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Liesel Henn

George Karpouzis

Keith Sloan

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A review of policy and economic instruments for peak demand management in commuter rail

Liesel Henn[1], George Karpouzis[2], Prof. Keith Sloan[1]

[1]School of Commerce and Management, Southern Cross University, Lismore NSW

[2] Economic & Financial Analysis Unit, Corporate Finance, RailCorp, 18 Lee Street, Chippendale, NSW

Email for correspondence: keith.sloan@scu.edu.au

Abstract

Urban rail systems in the larger Australian capital cities have considerable demand variability, with peak demand, mainly associated with daily commutes in many cases straining system capacity and adversely impacting on service levels and traveller satisfaction. Infrastructure responses and capacity improvements are expensive and require significant procurement lead times. System planners and managers dealing with all major transport modes have long recognised demand management as an effective tool to deliver greater efficiencies in the operation of transport infrastructure and reduce the need to invest in expensive infrastructure solutions.

Literature dealing with policy and economic instruments to manage peak demand for rail and other relevant industries provides guidance for identifying best practices for possible consideration in commuter rail.

In the area of transit, peak demand management constitutes the utilisation of a number of instruments with the objective of influencing travellers to vary their travel patterns in order to achieve more efficient utilisation of system resources and return a higher level of travel utility (satisfaction) to the transit system users. Instruments include social /institutional communication campaigns, quality of service, fares and/or system access fees, parking availability and pricing at transport terminals, as well as feeder services.

Keywords: Demand management, demand modelling, demand elasticity, peak smoothing, peak period, crowding, mass transit capacity

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1. Introduction

Overcrowding of rail services in major cities has become a worldwide problem. Currie (2009) suggests that finding solutions to these issues has become a major challenge for authorities, as new trains commonly cost up to $Aus 20-30 million purchase and up to five years to procure, while the cost of building new track lines can run into Billions of dollars and over a decade to implement. Cheaper and shorter term solutions are required,

[1] Economic & Financial Analysis Unit and Market Development & Research Division

prompting an investigation into the full range of demand management approaches. These solutions can buy time while other important long term initiatives may be put in place, including land use and population policy, as well as alternative modes of providing access.

This paper reviews literature relevant to demand management policies and practices in commuter rail and other relevant industries. The review documents evidence on both qualitative and quantitative ways of managing demand and gives guidance on the empirical impact of urban rail demand drivers, including price, flexible work/business/shopping/school hours, other transport mode interfaces, urban settlement and development structure and social and cultural influences. This review is being used to inform a larger work program under the CRC for Rail Innovation Project R1.107 and focuses on the identification of peak smoothing instruments and best practices to be considered in a subsequent phase of the project. A further objective of the project is the development of a pilot peak smoothing model for Sydney urban rail to better inform demand management policy development.

The following topics are covered: The concept of demand management in select industries that experience peak issues, the economic instruments and strategies employed, as well as peak smoothing case studies and econometric models to support such analyses.

This review drew on published scholarly and industry literature, government and transport organisation reports and studies, internal reports accessed through Rail CRC industry partners together with structured consultation with rail industry experts.

2. Demand management definition and objectives

Demand management is a concept that appears to be highly relevant in a number of public utilities where capacity is constrained and/or restricted by excessive infrastructure cost with long term implementation horizons, including transit, water and electricity services.

New South Wales Treasury (2004 p.3) defines demand management for public sector entities as follows: *"The active intervention in the market to influence the demand for services and the assets generated and/or used in supplying these services to best match available resources to real needs and ensuring the services provided are delivered with the best value for money."*

Gellings (1996 p.285) provides the following widely accepted definition for electricity demand side management (DSM): *"DSM activities are those which involve actions on the demand side of the meter, either directly caused or indirectly stimulated by the utility. Demand-Side Management is the planning and implementation of those utility activities designed to influence customer use of electricity in ways that produce desired changes in the utility's load shape, i.e. in the time pattern and the magnitude of a utility's load."*

The aim of electricity demand side management is described as peak load management through a combination of peak clipping (e.g. direct load control), valley filling (load management that increases off-peak usage for instance via thermal storage units), load shifting (from peak to off-peak or peak shoulder) and strategic conservation (e.g. building energy conservation) measures (Cheng 2005).

Demand management in other industries reviewed appear to have similar aspirations. Often a wider set of socio-economic goals are set for demand management. Demand management in the provision of water for developing countries is defined as follows: *"Implementation of a strategy by a water institution to influence the water demand and usage of water in order to meet any of the following objectives: economic efficiency, social development, social equity, environmental protection, sustainability of water supply and services, and political acceptability."* (Butler & Ali Memon 2006 p.184)

Cervero (1998 p.63) offers the following definition of demand management for transit:
"Transportation demand management ... aims to make more efficient use of transportation resources already in place by shifting demand ... or eliminating trips altogether."

Nelson Nygaard Consulting Associates performed an in depth assessment of demand management for the Bay Area Rapid Transit Authority (BART) in San Francisco and identified the overall goal as follows: *"... (to) optimize the supply of BART Service with ridership to make BART more cost-effective, while delivering high quality services to its customers."* (BART 2008 p.1-5)

This study identified the following methods for meeting this goal:

- Eliminating or postponing costly capacity upgrades to address peak-of-the-peak ridership spikes
- Managing peak hour ridership (e.g. shifting from peak to peak shoulder)
- Encouraging off-peak travel and travel to regional sub-centres
- Providing revenues to address capital needs

The UK Department for Transport (2005) identified that reducing peak demand could be brought about by four means, being:

- Trip suppression
- Mode switch
- Trip redistribution (to less congested lines/ stations)
- Time of day switch

The importance of increasing reverse commutes during the peak period, a problem particularly associated with monocentric cities with radial network designs is also highlighted (BART 2008).

3. Demand management instruments in relevant industries

This section provides an overview of demand management instruments which may warrant further investigation in addressing Australian cities' rail commute peak issue. Instruments were identified from a range of industries which typically experience peak issues and are subject to similar infrastructure constraints, including water, electricity and roads. In drawing conclusions it needs to be recognised that rail transit is a more 'perishable' commodity than either water or electricity sectors (it has to be consumed when it is offered, and can't be stored for later use). Nevertheless these sectors give us a good indication of peak demand management instruments that might be considered for rail.

3.1 Introduction

In a report to the TRL[2], Balcombe *et al* (2004) identifies a number of factors which influence transit demand, including fares, quality of service and personal safety. The paper also warns of other important factors to consider, including the different perceptions of public transport over time as generations change.

Whilst the majority of demand management related literature for transit focuses on the shifting of road traffic to public transport, a study that focused on the topic of smoothing peak demand within transit was commissioned by the BART Authority in San Francisco (2008). They identified two categories of demand management strategies:

- **Pricing strategies,** including peak fare pricing, station-specific surcharges, fare pass programmes, market rate parking pricing and peak parking pricing
- **Support strategies,** including feeder transit, bicycle access, pedestrian access, car sharing, land use/transit oriented development, promotion of bus transit as an alternative, improved wayfinding[3] and passenger flow enhancement mechanisms

[2] Transport Research Laboratory
[3] Provision of better information to passengers, including crowding levels

3.2 Instrument categories

Whilst recognising that the presence of peak congestion itself is probably the most effective albeit passive peak smoothing instrument, this study focused on reviewing demand management instruments which are actively pursued by industries experiencing crowding to alleviate peak pressures. NSW Treasury (2004) identifies six ways to actively manage demand of public services. This framework has been adopted below:

3.2.1 Reducing the underlying need for the service (voluntary)

Why do passengers opt for travelling at peak hour, despite the discomfort associated with crowded train and station conditions? This category focuses on understanding and impacting the underlying social and institutional drivers for peak demand.

The Australian Competition and Regulation Working Group (CRWG 2006) in investigating road demand management suggests that such measures are not only aimed at congestion reduction, but also more broadly at changing people's travel choices and/or travel patterns to achieve social, environmental and economic outcomes. The majority of these measures are voluntary in nature. Cervero (1998), however, found that while voluntary programmes may be more effective for water demand management, such initiatives were often found to fail for road traffic demand management, as they provide no direct control mechanism, and suggests that market based strategies work better.

Instruments to be considered for reducing peak rail demand falling into this category include the use of campaigns to improve office hour flexibility coupled with the promotion of alternative communication mechanisms, e.g. telecommuting and internet access (BART 2008). It would also include an analysis of the role of school and day care hours in peak travel behaviour and devising strategies to alleviate peak pressures, such as staggered starting times for schools and investigating the role of concessionary travel during the peak (NSW Business Chamber 2010). Given findings that voluntary programmes may not always be highly effective, the use of incentives to support such programmes may be considered, such as private sector incentives for office hour flexibility (NSW Business Chamber 2010). Land use policy and transit oriented development to shift travel patterns and ease peak congestion are also included in this category (BART 2008). Such policies are important instruments for managing peak demand, as it ensures greater use is made of counter-peak capacity and reduces commuting distances by encouraging a polycentric city form with greater urban consolidation.

3.2.2 Changing the way in which community needs will be met

A review of how other transport mode interfaces and feeder transit can be employed to strengthen rail peak management mechanisms falls into this category. This includes understanding the role of active transport (walking and cycling) as well as feeder transport timetables in reducing demand for peak travel. The CRWG (2006 p. 6) emphasises the importance of interaction with public transport modes to combat road congestion: *"The complex interactions of different elements of the urban transport network, and the impact on transport of land use and other factors which are the responsibility of different governments, mean more multi-faceted and integrated management responses are needed. Increased cooperation between levels of government would achieve better congestion management outcomes…"*

3.2.3 Educating customers to limit peak consumption (move travel to less congested times)

This category consists of measures to educate customers and use transparency of peak fares and crowding levels to aid in shifting demand for passengers that do have a degree of flexibility in their choice of travel time (from peak to peak shoulder or off-peak).

Butler and Memon (2006) identified public awareness and educational campaigns as a key demand side measure for public water supply. Apolinário *et al* (2007) also describes various educational methods to improve energy efficiency and thereby reduce demand, including drives to use more efficient lights and electric equipment in households, the service sector and industry. For roads, awareness was found to have a noticeable impact on consumer behaviour with the Transit Cooperative Research Program (TCRP 2008) highlighting the importance of communication and education in devising effective demand management strategies.

3.2.4 Financial and pricing mechanisms

Financial and pricing mechanisms remain an important demand management tool in all of the industries researched: Butler and Memon (2006) mentions pricing as an important demand side measure for water, Borenstein (2009) discussed the use of pricing measures for electricity and the use of peak pricing is also common amongst urban rail operators and road agencies. Balcombe *et al* (2004) lists a range of financial measures for road traffic demand management, including employer subsidies (often utilised to encourage public transport), congestion charging (e.g. route- or zone-based schemes) and parking policy (e.g. limiting the number of available spaces, increasing the price paid for parking and changing the mix of short and long term parking spaces available). The introduction of a variable road toll on the Sydney Harbour Bridge is a local example of road congestion charging.

Talluri and Van Ryzin (2004) found that dynamic pricing is one of the most preferred methods to address peak travel issues and increase capacity utilisation. Singapore is an example of a transit system that utilises dynamic pricing enabled by technology: Passengers board and alight buses or trains with the use of contactless cash cards, charging the full fare for a journey when a passenger boards a vehicle, whilst the balance from the exact fare is refunded to the card once the passenger alights (Lam & Toan 2006). Borenstein (2009) also expands on the employment of time–of–use (peak) pricing for electricity, whereby predetermined systematic price variances are based on variable time of day costs to manage peak electricity demand, including Georgia Power which introduced real time pricing in 1991.

Despite the availability of technology enabling dynamic pricing, including electronic payment options, transit organisations often continue to favour simplified fare structures. It was found in the US that the percentage of agencies using fare differentials has actually declined in recent years, as several agencies have reduced the complexity of their fare structures e.g. by eliminating or reducing the number of zones (TCRP 2003).

The CRWG (2006 p.12) found that pricing measures appear the most effective for addressing road traffic congestion, especially when delivered as part of a total policy package of complementary measures*: "They can provide a 'carrot' to encourage travel in less congested times of day or less congested modes, and a 'stick' for those travelling when the costs of travel, including congestion costs, are highest. Price-based measures also have the advantage of 'locking in' gains from non-price congestion management measures because they can reduce the 'induced demand' effect. However, development of substantial price-based schemes would require long lead times and a major investment of effort in gaining community acceptance."*

In an examination of the range of urban congestion management measures, it was also concluded that pricing measures (road and parking) appear to be the most effective congestion management tool (Council of Australian Governments 2006). Empirical studies of a congestion toll based on peak time of day (Burris & Pendyala 2002) found that it was more effective for participants meeting the following criteria:

- Flexibility in their time of travel, including flexible work hours where they were working
- Significantly less likely to be on a commute trip

- More likely to be older and retired
- Less likely to belong to the highest household income category

Measured against a range of criteria (including the ability to diffuse the peak, off-peak increase, productivity improvements, public acceptance, effectiveness, capital cost and operating costs) Nelson Nygaard (BART 2008) similarly concluded that the strategies with the best potential for diffusing peak travel were peak fare pricing and station specific surcharges, supported by the provision or enhancement of alternative modes.

Litman (2004) concluded from various demand elasticity analyses that transit fares, parking pricing and service quality (service speed, comfort and coverage) appear to have the greatest impact on transit ridership. These concepts are further explored in Hale and Charles (2009a, b).

Litman (2004) found that the major constraint on successful time of day fare changes was a lack of employees' flexitime privileges (especially where peak period boundaries were established too wide) and that discretionary riders (e.g. people who have the option of using a car) tend to be more price sensitive than transit dependent riders (including people with low incomes, non-drivers, people with disabilities, school and college students and elderly people).

Whilst setting prices according to full social cost for the user of a service or product is most consistent with economic theory, such policies may not be politically acceptable. In the US road agencies often place the onus on employees via regulations (including measures to eliminate any biases that favour peak travel e.g. employers to financially compensate employees who do not make use of office parking or inflexible working hours) as it is more politically palatable to target large corporations than voters. Possible other solutions include:

- Addressing the burden of higher peak fares on low-income users through targeted supplementary measures, e.g. vouchers and concessionary programmes
- Balancing peak surcharging with off-peak or peak shoulder discounts (or free fare programmes), could also counter some of the negative sentiments

Three pricing mechanisms emerge for further consideration in managing urban rail peak demand:

a. Fare pricing

The magnitude of peak fare increases need careful consideration, as the market segment involved (peak hour urban commuters in larger cities, with commutes covering large distances and where base fare levels are relatively low) appear to be the least price sensitive (Litman 2007, Balcombe 2004). Therefore if peak fare increases are considered, changes need to be significant enough or starting from a sufficient base level to be effective in shifting peak. Research by Whelan and Johnson (2004) concluded that more substantial fare differentials between peak and off-peak are required to affect overcrowding, suggesting a combined strategy of increased peak fares and reduced off-peak fares.

The risk associated with peak surcharges which may result in the shifting of peak commuters to private vehicles, however, needs to be considered. This could be counterproductive within the broader agenda (road congestion, pollution and reduced fare box revenues associated with overall trip suppression). The impact of existing fare structures on the effectiveness of new peak pricing instruments also needs to be considered, including discounted tickets for regular travellers[4] and concessionary tickets.

b. Employer incentives and disincentives

Employer incentives and disincentives could be utilised to shift peak demand e.g. tax

[4] Despite off-peak discounts, for many travellers peak fares are on average lower than off-peak fares because of the high levels of discount for regular travellers

incentives for employers participating in a flexi time drive combined with travel passes outside the peak window.

c. Station parking pricing and/ or availability restrictions

Lack of sufficient parking at stations later in the morning often assists in peak smoothing to the early morning peak shoulder. The introduction of peak fares at rail stations and/ or restrictions to ensure availability of parking, especially during the late morning peak shoulder, could be explored as mechanisms for further peak smoothing.

3.2.5 Revising service delivery levels

While there is evidence that quality of service may be more effective in managing demand than fare pricing (Savage 2002, Cervero 1990, Webster & Bly 1980), this category needs to be dealt with selectively for diffusing peak demand, given the requirement for acceptable levels of service and safety aspects.

Transit service levels are determined by a range of service quality factors, including availability, convenience, speed and comfort (TCRP 1999, Department of Transportation 2001).

3.2.6 Imposing restrictions and legal penalties

Examples of the last set of measures identified in industries reviewed include regulations mandating improvements in air quality, restraints on automotive use, and regulation of automobile performance for reducing road traffic congestion (Cervero 1998). Restrictions in public water supply include intermittent water supply (Butler and Memon 2006) and load shedding of electricity (Cheng 2005). In the urban rail industry, under crush peak conditions, it is also not unusual to resort to the closing of platforms or platform access e.g. London underground. These measures are usually reserved for circumstances where crowding may present a safety problem.

3.3 Lessons learnt

The following key lessons learnt from industries with experience in peak demand management emerged from the literature review:

3.3.1 A combination of instruments is required for maximum impact

The CRWG (2006) found that there is no single solution that is able to address the range of factors contributing to urban road congestion. Rather an integrated approach of complementary measures tailored to the particular circumstances of each urban area offers the best prospect of managing congestion. This is consistent with findings by Butler and Memon (2006) that public water supply demand management instruments are interdependent and mutually reinforcing.

3.3.2 Targeted measures are much more effective

The CRWG (2006) suggests that price-based measures with the primary purpose of reducing congestion when and where it occurs have most impact. The less measures discriminate on the basis of time and location of travel, as well as user groups (e.g., private car users, public transport users, and freight operators), the less effective they are from a congestion management perspective. This is consistent with observations by Cervero (1990) that geographically targeted free fare programmes (e.g. limited to downtowns) have been more successful than system wide free fare programmes.

Butler and Memon (2006) mention the need for market segmentation and understanding of market characteristics which drive demand for effective public water demand management. This is similar to findings by Borenstein (2009) for electricity peak demand management, who highlights that as real-time peak pricing requires expensive pricing and metering schemes, its use is often restricted to large commercial and industrial customers for maximum impact.

3.3.3 The need for an integrated policy framework

Cheng (2005) mentions the need for an integrated policy framework of design, cooperation and consensus building among different government and private institutions for successful electricity demand-side management. For rail, this would imply the need for cooperation with other feeder and competing transport mechanisms (including buses, ferries, etc.)

3.3.4 The need for customisation

Butler and Memon (2006) highlight that optimal application of peak demand measures for water requires recognition of the prevailing conditions. The CRWG (2006) suggests that the variety of circumstances in cities experiencing road congestion is so broad that it is not always possible to transpose experience from one jurisdiction to another; therefore the selection process involves a degree of qualitative assessment and professional judgement.

The implication for urban rail from the above lessons learnt is the need for customisation of responses to the context: Instruments that are highly effective in one situation, may completely fail in another. As peak and off-peak travel patterns are often undertaken by different market segments and for different trip purposes (e.g. commutes during peak, leisure during off-peak), different demand instruments are required to diffuse peak travel (e.g. shifting to peak shoulders) versus growing off-peak travel and reverse commutes. Similarly, morning and afternoon peak behaviour is very different and need individual consideration, while measures which may work in one rail network design, may not be effective in another (e.g. grid network design vs. hub-and-spoke or radial design).

3.3.5 Other lessons

Cheng (2005) lists a number of key criteria for successful electricity demand-side management, including:

- A shift away from traditional logics and systems to a new framework and way of thinking
- The need to involve end-users in policy formulation, as sustained behavioural changes are often required

Finally, the CRWG (2006) warns that demand management often does not replace the need for infrastructure responses, but frequently ‘buys time’ to embark on costly infrastructure responses.

4. Appraisal of instruments for urban rail

Table 1 summarises the findings from consultation of a range of knowledgeable Australian urban rail individuals (Appendix A) on the peak smoothing potential of the instruments identified above[5].

[5] Shifting demand from peak spike periods (also referred to as the peak-of-the–peak, e.g. peak hour) into peak shoulder timeslots

Table 1: Summary appraisal of peak demand instruments for urban rail

Category	Instruments	Effective -ness[6]	Cost[7]	Desira-bility[8]	Expert comments
Reducing underlying need for the service	1.Social & institutional peak drivers[9]	Low - medium	Low	High	Due to voluntary nature and passengers' lack of flexibility, traditionally not very successful. If combined with financial incentives for employers, may be more effective. Rail operator has little control.
	2.Land use, transit oriented development	Low[10]	Range	Medium	Important strategy, but longer term spatial impact, not necessarily temporal (peak). Rail operator has little control.
Changing way needs are met	3.Other transport mode interfaces[11]	Medium	Medium - high	High	Integration of public transport is important and desirable, as is integration of pedestrian and cycling access. However, not perceived as an important driver of rail peak demand changes, rather an aspect to be streamlined and optimised to cater for changes (growth) in rail patronage.
Pricing mecha-nisms	4.Increase peak fares	Low	Low - neutral	Low	Easy to implement, but politically unpopular. Increase needs to be significant enough to be effective, but need to control to avoid mode shift to car. Need to ensure all market segments are considered within the context of social inclusiveness.
	5.Reduce shoulder fares	Medium	Low - neutral	High	Mixed success in Australian cities, in view of low fare sensitivity (elasticity). Less objectionable than instrument 4 (i.e. carrot vs. stick).
	6.Station-specific surcharges[12]	Low	Low - neutral	Low	Impact more spatial than temporal. May work in a network design where there are viable alternative stations with excess capacity within walking distance to "shift" passengers to, but not in radial network design.
	7.Employer incentives & disincentives[13]	Low - medium	Medium - high	Medium	In conjunction with no.1 could be effective in shifting to more flexible office hour culture. Need to consider different flexibility by employment sectors, e.g. high income, white collar employees in CBD typically have a degree of office hour flexibility; while lower end positions in the service industry have little flexibility in view of time-critical nature of sector.
	8.Station parking pricing / availability	Low - medium	Low - medium	Medium	Relatively easy to implement, but impact questionable in terms of number of peak passengers shifted. May lead to customer dissatisfaction, if operator cannot guarantee parking at late peak shoulder. Instrument may also counter early morning peak spreading

[6] Defined as potential for shifting demand out of peak-of-peak into shoulder peak periods.
[7] Defined as financial expenses, not full economic cost (e.g. lost revenue/ avoided capital expenses).
[8] Defined in terms of external considerations by passengers and public perception.
[9] Including office hour flexibility campaigns
[10] In short – to medium term, focus of peak smoothing
[11] Including optimising bus/ ferry feeder timetables
[12] Where congestion high
[13] For flexible office hours

Category	Instruments	Effective -ness[6]	Cost[7]	Desira-bility[8]	Expert comments
					effect that is currently observed at crowded stations.
Improve service delivery levels during shoulder periods[14]	9. Express vs. "all stops" services	Medium	High	Medium	Has potential, need careful consideration of impact on scheduling and loading. Creative options could be investigated e.g. reducing stops and alternating between consecutive services.
	10.Service frequency	Medium - high	High	High	Has potential, need careful consideration of impact on scheduling and loading. Increases capacity of rail.
	11.Standing vs. sitting carriages	Low - medium	Low - medium	Medium	Given the appropriate network set-up, internal configuration of rolling stock should always be considered, noting different requirements for short (more appropriate) vs. long haul (less appropriate). Need to consider impact on platform dwell times and knock-on effect on service frequency. Whilst there is potential to alleviate peak crowding, instrument falls outside realm of peak trip retiming into optimising capacity. When moving into this field, many other tools to consider[15].
	12.Passenger flow enhancement mechanisms - platform congestion[16]	Low - medium	Range	High	Need to be considered within context of dwell minimisation strategy, incl. rolling stock configuration, station layout. As it may involve considerable cost, it should be investigated on a case-by-case basis where station crowding is a significant issue. Would improve network performance. Low to high cost, depending on mechanism selected. Whilst there is potential to alleviate peak crowding, instrument falls outside realm of peak trip retiming into optimising capacity. When moving into this field, many other tools to consider.
Education	13. Transpa-rency in peak fares & crowding levels	Medium - high	Low	High	Strong potential to shift behaviour, making people aware of park & ride options and crowding conditions. Information needs to be available in advance and must be very specific to the individual passenger. Better crowding information on a regular and readily accessible basis alone could be very effective, favourable results achieved at Sydney Olympic games via communicating expected crowding levels. Could be highly effective in conjunction with other instruments, incl. no. 1, 5, 9, and 10. Cost is also low.
Other	14. Rationing	High	Low	Low	Should be reserved for crush crowding conditions, posing safety concern. Politically unacceptable as day-to-day peak smoothing instrument.
	15.Queuing	Low	Low	Low	Low effectiveness for peak smoothing and politically unacceptable as day-to-day peak smoothing instrument.

[14] The three service aspects discussed here were identified through consultation with the rail experts listed in Appendix A.
[15] Other important capacity optimising instruments outside the scope of this study are the reliable (on time) running of services as a means of minimising/spreading peak crowding, as well as the potential scope for fine-tuning timetables within the peak period, to better balance supply with demand.
[16] Example: Mezzanine waiting areas & platform stewards

5. Peak smoothing case studies and models

5.1 Introduction

Peak smoothing is here understood to imply travel time displacement (shifting) to alleviate in-vehicle peak congestion. This section reviews peak smoothing case studies from London, Sydney (the SmartSaver trial in 2008) and Melbourne (the early bird initiative in 2008 – offering free travel before 7 am).

In addition, peak smoothing econometric models were uncovered for London and Melbourne. Both models were based on stated preference surveys. Stated preference (SP) methods refer to a family of techniques which use individual respondent's statements about their preferences in a set of transport options to estimate utility functions (Kroes *et al,* 1988). SP methods are used in choice experiments, in which an individual chooses among hypothetical choice sets, enabling estimation of a discrete-choice model and hence direct prediction of probability (at individual level), or market share (aggregate level) (Sanko 2001).

These models are ideally structured for policy analysis based on specific trip retiming time intervals during the peak period[17, 18]. This allows for the estimation of a combination of service and fare elasticities on an intra-time basis as passengers shift from the peak-of-peak to peak shoulder periods. Whilst both models are considered pilots, they do present an attractive option for further consideration in comparable analysis in other Australian cities, allowing for further substantiation of model integrity.

5.2 Key findings

The following key findings emerged from a review of the three case studies, and were found to be consistent with the lessons learnt from other industries dealing with peak issues discussed above.

5.2.1 There is potential for peak smoothing

Peak smoothing does not necessarily require a large reduction in peak loading, often all that may be required to "buy-time" for capacity improvements is an interim reduction of peak loading between 10 to 20 per cent.

London research conducted by Consolidated (Passenger Focus 2006) concluded that four out of ten people could be persuaded to travel outside of the morning peak time period. The same research also found that although passengers' force of habit is strong, and some passengers will never change their behaviour, evidence suggests that it can be overcome and that even passengers with entrenched viewpoints could be persuaded to consider alternative travel timings by exposing them to different ideas and prompting consideration of their routine. Work and educational commitments were cited as the major constraint for trip retiming; however, it was the importance of leisure time which was critical to persuade them to change their travel times. Passengers also felt that education of employers in terms of allowing flexitime to be worked was important.

While user surveys conducted in London by Faber Maunsell (DfT[19] *et al* 2007) indicates that over half of passengers have a degree of flexibility in their travel time, their focus group research concludes that the only way to reduce peak travel was to get more employers to accommodate flexible hours.

Sydney's SmartSaver trial tickets entitled customers[20] on weekdays to a 50 percent fare discount and was valid for trains scheduled to arrive at Central between 4 am – 7:15 am or

[17] Melbourne am peak definition: Peak-of-peak: 7:45 am – 9 am (arrival at CBD); Shoulder: 15, 30 minutes of either side
[18] London am peak definition: Defined as arrival in Central London of 7 am – 9 am.
[19] Department for Transport, UK
[20] Travelling on Western, Carlingford and Richmond Lines

between 9:15 am and 10:15 am, departing from Central anytime before 4 pm and after 6:30 pm. Research by TNS on the trial identified that there is a viable degree of flexibility in some travellers, with 21 per cent of customers surveyed indicating that they would ideally like to travel into the city earlier than current patterns, and 34 per cent saying that they would like to leave the city earlier if they could (Railcorp 2008). They concluded that while most customers will not shift their travel out of the peak period, SmartSaver has had an impact and given a few key adjustments within the control of the rail operator, there was scope for a much greater impact in terms of shifting travellers out of the peak.

In Melbourne, Nature estimated that if the ticket price for high peak travel increased by 20 per cent, 13 per cent of high peak travellers would stop travelling in high peak (displacement or cross time demand elasticity of -0.65) (Metlink 2009). These are encouraging findings and point to the potential for peak smoothing through the application of peak fares within the Australian rail context. Whilst the numeric value of displacement elasticities for Melbourne as reported by Nature appear high, they cannot be reasonably compared to measures of other types of demand elasticity such as cross-modal or direct fare elasticities often reported in the urban rail literature. The importance of distinguishing between these concepts is also emphasised by Nature, who highlights that displacement or cross time demand elasticity will typically be higher than other types of demand elasticity.

Combining fare differentiation with service aspects (e.g. introducing additional express services during the peak shoulder periods), significantly improves the peak smoothing results (refer sect. 5.2.5).

5.2.2 Significant fare differentiation is required

Research by Consolidated in London found that reduction of fares was the instrument most cited by passengers for motivating trip retiming (56 per cent of interviewees) and that discounts in excess of 25 per cent would be required to make it worthwhile (Passenger Focus 2006). The importance of rewarding “good behaviour” with discounts rather than penalties for bad behaviour was also highlighted in this study.

Faber Maunsell (DfT *et al* 2007) surveyed passengers’ trade-offs between fares, crowding levels and arrival time during the peak period[21], allowing for the estimation of passengers’ valuations[22] of trip-retiming. They found that passengers are willing and able to trade-off time of travel to avoid overcrowded conditions and also concluded that significant fare reductions (the basis of their model) would be required to encourage peak smoothing (trip retiming) as follows:

- Penalty cost of travelling 60 minutes earlier is £2.40
- Bonus for travelling 30 minutes earlier £1.80
- Penalty cost of travelling 30 minutes later is £3.90
- Penalty cost of travelling 60 minutes later is £12.00

One interpretation of the above is that it would require a peak surcharge of £2.40 to shift people to travel an hour earlier, or £3.90 to travel 30 minutes later. Faber Maunsell comment that their models consistently showed a preference for travelling 30 minutes earlier than currently. Surveys indicated that the main reasons were as follows:

- No available train that would get them in for their preferred time (30 per cent)
- To avoid overcrowding (13 per cent)
- Missed train/late leaving home/delayed on route (12 per cent)
- Train delayed/cancelled (8 per cent)

[21] Defined as arrival in Central London of 7 am – 9am.
[22] In laymen’s terms, an indication of financial compensation required to make up for crowding conditions during peak periods, as well as trip-retiming out of the peak-of-the-peak into shoulder peaks

- To get on direct/quicker train (7 per cent)

In Sydney, TNS research indicated that consideration of taking up the SmartSaver off-peak fare discount trial increases from 45 per cent to 53 per cent if the off-peak discount were to be combined with increased peak prices (Railcorp 2008).

In an analysis of the Melbourne early bird initiative, Currie (2009) concludes that no equivalent measure could have achieved the results (albeit modest) in such a short time frame. The overall impact during the first year was a reduction in peak demand of between 1.2 per cent and 1.5 per cent, the equivalent of some 3 per cent of total peak trains or a maximum of 5 average peak train loads. Currie highlights the likely improvement of results over the medium to longer term, consistent with general fare elasticity trends, pointing to the effects outlined in 5.2.3 below.

5.2.3 Allow enough time for changes to take effect

Faber Maunsell (DfT *et al* 2007) warns that trip retiming should not be expected overnight, as passengers are more likely to respond to fare changes in the medium to long term after allowing for lifestyle changes to take effect.

In Sydney, TNS concluded that there was undoubtedly scope for longer-term change among significant numbers of peak–time travellers, given a package of measures and an opportunity to negotiate their working hours. Roughly one in two respondents indicated that they would consider taking up the SmartSaver offer if it was available beyond the trial period of about 10 weeks (Railcorp 2008). An online survey conducted following SmartSaver indicated that respondents felt that the trial should have been offered for longer as it was not enough time to change their travel behaviour (Railcorp 2008).

5.2.4 Target the critical peak period

London research concluded that shortening the peak period targeted with peak management instruments was seen as useful and that some passengers valued time more highly than money (Passenger Focus 2006). Faber Maunsell (DfT *et al* 2007) found that significant time penalties exist for changing time of travel and these heavily influence potential for peak smoothing. Their research showed that the proportion of travellers who could make time shifts in excess of 30 minutes, is nearly half that of those who could retime their peak trip by up to half an hour.

The SmartSaver trial in Sydney was abandoned due to poor results (2 per cent of customers had switched completely from peak for five days a week on SmartSaver). A key barrier to take up was identified to be the broad peak travel time exclusions of this trial, with 50 per cent of customers indicating that the removal of restrictions on return tickets would have encouraged take-up (Railcorp 2008), broadly consistent with RailCorp survey findings that a significant amount of customers rejected the offer based on the afternoon peak restriction (RailCorp 2008). The afternoon peak period often offers more scope for lifting peak travel restrictions, as the loading is typically less concentrated than in the morning peak.

In his assessment of the Melbourne early bird initiative, Currie (2009) suggests that the 7am cut-off for off-peak fare discounts resulted in a greater reduction in the non-critical 7–8 am time period, as opposed to the critical 8-9 am peak period. He suggests consideration of a more targeted approach, e.g. a 7:30 am cut-off. People also indicated in a Metlink study that they are likely to shift their travel time by a maximum of 30-45 minutes, not more (Metlink 2009). A half hour shift by a 10 to 20 per cent proportion of travellers would, however, often significantly alleviate peak-of-peak congestion, as the demand spike during that period is often concentrated within a period of about 30 minutes to an hour, with train passenger loading dropping off dramatically on either side.

5.2.5 Service differentiation is key

Improved frequency of service was mentioned as the second most important trip retiming instrument for London rail passengers (16 per cent of interviewees) (Passenger Focus 2006). A critical issue highlighted by this research was that passengers will not change journey times if service in the off-peak (or peak shoulder) period is unreliable.

In Sydney, TNS' research found that if discounted off-peak tickets were combined with improved peak service, the potential for peak smoothing is significantly enhanced (36 per cent of Sydney customers said that they would buy SmartSaver, up from 24 per cent for discounted off-peak fares only). Given the broad definition of peak travel time exclusions in the SmartSaver trial, service during the off-peak period qualifying for the SmartSaver discount was not always comparable with peak services, including less frequent and less express trains. When asked what would have encouraged take-up of the offer, 47 per cent of customers cited more express trains. When asked what the main disadvantages were that discouraged take-up of the trial, fewer trains (48 per cent of customers) and slower trains (42 per cent of customers) were amongst the top four reasons (Railcorp 2008).

Nature's peak model findings for Melbourne (Metlink 2009) also concluded that service differentials, especially the use of express trains, have significant potential to shift peak travel behaviour.

5.2.6 Don't make it difficult and inconvenient

Greater comfort was found to be a close third ranking trip retiming instrument for London rail passengers (14 per cent of interviewees). The majority of passengers also stressed that financial incentives should be administered via a flexible and clever delivery mechanism, e.g. Oyster card (Passenger Focus 2006).

TNS in their research on the Sydney SmartSaver trail (Railcorp 2008) found that the main problems with the offer related to Railcorp's operating infrastructure and the design of the ticketing arrangements, including having to queue for a ticket every morning. Many commuters found that it was not practical to use the offer as they already had long-term tickets and/or they were not being able to buy SmartSaver tickets online. Having to buy tickets every day was identified as the top ranking drawback by 70 per cent of customers interviewed, followed by return travel restrictions (52 per cent of customers). RailCorp's post trial survey also indicated the importance of convenient ticketing arrangements, with significant numbers of customers indicating that they did not take up the offer because they prefer to buy a longer term ticket (e.g. weekly), or because SmartSaver tickets weren't available from their station (Railcorp 2008).

In an analysis of the reasons for not using the Melbourne early bird offer, 20 per cent of passengers indicated access to tickets as an issue (including having to buy another ticket and some stations not selling the early bird ticket) (Gaymer 2008).

5.2.7 Other considerations

Other considerations resulting from the case studies reviewed are listed below:

- Passengers are more likely to travel earlier rather than later in the morning period, a function of the need to arrive at work by a certain time, whereas this trend is reversed in the afternoon peak (DfT *et al* 2007)
- Strong linkages exist between morning and afternoon peak travel, and a policy that would focus on morning peak demand management is also likely to address afternoon peak issues (DfT *et al* 2007)
- Since a trade-off exists between fares, crowding and trip retiming, as crowding conditions worsen the potential for influencing behaviour may well increase (DfT *et al* 2007)

- Availability of a seat is more important in the afternoon. The hypothesis is that long distance travellers are almost always guaranteed a seat in the morning, while they have to compete with the other passengers for a seat in the afternoon (Metlink 2009)
- Longer distance commuters have higher am peak time displacement penalties, reflective of the fact that they have less negative crowding impacts (normally get a seat), the length of their existing day, less frequent services and work/life balance issues (DfT *et al* 2007)
- Motivating passengers to "get out of bed" earlier was a significant barrier in London, particularly during the winter months and for passengers travelling longer distances (already travelling earlier) (Passenger Focus 2006)
- While Sydney studies found with the SmartSaver trial that those who switched to off–peak travel are more likely to be on lower incomes and working part-time (Railcorp 2008), London studies identified that high earners have greater flexibility of travel time, posing potential social equity issues for fare differentials (DfT *et al* 2007)
- Differential pricing can only work where sufficient seat capacity exists in the peak shoulder periods to accommodate those switching from the peak without creating immediate overcrowding problems, necessitating the need for judicious and achievable capacity increases combined with demand management tools (DfT *et al* 2007)
- As a large section of customers will never change their peak time travel patterns, operators should plan around the long-term needs of its customer base (Railcorp 2008)
- Security is a consideration but not top of mind (Passenger Focus 2006)

6. Conclusion

This study identified and appraised a range of demand management policies and instruments in urban rail and other industries which experience similar peak challenges. The concepts explored in this review and the key findings will inform a larger work program under CRC for Rail Innovation Project R1.107 to better inform demand management policy development.

Literature reviewed revealed that there are a number of consistent and transferrable peak smoothing lessons to be learnt from a range of industries grappling with the issue of peak demand, and was found to be useful in the following ways:

- Suggesting possible factors or instruments that could act as levers in shifting peak demand
- Highlighting the concepts and complexities involved in approaching demand management strategies
- Pointing out peak demand management lessons learnt in other industries facing similar challenges to avoid the proverbial "re-invention of the wheel"

Local rail expert consultations provided a further refinement of possible instruments identified in the literature, by testing concepts gleaned from other industries against the local rail environment and experiences. The following instruments appeared to have most potential for peak smoothing in Australian urban rail:

- Combining peak surcharges with reduced shoulder fares
- Differentiation of service aspects in the peak vs. shoulder peak period (express vs. all stops and frequency)
- Targeted office hour flexibility campaigns, combined with employer incentives and disincentives
- Better crowding information on a regular and readily accessible basis

The results of studies reviewed in sections 5 furthermore indicate significant potential to alleviate peak loading stresses through a combined application of peak fare differentiation and variations to service level provision in the shoulder period. In addition, peak smoothing case studies provide important guidance on the requirements for success of these policy measures, including:

- Targeting the critical peak period
- The importance of convenient ticketing arrangements
- Allowing sufficient time for policy measures to take effect

Confirmation of these results through further research and possible trials may provide rail operators with an effective and cost efficient way of ameliorating peak loading issues.

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Appendix A: Expert consultation

Table 2: Urban rail experts consulted

Name	Position/ Department	Organisation
Peter Martinovich	Executive Director Infrastructure Planning and Land Services	Public Transport Authority of WA
Prof Phil Charles	Professor of Transport Strategy and Director, Centre for Transport Strategy	University of Queensland
Prof Luis Ferreira	Professor, School of Urban Development	Queensland University of Technology
Kirby Francis	Principal Advisor	Queensland Rail
Phillip Stewart	Strategic Network Planner: Planning and Infrastructure Group	TRANSLink
Simon Gaymer	Manager: Market Intelligence	Department of Transport (Victoria)
Mark Williams	Senior Policy Advisor, Policy and Planning Division	TransAdelaide
Prof Graham Currie	Chair of Public Transport Institute of Transport Studies	Monash University
Balbir Bhall	General Manager: Market Development & Research	RailCorp
Tony Eid	General Manager: Operations & deputy chief operating officer	RailCorp
Michael Doggett	Manager demand analysis	RailCorp
Alexander Andreopoulos	Manager fares & ticketing	RailCorp
Stephen Scott	General Manager: Timetable Development & Program	RailCorp