the same time. If a marketing programme was targeted at people switching then even more synergy would apply.

Policies that price single car use in different ways (distortion correction) and improve speed and frequency will increase the reliability and quality of public transport as they combine ‘carrot’ and ‘stick’ aspects of behaviour change. An extreme example of this concerns public transport based service expansion during the Sydney Olympic Games. Event organisers banned car access from sites (and specific lanes of arterial roads) to ensure a substantial upgrade to the public transport network (rail and bus) and reliable services could be provided.

Parking measures combined with non-public transport based travel demand management measures can also be important. Avoidance of the congestion charge in London is done so by walking, cycling (up 43%), public transport (buses up 45%), sharing a ride, not travelling at all (overall reduction in traffic -21%). The scheme has largely funded improvements to buses and hence might be seen as valuable from this perspective.

A focus on bus quality or frequency alone has tended to be less effective without addressing the low cost of car use to consumers. People who think using their car is better value for money than using public transport will continue to choose the former option. If parking and use of motorways are unpriced then the public has a distorted view of their costs which influences their travel decisions.

9 Conclusions

This report reviews the value for money of urban public transport enhancements where 'effectiveness' in revenue and cost terms is emphasised (although other perspectives on value are also considered).

The research concerned conventional urban public transport systems; however, the central focus was on bus-based measures, and on incremental service improvements rather than large infrastructure projects. Consideration was given briefly to other conventional public transport modes and larger projects.

The central approach adopted in the research was a review of the research literature and published evidence from public transport practice.

Value is commonly seen in public transport systems from a patronage and revenue growth viewpoint with cost effectiveness referring to the profitability of services relative to fare-box revenue. This can be seen as a limited view since most New Zealand (and world) public transport services require subsidy. In these systems value is seen to result from congestion relief, environmental benefits and social support from public transport. The government's goal is to grow patronage for public transport services, while reducing reliance on public subsidies.

A wide range of improvements to public transport have been considered and evidence of their performance examined. The improvements most likely to be financially effective are:

- increased development (and densities) around public transport nodes
- information provision
- bus priority measures
- bus route (and network) simplification
- fare increases (which increase revenue but decrease patronage).

Several improvement measures are thought to be 'on the edge' of profitability including bus route and network restructuring (where the focus is on reducing costs and refocusing resources on more patronage and revenue effective routes and services), new buses, personal safety and security measures (low-cost measures), real-time passenger information measures and branding, promotion and signage measures.

New services including new routes, extended service hours and spatial coverage plus increased frequency are considered to be higher cost items with medium impacts. Increased frequency and reduced fares are identified as measures with medium-to-high patronage and revenue impacts but with high costs. Hence, these are likely to be financially high net cost items requiring subsidy.

Increasing development and land-use density around transport nodes has a double win for operators who are given land development powers (the case in most of south-east Asia). The land development (sales and rental income) often provides greater revenue to the railway than revenue from fares.

Table 9.1 Other impacts of the most financially effective improvements

Improvement	Environmental	Social	Economic
Increased development around public transport nodes	Reduced vehicle emissions Changes to the public realm	Improved access to services Improved housing affordability in areas with good access Improved public safety and security	Congestion relief Agglomeration economies Reduced public spend on other services, health, emergency and basic infrastructure
Information provision	Reduced need for paper timetables	Changes in equity of access to information	Can speed up changes in behaviour (bringing forward impacts resulting from patronage changes)
Bus priority measures	Impact on public realm Can impact on natural environment Reduced emissions Reduced fleet requirements	Improved perceptions of value across wider market segments Increase social inclusion	Reduce congestion Provide competition in markets that are car dependent
Bus route (and network) simplification	Reduces impact of routes on external environment	Less confusing routes are easier for all people to understand and use	Reduces overhead costs
Fare increases	Increase vehicle emissions	Reduce equity of access	Affect a range of economic factors such as cost of living, distribution of wealth, transport efficiency and productivity.

None of the measures identified have high patronage/revenue impacts for short-term measures (other things being equal). Arguably increased frequency and new routes/networks might achieve patronage gains but this would be at a high net cost making such measures less realistic under present economic conditions.

A range of conditions can add much value to public transport improvements. Off-peak and CBD-focused measures may be more effective from a patronage and revenue perspective. CBDs can be effective locations for targeting improvements since they represent areas with the highest patronage hence benefits can be spread further. Conversely they are quite small areas spatially and hence require comparatively smaller operating resources than suburban contexts.

From a congestion relief perspective, the peak period and CBD bottlenecks are effective targets. From an environmental perspective the peak period is important notably for the increase in single occupancy cars. Social perspectives on value target reduced fares, equity in service distribution and youth and aged markets.

In terms of future research in this field there is clearly a need to extend the analysis basis of the effectiveness of public transport improvements notably longer-term measures. Post-implementation reviews of major infrastructure projects rarely consider the impact on public transport despite the considerable public investment in these schemes. Mandating reviews of major projects by independent authorities would act to address this gap in knowledge.

Despite the clear value identified in congestion and environmental relief measures and social support associated with public transport enhancements, there is clearly little research on their effectiveness.

There is also little information on commercial viability and the fare-box revenue returns on improvements. Commercial concerns often act as a barrier to this, although it possible to generalise data on services to protect commercial concerns regarding specific routes and services.

10 Recommendations

While there is a need to collate a better evidence base of existing improvements there is also a need to recognise that the types of improvement made are changing and that socio-economic and changes influence how the public responds to improvements. A good example is found in the advances in communications technology. Public transport users can now access a full suite of timetables from their phone (even access real-time information) and providers have relatively low costs in making this available. These are constant innovations in many spheres that can affect public transport. For example improvements to mobile communications have made service information (even real time information) much more accessible to potential customers. Planners and researchers should monitor these improvements to continually adapt to changing market needs.

10.1 Recommended further research

Funding of a project to regularly collate transport data (operational and passenger) and make the information generally available would be of much value to the public transport sector and to the public.

It is recommended that the public transport sector undertake

- further work to examine the use of different appraisal techniques (such as cost–benefit analysis and multi-criteria analysis) which allow transport providers to quantify a range of financial and non-financial benefits and rank schemes and enhancements based on various decision criteria
- research into structured appraisal techniques to illustrate how benefits accrued by specific market segments can be identified and acknowledged
- research into the impact of marketing on patronage and subsidies, including additional research relating to perception gaps in various market and stakeholder segments to identify the extent to which these gaps negatively influence levels of passenger demand
- research into the impact of simplifying fare structures and service levels on patronage and subsidies.

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