I very much support the Transport Minister's recent statements advocating "subscription" plans, which is what underpins the approach to pricing I describe at: *http://davidthorp.net/transport-plan/pricing*.

The general proposition is to replicate the well-established pricing models of other utilities (such as electricity, water and phone networks, which like transport, have similar pricing & cost-recovery difficulties due to their high fixed costs)
- that is, with "pricing plans" that include a periodic (e.g. monthly), fixed "network access fee" (or "subscription payment"), plus further marginal charges for specific higher-cost consumption - particularly at peak times (when extra capacity is very expensive).

Different pricing plans can be offered with varying levels of access & marginal charges to suit different types of customers (different "market segments"). For example, frequent users may prefer a higher access charge with lower marginal off-peak charges. The attached documents, "*Opal pricing reform*" and "*Rail pricing market segments*" describe how this approach could be applied to public transport. One important aspect is that morning & evening "peak pricing" windows should be quite tightly defined in order to effectively encourage customers to travel outside of peak periods - see *Douglas Economics' report on rail peak pricing* attached, which was reflected in *section 8.5.1 of Infrastructure NSW's recommended 2012 State Infrastructure Strategy (SIS)*.

Different product-pricing packages could also offer different levels of access to a varying frequency of service, for example with a "gold" travel pass allowing a customer to use any of the services running every few minutes across the network, but a "bronze" pass only allowing use of identified bronze buses operating 1-in-3 services.
Another option is to segment the market according to "ability to pay", i.e. depending on the customer's income or wealth. Discounts for children are an example of this.

Further packages could deliver synergies to operators and customers from combining/bundling public transport with access to complementary services such as taxis/Uber which I discuss at *http://davidthorp.net/transport-plan/flexible*.

These pricing concepts, based on "market segmentation", aim to best meet the differing preferences of different groups of customers, whilst also maximising revenue, and in the deregulated mobile phone industry, competition encourages different operators to design the best pricing plans to suit demand. Some mobile operators are "virtual" ones, because they bulk-buy capacity from operators with real physical networks and then resell it through their own pricing plans.
Similarly, competing public transport retailers could buy capacity from public transport operators (via Opal or directly) and then resell this to individual customers using a variety of different innovative pricing plans suited to the different market segments they identify. The attached "*Competitive PT fare retailers*" describes how this concept of competing fare retailers could be linked to IPART's price-setting process.

Regards

David

Competing Fare Retailers for Public Transport

updated from a submission to IPART 2015 Sydney Public Transport Fares Review
& http://davidthorp.net/transport-plan/pricing
by Dr David Thorp

Summary

IPART should establish a regulatory framework that can promote more innovative and efficient public transport pricing by competing "public transport retailers". These retailers would operate similarly to mobile phone and electricity retailers that buy service capacity wholesale from network owners / public transport operators, and then sell it to customers through pricing plans that are tailored to different market segments.

Retailers could use the following three well-established pricing strategies that are especially useful for maximising demand and revenue in industries with high fixed costs (noting that in the short-term, almost all of a fixed-schedule public transport service is fixed cost):

1. 2-part pricing structures, comprising a fixed monthly network "access fee" (or "subscription"), plus a marginal usage or volume price (which is lower than it would otherwise be without the fixed fee, especially in the off-peak).
2. "Market segmentation", with different "price plans" developed to suit different customers, e.g. frequent users, moderate and off-peak users (e.g. part-time workers) and occasional/infrequent users (e.g. see Rail pricing market segments.pdf at the above link).
    - This enables the supplier to encourage higher demand from different market segments (who value certain trips differently) and recover more revenue from them without over-pricing other market segments (and either suppressing demand or provoking community backlash).
3. "Bundling" of public transport with other complementary products into a single pricing package.
    - Opportunities include volume discounts for bundled plans that include public transport, taxis/Uber, car rental (e.g. "Goget"), airlines and broader "frequent flyer"/loyalty schemes with various retail partners.
    - Bundling may be a significant opportunity for private/franchise public transport operators (existing and potential new operators).

Implementation - potential regulatory framework

In a regulated environment (unlike mobile phones), a potential way of facilitating pricing innovation could be to establish a "default price plan" through the IPART process, which may be in line with the simple per-trip fares (varying by mode and peak/off-peak) suggested by IPART in this Review. This default pricing would have to be offered by at least the incumbent retailer (Opal), and perhaps also by any new competing entrants (depending on the barriers to switching retailers).

The presence of this default regulated pricing would enable new retailers to innovate competing price plans without any regulatory restrictions, since customers can simply choose the regulated prices if they prefer. Operators (of trains, buses etc.) would also be free to negotiate any wholesale pricing agreement with any retailer. This negotiation process may in turn enlighten operators on key value and cost drivers (through the subsequent revenue and demand impacts), which may in turn inform future refinement of the regulated default prices.

Before IPART finalises any framework and price determination, it would be highly desirable to discuss opportunities, risks and practical constraints with prospective public transport retailers and/or professionals with relevant industry expertise (e.g. a mobile phone retailer like Virgin Mobile, which owns no network assets).

Specific issues raised by the 2015 IPART Review

Should regulated prices be a maximum fare or the average allowed to be recovered?

- The above approach suggests neither - it would be the 'default' regulated price. Competing price plans could then charge a higher peak rate than the regulated price in return for having lower off-peak prices.
  - However, if this default pricing approach is not adopted then it may be best to set the regulated price as a maximum fare, as an "average fare" control may more strongly cap total revenue, thus reducing incentives for pricing innovation.

Design and application of 'peak times':

- INSW's 2012 Infrastructure Strategy provided expert analysis by Douglas Economics [1] showing that peak hour windows need to be quite tightly defined in order to materially shift demand to the peak shoulders, as section 8.5.1 of INSW's report recommended.[2]
- Peak pricing should be applied to buses, especially in Sydney CBD and other major centres where they contribute significantly to road congestion. Shifting demand away from the peak could avoid or substantially defer very expensive new infrastructure requirements (of any mode).

Variation by mode (vs 'full integration'):

- Fares need to reflect both cost and value delivered. i.e. customers should, and will generally be more "willing to pay" more for fast, expensive trains than slow, cheap buses.
- Fares should not be a constant amount per km regardless of mode as this will distort demand (subsidising trips that require more expensive infrastructure) and reduce total revenue (because limited 'willingness to pay' on low-value trips will reduce revenue on trips that customers would be willing to pay more for).

Relationship to government funding:

- Although government has historically subsidised rail entities on a "deficit basis" (whatever is required), both public and private buses are funded on a per-passenger basis (so the operator is responsible for managing business financial risks) and this approach may well be applied to rail in future. The regulatory pricing framework should be designed to support this more commercial approach.
- Whilst fares may initially be set at a pragmatically low level that prevents recovery of rail infrastructure costs, this should be fully transparent. There is no strong theoretical argument

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[1] http://www.infrastructure.nsw.gov.au/media/1151/douglas_economics_insw_modelling_fares.pdf

[2] http://www.infrastructure.nsw.gov.au/media/1138/sis_report_section80_print.pdf

for excluding fixed infrastructure costs from pricing but including other operating costs that are still essentially fixed in the medium-term.

- IPART should include all costs and an estimate of an 'efficient subsidy' that reflects externality benefits, and then Government may choose to further, transparently subsidise prices (perhaps through a transition period) if it wishes to avoid community impacts.

Proposed regulated prices:

The proposed "default pricing" will need to have reasonably high fares and discard the current frequent-user price cap/free weekly trips, in order to give scope for competing price plans to offer attractive 'access pricing' plans. The current frequent-user approach is inefficient, as it encourages gaming and gives free trips for expensive modes and peak times.

I propose default regulated prices as follows:

1. Simple per-trip price by mode and peak / off-peak (as IPART suggest in this Review), but reflecting full "efficient costs" of provision, including a return on existing capital stock (excludes inefficient new infrastructure investment; single-deck metro rail is required on all lines to make efficient use of existing infrastructure[3]),
2. A per-km subsidy representing calculated externalities, by mode, to give economically efficient prices,
3. A "welfare subsidy" with two components (level to be decided by Government rather than IPART in future determinations):
    a. "default pricing subsidy" for casual users, which brings the default per-trip prices down to roughly current levels, plus
    b. a "higher needs" *cash refund*, made *monthly* to Opal accounts with monthly expenses over a threshold level (instead of the current free trips for the rest of the week after 10 trips)
        - cash refund maintains differential peak hour & mode pricing incentives for trips above the threshold
        - monthly operation is fairer for those with irregular travel patterns and avoids subsidies for those with a rare busy travel week (e.g. tourists)
        - the % refund rises with total monthly expense, reflecting "need" (as a first approximation)
        - simplest form would to refund x% of monthly expenses above a given threshold
        - families linked to one account would automatically get a bigger refund (as they will more easily exceed the threshold)
        - possibly better to gradually increase the % refund (above a lower threshold)?
        - ideally the refund level would vary with family income / concession card holders.

[3] http://davidcthorp.net/transport-plan/sydney-metro-hst

A Strategy for NSW Public Transport Pricing Reform

- new Opal ticket products

Contents

Conclusions and recommendations – Opal ticket product reform

Opal offers an opportunity to phase in simpler, more flexible, more efficient and *fairer* pricing.

The proposed pricing structure would strike a balance between encouraging greater use of public transport and ensuring those that use services more pay a fair amount more (especially in the peak).

The system would be simple, with only **two basic ticket types available:**

- **single trip e-cash fares, and**
- **personal, periodic-payment accounts**.

Periodic-payment accounts would involve regular, direct-debit payments of around $10-$20 per week, which would entitle the customer to discounted (but not free) marginal trip fares. This pricing structure follows the principles of classic "access" or "Ramsey" pricing, similarly to that found with utility bills. This is efficient because it matches a regular "access fee" with the business' high fixed costs, and thereby allows *marginal* trip fares to be reduced (in line with the low marginal business costs of an extra passenger boarding), so as not to suppress demand below economically optimal levels (see appendices).

These pricing structures could be implemented with smartcards/phones linked to online accounts **and integrated with similar new taxi pricing plans**.

To encourage uptake of off-peak ticket products (and relief of capacity constraints), **morning and evening peak hour windows should be more precisely defined**. A morning peak start time of, say 7.30am could encourage customers to travel before the peak, which may be a more realistic prospect given the nature of most employment working hours.

Contra flow (e.g. out of the CBD in the am peak) should also be at off-peak prices during peak hours, to encourage long term changes in residence and employment location decisions.

The proposed ticket types are described in more detail following.

Potential new ticket structure

1. Single-trip (one-way) fares (using the Opal as an e-wallet)
   - Fares discounted relative to the on-board cash fare (reflecting the benefit of faster boarding)[1]
   - Automatic credit of frequent-use discounts or rewards
   - Peak fares applying in narrow a.m. and p.m. windows, in peak flow direction only [2]
   - No Travel-10s (which have no rationale outside paper-based ticketing) [3]

2. Periodic-payment personal accounts (replacing all current periodicals and travel passes)
   - Fixed regular payment (direct debit from bank) entitles user to a discount on single-trip fares
   - Each customer may sign up to only *one* bus and/or *one* rail "price plan" / "travel pass"
     - A discount may be offered to customers that sign up to both bus and rail plans.[4]
     - Groups of up to five people may "link" their personal accounts to receive a "family" discount when members make the same trips at the same time.[4]
       (this is to help public transport compete against multiple-occupancy car travel, but without sacrificing revenue on single person trips)
     - Discounts for committing to periodic payments for a number of years.[4]
   - Each bus or rail plan has two options for the level of fixed payment and discount:
     - "frequent" user (> 10 trips / week)
       - high fixed payment and high discount (75% ?) on single fare
         e.g. $15 / week, plus trip surcharges of $1 (peak) and 50c (off-peak)
     - "moderate" user (≈ 5 trips / week)
       - lower fixed payment and lower discount (≈ 40% ?)
   - No zones. Bus passes valid on *all* metro buses (not just STA).
     - Three distance options, at different fixed payment levels – short, medium, comprehensive [5,6]
       (Shorter distance plans only discount short trips and incur full fare for longer trips)
     - Discounted fares matched to the patronage payments in new bus operator contracts

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[1] The *percentage* discount will be higher for short trips, as the fixed cost to the operator of each boarding is relatively higher for shorter trips. This is the justification for current Travel 10 percentage discounts being higher on short trips.
[2] New off-peak bus fares should be set to maximise profit. i.e. demand boost should outweigh avoided costs and revenue loss.
[3] Travel-10s are primarily designed to reward bus customers for avoiding time-wasting cash fares. This is not relevant with Opal. Travel-10s are also currently used to offer loyalty discounts to moderate users, for whom periodicals are not suited. However such discounts are not dependent on the frequency of use and are also unnecessary if "moderate user" price plans are available, as proposed here.
[4] The discounts should be set to maximise total revenue (low enough to make the deal attractive, but not so low as to lose revenue).
[5] The three fare plans would be mapped to the five Transitway distance bands. The "short" plan would only discount trips in the first distance band, the "medium" would discount trips in the first 3 distance bands, and the "comprehensive would discount trips in all five distance bands.
[6] Rail fare plans may only be valid between specifically nominated stations (as at present), rather than valid for any trips of a given length (as described for buses). This would allow rail to charge the higher costs per passenger-km that are incurred on more poorly patronised services at network extremities. Alternatively, more flexible distance-based rail plans may also be offered (applicable to any trips between stations within the specified distance), but at a higher price.

Benefits of the proposed ticket structure

The proposed ticket structure:

1. Has strong economic underpinnings, with an efficient pricing structure designed to maximise demand and economic benefits (see appendices).
    - Optional, personal price plans match the successful pricing structure of private cars (and mobiles) – relatively high fixed costs but low marginal cost of use
2. Strikes a balance between encouraging loyal, regular use of public transport, and ensuring those that use services more, pay a fair amount more.
3. Encourages off-peak travel and ensures that peak hour customers pay a fairer share of the high costs of peak capacity.
4. Is simple, with a limited number of ticket products.
5. Is flexible to the varying needs of different customers (e.g. “moderate” user price plans).
6. Satisfies community expectations for Opal to deliver a comprehensive, metro-wide “travel pass” product, but avoids complicated revenue allocation negotiations with many bus operators.
    - Periodic payment “passes” will discount trip fares on any operator anywhere in the metro area.
    - The discounted fares, at around $1-$2 (depending on distance or concession), can be closely aligned to the new operator funding model.
7. Avoids the complications and unfair anomalies of zonal passes.[7]
8. Through “family plan” discounts, may make public transport more competitive with the car for small groups.
9. Encourages and equitably rewards long-term, committed customers through periodic payment accounts
    - Offers a fair discount to loyal, moderate users (less than ≈ 5 trips per week) through “moderate” user price plans. (Travel 10s are the only current means of offering such a discount, but take no account of frequency of use – someone making 10 trips per year gets the same discount as someone making 10 trips per fortnight.)
    - Rewards customers for committing to periodic payments for a number of years
    - Abolishes longer term travel passes (e.g. annual passes), which unfairly restrict access to larger discounts to those with more available free cash (typically those least in need).

[7] e.g. a person making short trips across a boundary may require a two-zone pass, costing more than someone making long trips within a single boundary

Appendix A – Efficient and Fair Pricing Principles

Standard economic theory says that products (or services) should be priced at marginal cost. Then if the product is worth more to the customer than the marginal cost of production, they will be willing to pay the price, and producing and selling it will produce economic value that exceeds the economic cost. If on the other hand the price were to exceed marginal cost, then demand may be suppressed even when the marginal value exceeds the marginal cost, and potential economic benefits may be lost.

This theory assumes that the industry will exhibit decreasing returns to scale, so that the last unit of production will have a marginal cost that exceeds the average cost (including all fixed costs). Then if the market clearing price of the product is the marginal cost, this will deliver sufficient revenue to cover all costs.

In practice, in an industry such as public transport (especially rail), with high fixed costs and economies of scale, pricing at marginal cost is not financially viable. In the off-peak, the marginal cost is only the cost of the delay incurred to operations by a passenger boarding (given that schedules are pre-determined and excess seats generally available). Pricing at this level (close to zero) will not even recover the cost of off-peak operations, let alone contribute to infrastructure costs. Therefore alternative pricing strategies are required.

The following describes two efficient pricing strategies for maximising revenue:

1. Segment the market (and optimally price each segment by value)
2. Encourage fixed "access fees" (in line with fixed costs) – see also Appendix B

1. <u>Segment the market</u>

Ideally peak prices should reflect the long-run marginal cost of capacity, but in the off-peak, prices should be set in line with *value* (to the customer), or willingness-to-pay, rather than marginal cost.[8] From a purely commercial perspective, the pricing strategy should be to maximise revenue by separately pricing each and every trip made by each customer at the maximum level that the customer would be willing to pay.

In practice, businesses need to find a practical way of dividing the market into different segments, and optimally pricing each segment in line with the willingness-to-pay of customers in that segment. The technique is called "yield management", and one way that airlines do this is by creating different classes of different quality (economy, business, first). The price premium on these higher quality products is greater than the increase in costs (i.e. higher margin), in order to contribute a greater amount to the business' fixed costs (otherwise there would no point in having the higher value product).

Despite apparent constraints on public transport, a commercial pricing strategy should, in the broadest sense, be exactly the same as for private competitive businesses. i.e. To maximise revenue by segmenting the market and pricing each segment in line with its willingness-to-pay. The only difference is the process moderating prices. In public transport, with its natural monopoly characteristics, *fair* prices are controlled through an oversight process on behalf of the community (IPART), rather than relying on individuals' power of choice (walking away if the price is too high).

Note that there is a nexus between *efficient* pricing and *fair* pricing, because fair pricing requires that concession fares be set in line with *ability-to-pay*, and willingness-to-pay is strongly influenced by ability-to-pay. This is because wealthier people have proportionately much more free cash (after deducting minimum living expenses), and hence tend to *value* the same things (especially time) higher than poorer people do (i.e. in *proportion* to their available cash). Means-tested fares are therefore one way of segmenting the market into different groups, each with a different willingness-to-pay.

[8] In the unlikely event that such pricing recovered more than the marginal cost of off-peak operations, and therefore contributed to infrastructure costs that are common to both off-peak and peak services (e.g. vehicles/rolling-stock, stations, track, etc.), then the peak price could be reduced to recover less of these infrastructure costs.

2. Encourage fixed "access fees"

Appendix B describes a number of advantages of "access pricing" (or "Ramsey pricing") and explains with some examples why such pricing is an efficient approach for public transport.

In short, a regular, fixed access fee is well matched to the fixed costs of public transport, and enables customers to be charged only a small (or no) additional marginal fare (especially in the off-peak) – thus ensuring marginal demand is not unnecessarily suppressed, and economic benefits are maximised. This is the pricing structure adopted by other regulated utilities (e.g. phone & electricity line rental). *It is also worth noting that the unregulated mobile phone industry voluntarily encourages customers to sign up to similar pricing structures. i.e. Assuming competitive markets encourage the development of efficient pricing, this provides evidence of the greater efficiency of such pricing structures.*

Naturally, such a price structure does not suit all customers, such as casual users. Therefore, like the mobile phone industry, **public transport should have a variety of pricing structures to suit different market segments, but with a strong focus on encouraging customers wherever possible to sign up to regular "access fees" that can support the businesses' fixed costs.**

The higher the access fee that the customer is willing to pay, the lower the marginal fare that they can be offered as part of this price plan. However, there is likely to be a minimal marginal fare (about $1?) that does not significantly discourage demand, and hence below which further fare reductions would only reduce revenue without a compensating boost to demand. By this logic, current travel passes, with zero marginal fares, may not be optimal.

Appendix B – Benefits of "Access" or "Ramsey" pricing for Public Transport

Contents

Summary / Conclusion

Access (or "Ramsey") pricing offers a number of benefits for public transport – maximising demand, revenue and economic benefits and reducing risk for customers and investors. Loyalty (frequent use) discounts do not offer the same benefits, and are considerably more expensive for operators.

Therefore NSW's integrated ticketing system should offer such pricing to customers. e.g. travel passes with peak surcharges. Zones could be replaced by distance caps.

Travel passes with peak surcharges would be priced less than current periodicals, for customers making only a few peak trips per week. Even if this ticket only encouraged a small spreading of peak demand (in combination with new, more precise peak times of, say, 7.30-9am and 5-6pm), it could significantly relieve rail capacity issues & costs.

1. Access Pricing

- Customer pays a fixed weekly or monthly "access charge", *and* a marginal fare per trip.
- Off-peak marginal fare may be very small or zero (as with current periodicals/travel passes).
- The peak marginal fare is higher than in the off-peak, but this peak marginal fare is lower than for customers that choose not to pay an access charge (i.e. who choose simple per trip pricing).
- If the access charge is high enough then even the peak charge could be small.
- The number of trips, the length of each trip and/or the total length of trips allowed at the discounted marginal cost may be limited, depending on the level of access fee paid.

This is the same pricing structure adopted by other industries with high fixed costs, such as electricity, water, telephone. The deregulated mobile phone industry has voluntarily adopted these pricing structures (because they are more efficient), and *offers a variety of different "price plans"* (with varying access fees and marginal call costs) to suit different market segments – and thus maximise revenue. Sydney's Metro Light Rail also offers heavily discounted weekly passes, even though fares are unregulated.

This pricing structure is termed "Ramsey pricing" – put forward (in early 1900s I think) as a theoretically more efficient pricing structure for industries with high fixed costs / economies of scale. Current periodicals / travel passes are a simple version – with no additional marginal fare.

Further option - Long term contracts

- Optional long term contracts allowing those customers that want to, to commit to monthly payments of a fixed amount, for perhaps many years.

2. Benefits of access pricing

a. Maximises demand, revenue and total economic benefits

Buying a car is a financially worthwhile proposition to customers because it will be used for **lots of small value trips**. **Volume is the key, and it is achieved by encouraging demand through a very low marginal cost of use.** 80% of the volume is in the off-peak.

If the car was free but the marginal cost of each car trip incorporated a contribution to the car company for the cost of the car, then the marginal cost of a trip would be significantly greater than at present. This would discourage demand (i.e. many trips wouldn't be worth the extra cost), potentially with the result that total car company revenue would be less than the cost of manufacture, making the business unviable.

Access pricing for public transport copies these principles. An example demonstrates the point:

A customer may plan to make five off-peak trips in the week, each with a different value, as follows:

Trip no. and purpose	Value (maximum amount the customer is prepared to pay)
1. Go and buy some bread & milk	$1
2. Pick up pizza	$2
3. Go to cinema	$2.90
4. Go to pub	$4
5. Go to Rugby	$5.10
Total of 5 trips	**Total value = $15**

This customer would be prepared to pay up to $15 for a weekly travel pass providing free off-peak travel. They would then make all these trips, because even the least valuable trip, at $1, is worth more than the marginal cost of zero.

The public transport operator has a fixed service schedule and hence fixed costs. Its marginal cost of additional passengers in the off-peak is zero. Therefore the $15 revenue translates to $15 gross profit margin. This helps to pay for the fixed cost of operation.

The average revenue per trip is $3. However, what happens if the public transport operator instead tries to allocate its fixed costs to each trip price, by charging each trip at the average of $3? Then the customer will no longer make trip no.s 1-3, because the marginal cost exceeds the marginal value. Whilst the customer will gain a "consumer surplus" of $3.10 (value – cost = $1 on trip no.4 plus $2.10 on trip no.5), **the operator loses $9 in revenue (over half of the potential $15).** The combined net loss for the customer and operator is $5.90. **A further consequence may be that the operator's total revenue is insufficient to cover its fixed costs, and the business becomes unviable. Then the full potential economic benefits will be lost.**

Alternatively, if the weekly ticket is priced at say, $10, then the customer happily gains $5 of the operator's $15 profit (as "consumer surplus"). A change to $3 per trip pricing would then cause the operator to lose $4 in revenue (& gross profit), and the customer's surplus would be reduced by $1.90 from $5 to $3.10 (giving a combined net loss of $5.90 again). **To put it the other way, replacing $3 per trip pricing with a $10 weekly pass would benefit both the customer and the operator.**

Note that even a loyalty discount of 20%, reducing the trip price to $2.40, would only regain trip no.3 – and at considerable extra expense to the operator.

b. Regular direct debit for increased convenience, reduced transaction costs and increased revenue

With smart card ticketing linked to personal accounts, weekly or monthly travel passes could be automatically paid by direct debit. This would:

- increase customer convenience and ensure they don't forget to buy a new ticket and are unable to travel (leading to lost operator revenue)
- avoid the transaction costs otherwise incurred at smart card recharge stations
- enable customers that have limited ability to finance annual ticket passes to instead commit to one year of monthly payments, and therefore have equal access to corresponding discounts
- increase operator revenue, because sometimes customers will keep the direct debit going even when they don't need a travel pass (e.g. if they're going on holiday) – simply to avoid the hassle of cancelling and restarting the direct debit.

c. Increase revenue by capturing "option value"

The above example demonstrating the economic benefits of periodical tickets was based on the customer having a known set of trips for the week. The reality is quite different, especially for off-peak trips. **When trip needs are uncertain, customers value the mere availability of services.** *Access* to these services provides the customer with "option value" – because it gives them the option to use them, should they find they need to. **Access pricing (i.e. periodical tickets) can capture some of this option value, offering even further revenue benefits over per-trip pricing.**

For example, a customer may nearly always travel to work at 9am and back at 5pm, but they still value the fact that late evening services are available – just in case they need to work late. In fact, they may not use public transport at all if it were not for the availability of these late services – they may drive every day, just in case they need to work late. **The value of the late evening services is greater than the revenue obtained from its patronage – it helps to maintain the viability of the peak services.**

How can we capture option value in public transport pricing? If we rely on per-trip pricing, and increase the price of peak hour services to cross-subsidise off-peak services, then this would further suppress demand (& revenue), just as described above. **Periodicals, on the other hand, allow us to further increase the ticket price and capture this option value, yet without increasing the marginal cost of each trip and suppressing demand.** (We may *also* have to increase the per-trip price as above, otherwise people may switch to per-trip pricing to get *access* to off-peak services for free.)

If in addition to an expected 5-trip demand as in the example above, a customer has an unlikely (probability of say 1/5) but important trip need (e.g. getting home quickly when late & tired) valued at say $5, then this would add $1 to the value of the weekly ticket, increasing operator revenue by perhaps 7% or more (compared to a single-route, peak-hour only weekly ticket costing $10-15). **Revenue increases of this magnitude (5-10%) may well be realistic**, because people, being risk averse, tend to exaggerate the probability of events happening, especially if they are of high impact (high trip value).

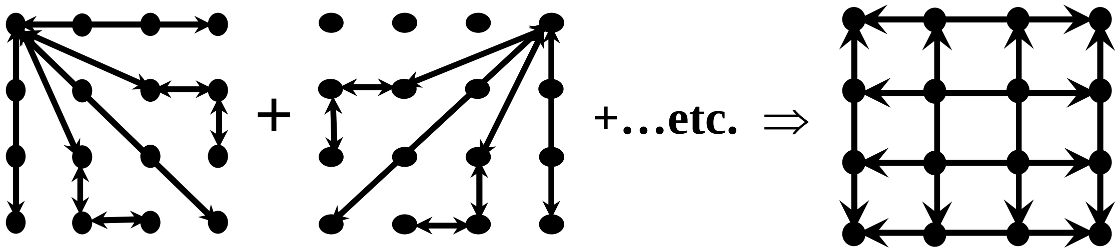
Evidence of this logic at work is displayed in a number of areas:

- The success of the car indicates the value of this approach. People buy a transport capability that offers "anytime, anywhere". They would pay a lot less for a car that could only travel on a certain limited number of roads at certain times, even if this covered the expected travel needs. Its worth paying more to cater for unexpected changes.
- Option value is partly revealed in house prices, and in the marketing of houses with good "*access* to public transport". People pay for having access, even though they must pay again to use it. (although part of the premium in house prices is because public transport is inevitably underpriced for some people, such that there is a consumer surplus worth paying for)

The same principles as above, linking peak and off-peak trips, also apply to different routes in an integrated network. For example, a customer may value services that go from their workplace and to the shops, and from the shops to their home, *in case* they need to go to the shops on their way home – even though they may very rarely do so. **Thus multi-route and multi-mode travel passes offer further potential to extract option value (higher prices) from customers.**

d. <u>Free or discounted transfers to encourage network synergies</u>

The figure below shows how an interlinked network of 8 routes (4 horizontal and 4 vertical), where passengers change from one line to another in order to reach their final destination, can replace the many more direct routes (20, vs 8) required to serve the same diverse range of origin-destination (O-D) pairs (there are 120 O-D pairs in this example). The benefits of this network effect increase exponentially as we scale up to a real-life sized metropolitan network. This is the fundamental advantage underlying networks such as the London & Paris metros, which rely heavily on interchange between routes in order to serve customers' diverse trip needs.



Clearly if it is more efficient for operators to provide services through interlinked networks, then it makes sense to set prices that encourage customers to make use of interchange (and to at least partially balance the inconvenience of this interchange for customers). Travel passes, allowing free transfer between routes, are one way of doing this.

No need for zones

Conventionally, travel passes are based on zones. Higher priced passes allow unlimited travel in larger zones. But zones do create anomalies at their boundaries. For example, customers travelling regularly a short distance across the boundary of two zones may be required to pay substantially more than someone who makes a large number of long trips that happen to be contained within a single zone.

Zones also create additional unwanted complications for implementation in a smart card ticketing system. However, smart cards with "tag on, tag off" features do not need to use zones. Because they record the length of trips made by customers, a travel pass ticket can be limited by the total distance travelled (e.g. during the week), &/or by a maximum distance. This would be simpler to implement and avoid the anomalies of zones. Customers could check their remaining distance allowance for the week by inserting their smart card in an appropriate reader (at a station or perhaps connected to a home PC).

Benefits of long term contracts:

e. Offer customers protection against future "spot price" uncertainty
(thus reducing community opposition to greater volatility and possible future price rises)

The ability of the Government to raise prices is constrained by the fact that many members of the community have made a *commitment* to where they live and work on the assumption that the price of the public transport services they *depend on* will stay roughly constant. They have little ability to respond to price signals, especially in the short term, and this is a primary source of community opposition to price increases and greater cost recovery for public transport services.

Unfortunately, not increasing prices only worsens the problem, because it encourages more people to move to locations with heavily subsidised services (e.g. distant commuter suburbs). What is needed is a pricing system that can distinguish between these two types of customers – so existing commuters can protect themselves from future price rises, but everyone else, who currently have no dependency on the subsidised services, would be subject to higher (more efficient) prices if they chose to move to these locations in the future.

There is a well-established price mechanism that can achieve this. Participants in efficient markets who have little ability to adjust to short term price risks are able (at their choice) to "hedge". i.e. buy long term, fixed price contracts. Examples are fixed rate home loans, and long term electricity hedge contracts between retailers and generators.

If public transport customers had the option to commit to long term, fixed price contracts (e.g. $x/month for 5 years), then their opposition to uncertain future "spot" prices would be reduced. The Government could then increase the price of short term tickets to more efficient levels, thus discouraging economically inefficient growth on heavily subsidised services.

f. Reduce risk of new investments and increase responsiveness to customers

Developer charges to fund public transport in new areas (such as Bringelly) are essentially compulsory access pricing. Their advantage is that they reduce the financial risk of major new investments, such as rail lines – the developer charges help cover the up-front cost of the investment, and user charges are made closer to marginal cost (boosting demand).

In places where residents are already in place (or have at least signed up to the new lots), it is possible that the same outcome could be achieved on a voluntary basis. i.e. Those that wanted access to new public transport services could sign up to long term access pricing contracts. (This would be encouraged if per-trip pricing was set too high to be worthwhile for anyone except the most infrequent user.) If sufficient people signed up to long term contracts then the project would go ahead. If insufficient people signed up, then this would indicate that the project was not well matched to people's needs, and it would be abandoned. Hence **offering long term contracts would be a good test of the project's worth, *before* the funds are committed. This would significantly reduce project risks, and** even if the funds raised were only a minority of the total required, as a good future patronage indicator they would reduce the risk for external financiers, hence **reducing the cost of private finance**.

This process is similar to an Initial Public Offering (IPO) of shares in a new business venture. The business investment only goes ahead if the IPO is sufficiently subscribed, otherwise funds are returned.

If customers signed up to very long term pricing contracts, against which the operator could borrow low interest debt (to fund up-front costs), then customers would be covering the investment risk and would essentially be playing the role of shareholders. As for other shareholders therefore, it would be appropriate for the holders of the investment risk to have control over the company. These **committed, long term customers could be recognised as shareholders, with full voting rights. Such customers could elect the directors of the public transport company (perhaps facilitated by on-line voting), leading to greater responsiveness of ongoing service management to customer needs.**

Like shares, take up of long term contracts would be encouraged if customer-investors could sell their contract at any time to another customer. The price would be dictated by the remaining length of contract and the current price of contracts of this length being sold by the public transport operator.

3. Example: off-peak pass for Bankstown to Central (NB. 2006 data analysis)

Rail costs are determined by the extremely peaky nature of CBD commuting demand, and pressures are growing for increased capacity expenditure (e.g. Clearways). **Yet there is currently very little incentive for rail commuters to travel in the off-peak.**

Many commuters will need to travel at least some days in the peak, but on other days they may have more flexibility. The table below shows the cost of one week's travel (5 return trips) for current rail fares between Bankstown and Central, for different numbers of peak vs off-peak trips. A commuter who is likely to need to travel just two mornings in the peak need only pay an extra 40 cents to get a weekly pass. For this extra 40c they get the option of travelling in the peak hour every day, as well as the ability to travel as much as they like (e.g. at the weekend also). The uncertainty that a commuter has over whether or not they will need to travel in the peak has an important influence on their ticket purchasing decision. If it is *possible*, even though perhaps unlikely, that they will need to travel several times in the peak, then it is worth buying the travel pass to avoid the risk of having to pay higher prices on many days.

The incentive to travel in off-peak reduces even further as you consider passes of longer periods (e.g. monthly or annual passes). Furthermore, off-peak tickets only apply after 9am, so there is no incentive for customers to travel, e.g. before 7.30am, which could equally reduce pressure on the rail system. There is also no incentive at all to avoid travel in the evening peak, or to travel in contra-flow direction in peak hours (e.g. CBD to Parramatta).

Arguably the weekly travel pass could be increased in price somewhat; perhaps to say, $32, but this would still not create a very large incentive for off-peak travel. But a much bigger incentive for off-peak travel can be created with an off-peak "access pricing" plan. e.g. a travel pass that allows unlimited travel in the off-peak, but requires a surcharge in the peak. The table compares current tickets to the total cost with such a ticket set at $16, and a surcharge equal to half the full single-trip peak fare. The key ticket-buying incentives created by this pass are as follows:

- The new off-peak pass is worth buying for anyone travelling four or more off-peak trips during the week (just as the current weekly pass is worth buying for anyone doing four or more peak trips).
- The off-peak pass is cheaper than a peak pass for 3 or less peak trips per week (with the remainder of the total 5 trips as off-peak trips). The discount for making no peak trips is a hefty $12/week relative to the existing weekly pass. The *possibility* of this saving could attract a lot of people given the relatively low surcharge if they end up having to travel even 4 times in the peak.
- Customers currently making 3 or less peak trips per week, but no off-peak trips, have no incentive to buy the new off-peak pass.

Bankstown to Central

Current tickets			New off pk pass with surcharge	
pk rtn	off-pk rtn	weekly pass	off-pk pass	pk rtn surcharge
$7.20	$4.40	$28	$16	$3.60
# pk trips	# off-pk	cost on single tickets	total cost on off-pk pass / saving	
0	5	$22.00	$16.00	$6.00
1	4	$24.80	$19.60	$5.20
2	3	$27.60	$23.20	$4.40
3	2	$30.40	$26.80	$1.20 (vs weekly)
4	1	$33.20	$30.40	(-$2.40, vs weekly)
5	0	$36.00	$34.00	
4	0	$28.80	$30.40	
3	0	$21.60	$26.80	
2	1	$18.80	$23.20	
2	0	$14.40	$23.20	
0	4	$17.60	$16.00	$1.60
0	3	$13.20	$16.00	

The potential impact of these incentives on SRA demand, revenue and costs is discussed in the following table.

Possible demand, revenue and cost impacts:

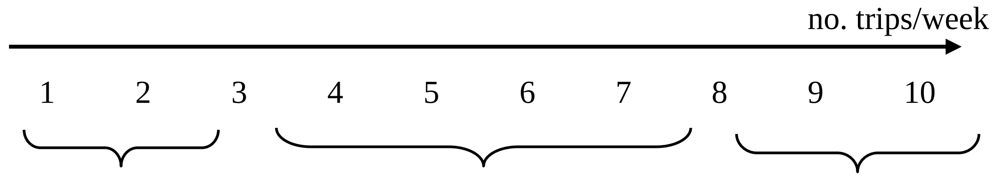
Change in ticket purchases	Impact
Switching of current peak-pass customers to off-peak pass	Could be significant, as is the objective of the new ticket. Primary benefit is reduced capacity costs. Pricing may need to be adjusted after implementation to ensure revenue loss is less than saved capacity costs. Possible revenue increase from those customers that buy an off-peak pass but subsequently find the need to make 4 or more peak trips in the week.
Switching of current purchasers of off-peak single trip tickets to off-peak travel pass	Revenue loss is likely to be small. Only customers travelling 4 or more off-peak return trips per week would do this. Their number is likely to be small, and the revenue loss is only around 10% (for customers travelling 4 off-peak return trips / week). There is scope to reduce this loss through increasing the off-peak travel pass fare (e.g. to $17 or 18) without significantly reducing the incentive for increased off-peak commuting.
Switching of current purchasers of peak single trip tickets to off-peak travel pass	Current purchasers of peak single-trip tickets will probably be making less than 3 peak trips per week (or 3 peak trips only, as 3 peak trips plus one off-peak trip would cost $26, little less than a current pass at $28). And for these, the new off-peak pass would only be cheaper for customers doing 1 or 2 peak trips a week *and* 3 or more off-peak trips. So the number of these customers is likely to be small at present, and the revenue loss small.
Increased rail demand through lower cost of off-peak travel	Positive revenue impact with close to zero marginal cost impact

Rail Pricing and Ticketing
- market segmentation

Key strategic understandings:

1. Fares are strongly influenced, through the IPART process, by the community's "willingness to pay".
2. "Willingness to pay" is strongly influenced by ability to pay (income).

CityRail's customer base:



<u>Low users</u>
Various income.

Single Fares

Low use ⇒ total cost is low even with high unit fares.
⇒ Income (of poorest low users) is not a severe constraint (through IPART) on the single fare price.

<u>Moderate users</u>
Casual / part time workers (low pay).

Some use singles, some periodicals.
No tailored ticket product!

These users, through IPART, drag down the price of singles and periodicals.

<u>High users</u>

Full time workers, often (but not always) in CBD with above-average pay.

Periodicals / weeklies

Price not severely constrained by income of this market segment.

Conclusion 1:
Developing a ticket product tailored to moderate users and part time workers may make increases in single and periodical fares more acceptable to remaining users of these tickets.
An example solution, using smartcard/phone technology, could be a "moderate user pass", where a monthly access charge provides for, say, 50% discounts on unit fares. This ticket type would be half way between the two extremes of single tickets and current periodicals, and would only be an attractive proposition for moderate users.

Conclusion 2:
The general conclusion from the above is that CityRail's "pricing" strategy (i.e. on the *level* of fares) must be intimately integrated with its "ticketing" strategy (on ticket *structure*). One may facilitate the other.

A Practical Strategy for Road Pricing Reform

Issues:

- Growing population and car travel demand leading to rising costs of congestion and new supply (due to increasing need for tunnelling).
- Declining fuel excise revenue as vehicle efficiencies increase in response to higher oil prices.

Cost-reflective road pricing with differential peak / off-peak rates could match supply and demand at economically efficient levels, reduce peak congestion and make better use of assets in the off-peak.

Complication:

- Political resistance to differential peak / off-peak pricing due to concern for those with perceived limited choice over peak hour car use.

Strategy:

a. Set a default flat-rate "regulated" price with contracted annual increases for, say, 10 years.
   - Private sector buys future revenue stream; contract provides (Government?) some longer term flexibility (e.g. after > 10 years) to increase the rate of price increase and introduce some peak / off-peak differential (subject to traffic > pre-specified levels).

b. Allow toll owner to offer customers a choice of alternative (deregulated) pricing plans with different peak, off-peak rates and monthly access charges, similar to mobile phone price plans.[1,2]
   - Private owner of tolls has commercial incentive to optimise price plans to maximise revenue and manage congestion (subject to contract constraints), especially through encouraging increased off-peak traffic.

c. Phase in and encourage increased use of such 'choice' pricing plans across the road network over 20+ years.

   Potential Stages:

   Incrementally increase regulated toll and offer choice of price plans on:

   1. new Sydney motorways (i.e. WestConnex & F3 to M2) – establish principle and assist financing
   2. other existing tolled motorways – establish consistent regulated rate/km + premium near CBD & in peak[3]
      - Government negotiates lower Cashback funding in return for revenue available from new price plans
   3. other congested main roads in NSW – may use alternative toll technology (e.g. GPS) instead of e-tags
      - offset new optional tolls with reductions to existing taxes & charges (rego, fuel tax etc.)
   4. all other roads
   5. Comprehensive reform / clean up of all national road pricing (including fuel tax, rego, weight tax, etc.) and commercial financing of all future roads (with transparent subsidies for non-commercial roads).

Potential Price Plans:

Casual off-peak (rare peak use)	Modest off-peak discount and peak surcharge
Frequent off-peak	Fixed monthly fee, free in off-peak, standard rate in peak
Frequent peak	Higher fixed monthly fee, free in off-peak, discounted rate in peak
Long-term committed / risk averse	Guaranteed toll rates over 10+ years (protect against price rises) for "customer investors" in "Warratah" bonds or toll-road equity. – Discounted tolls could be in place of coupons/dividends (investment risk reduced as the return is controlled by the customer's toll-road usage).[1] – Investment could be via super funds (i.e. redirection of individuals' existing funds rather than requiring additional household investment).

[1] D.C. Thorp, *Strategies for Growth in Integrated Public Transport Networks*, for *Sustainable Transport for Sustainable Cities*, The Warren Centre (Sydney University), 2001.

[2] David A. Hensher & Michiel C.J. Bliemer, *What Type of Road Pricing Scheme might appeal to Politicians?* (submission to NSW Inquiry into Road Access Pricing), Institute of Transport and Logistics Studies, Sydney University, September 2012.

[3] Stage 2 should be developed before writing contracts for stage 1 and could be introduced simultaneously. Peak premium on the regulated toll may be after 10 years (say) and subject to traffic > defined level.

Modelling the Ability of Fare Incentives to Spread AM Peak Passenger Loads

May 2012

For

Infrastructure NSW

By
DOUGLAS Economics

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Date	Report Issue	Prepared By
23/05/12	Final Report INSW_ModellingFare_3 Incorporation of client comments	NJD 

Foreword

DOUGLAS Economics was engaged Infrastructure New South Wales to model the ability of fare discounts and surcharges to 'spread' peak passenger loads more evenly across the AM peak. The forecasts use a 'rooftops' model developed by Douglas Economics in association with Southern Cross University (SCU) as part of a wider study undertaken by SCU for the CRC for Rail Innovation: funded Project R1.107 *"Urban Rail Demand Management Strategies"*. A summary of the study was published at the 2011 Australasian Transport Research Forum held in Adelaide.

This report presents a non-technical description of the model. Some forecasts of the effect of introducing fare discounts on early morning and late AM peak trains and of fare surcharges on peak hour trains are presented.

The forecasts are compared with the Melbourne Early Bird and Sydney SmartSaver fare.

Disclaimer:

The model was developed as a 'proof of concept' rather than a detailed timetable assessment model tailored to the characteristics of individual rail lines. The forecasts presented should be considered with this in mind.

Executive Summary

DOUGLAS Economics was engaged by Infrastructure New South Wales (INSW) to model the ability of fare discounts and surcharges to 'spread' peak passenger loads more evenly across the AM peak. The forecasts use a 'rooftops' model developed in 2010 by Douglas Economics in association with Southern Cross University. The model was developed using timetable and patronage data for the Illawarra line. In this study, the forecasts for the Illawarra line have been used to derive patronage and revenue estimates for the CBD as a whole.

The 'rooftops' approach originates from work in spatial economics by Hotelling in the 1920s. In the 1970s, the approach was used to assess passengers' choice of train services. The name 'rooftops' reflects the shape of the train choice graphs which resemble streets of rooftops.

The parameters used in the model were based on market research undertaken in 2010 across the Sydney suburban rail network. A total of 786 passengers travelling in the peak were interviewed. The survey found passengers to value late displacement higher than early displacement. Travelling an hour earlier was treated the same as spending 32 minutes longer on the train whereas travelling an hour later was treated the same as 56 minutes extra on the train.

The survey also estimated a marked difference in how passengers value travel time depending on whether a fare surcharge or discount is levied. Passengers were found to be willing to pay a surcharge of $13.85 to save an hour of travel time but require a much larger discount of $33.80 to travel an extra hour. The surcharge value was reasonably precisely estimated and was similar to the peak value of $12.85 per hour used by CityRail. By contrast, the discount value had a wide survey error and was nearly three times higher than the CityRail value. Therefore in the forecasting model, although the 'surcharge' value of time was used, a lower 'discount' value of time of $20 per hour was substituted for the survey estimate.

The model was used to model the patronage and revenue impact of a range of fare incentives. Two incentives were designed to be similar to actual incentives introduced in Melbourne and Sydney. All the incentives were modelled assuming an adult average fare of $3.30 per trip.

Table 1: Predicted Change in Patronage and Revenue

Percentage and absolute change in CBD rail trips and revenue (2009 base figures)

	Incentive	Peak Hour Patronage		AM Peak 3.5hr Revenue	
		Percent	Trips	Percent	$m p.a.
1	Free Travel before 7am	-2%	-1,600	-11%	-13
2	Free Travel before 7.30am	-6%	-4,900	-22%	-26
3	Free Travel before 8am	-11%	-9,000	-37%	-44
4	50% Discount before 0715 & after 0915	-4%	-3,300	-15%	-18
5	25% Discount before 8am & after 9am	-4%	-3,300	-14%	-17
6	25% Surcharge 8-9am	-6%	-4,900	10%	12
7	10% Surcharge 8-9am & 10% Discount Before/After	-4%	-3,300	-1%	-1
8	10% Surcharge 8-9am & 30% Discount Before/After	-8%	-6,600	-13%	-15
9	25% Surcharge 8-9am & 25% Discount Before/After	-11%	-9,000	-5%	-6

Offering free travel on trains arriving Central before 7am was forecast to reduce CBD patronage by 2%. If applied to all passengers exiting CBD stations, 1,600 fewer trips would be made in the peak hour. The percentage reduction is of a similar magnitude, albeit slightly higher than the response to the Melbourne Early Bird ticket (free travel for trips completed before 7am) which has been forecast to have reduced peak hour patronage by an estimated 1.2% to 1.5%. In terms of revenue, offering free travel before 7am for all CBD-bound trips would reduce AM peak 3.5hr CBD ticket revenue by 11% or $13 million per year. This compares with $6 million estimated for Melbourne.

Extending free travel half an hour to 7.30am increased the shift out of the peak hour threefold with peak hour loads falling 6%. The loss in AM peak revenue was forecast to be significant at 22% or $26 million per year. Offering a 50% fare discount on trains arriving Central before 0715 and after 0915 (scenario 4) matches the fare conditions of the Sydney Smart Saver which was trialled for ten weeks on the Western line in 2008. The model forecasts that peak hour CBD trips would reduce 4% which is double the 2% reported for the Smart Saver trial. Revenue was forecast to reduce by 15% or $18 million.

The disadvantage of these early discounts is that they are not focussed on the crucial 8-9am period when CBD station capacity is most stretched. Extending free travel up to 8am (scenario 3) shifts 11% of passengers out of the peak hour but would reduce revenue in this morning period by 37% or $44 million p.a. (if applied to all lines into the CBD). If similar incentives were offered to customers with non-CBD destinations and/or to those avoiding the evening peak then the revenue loss would be even greater. This fare structure could also be practically difficult to implement as it could create a large customer build up behind CBD barrier exits shortly before 8am. The remaining scenarios therefore adopt a more focussed approach to fare incentives with a lesser level of discount.

A 25% discount on trains before 8am and after 9am (scenario 5) produced a 4% reduction in peak hour patronage, similar to the more generous but less focussed 50% discount of scenario 4. A 50% larger shift out of the peak hour of 6% was forecast for a 25% fare surcharge on trains arriving between 8-9am (scenario 6). The higher demand response reflected the lower 'surcharge' value of time estimated by the market research. Unlike the other incentives modelled, the revenue effect was positive with AM 3.5hr peak revenue increasing by 10% or $12 million a year.

Scenarios 7-9 combine surcharges and discounts. A 10% surcharge on peak hour trains combined with a 10% discount on early and late trains produced a 4% reduction in peak hour patronage and had a near neutral revenue impact. Increasing the fare difference to 25% (scenario 9) produced the largest patronage shift out of the peak hour with CBD trips falling 11% or 9,000 trips. Revenue was forecast to reduce by 5% or $6 million annually. Scenario 8 adjusts this fare structure to give a greater discount (30%) than surcharge (10%), which more than doubles the revenue loss (to 13%) but reduces the patronage shift to 8%.

In conclusion, the model demonstrates how differential fares can spread peak loads. The results provide guidance on the best structure of peak hour fare incentives, but the accuracy of the forecasts is naturally dependent on a range of assumptions. It should be noted that the model was developed as a 'proof of concept' with several simplifications made in the treatment of fare and the description of passenger journeys. The model was also developed for only one line - the Illawarra line. The accuracy by which the results can be generalised to other rail lines depends on the similarity of the timetables, demand and fare profiles. Finally, the forecasts were based on the stated response of passengers to hypothetical situations presented in a market research questionnaire rather than actual behaviour. Sensitivity tests of key parameters suggest actual demand shifts could be greater than forecast, although the forecasts are slightly higher than the observed response to actual fare initiatives in Melbourne and Sydney.

Table of Contents

1. Introduction

DOUGLAS Economics was engaged Infrastructure New South Wales (INSW) to model the ability of fare discounts and surcharges to 'spread' peak passenger loads more evenly across the AM peak. The forecasts rely on a model developed in 2009-10 by Douglas Economics in association with Southern Cross University (SCU) as part of a wider study undertaken for the CRC for Rail Innovation: funded Project R1.107 *"Urban Rail Demand Management Strategies"*. A summary of the study was presented at the 2011 Australasian Transport Research Forum.[1]

The model was developed as a 'proof of concept' rather than a definitive assessment tool and used the Illawarra line including South Coast intercity services as a case study.[2] Some simplifications were made in developing the model. Of particular relevance is the modelling of fare. The model assumed that all adult passengers pay the same average fare of $3.30 per trip (i.e. the fare was not related to trip length). Fare discounts and surcharges were then modelled as percentage changes to the average fare. Thus a 10% discount was modelled as a 33 cent fare reduction applying to all adult trips.

The effect on patronage was measured in terms of the change in train passenger load at Sydenham rather than at CBD stations such as Town Hall. Individual train loads were aggregated according to the arrival time at Central with trains grouped into early peak (before 8am), peak hour (8-9am) and late peak (9-9.30am).[3]

On the request of INSW, the model was used to assess a set of nine fare incentives ranging from free travel on early trains to a surcharge of 25% on peak hour trains. Three of the tests matched actual fare trials undertaken in NSW (Smartsaver) and Victoria (Early Bird) in 2008 and a discount fare ticket offered on non peak trains in Wellington. In this way, the model predictions could be compared with the observed response to actual fare changes.

INSW requested that the patronage and revenue impacts be estimated for North Shore, Main services and all services to the CBD. This was done indirectly by applying the Illawarra forecasts to patronage and revenue estimates for other lines derived from the Compendium of CityRail statistics.

It should be noted that the model only assesses the impact on train choice. A key assumption was that the total volume of rail patronage remains the same. That is, fare discounts or surcharges did not affect overall AM peak rail patronage, only when trips are made within the period.

The parameters used in the model to describe the response of passengers to changes in travel time and fare were based on market research undertaken in 2010 on suburban services across the CityRail network. A sensitivity analysis was undertaken to assess the impact of variations in the parameter values.

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[1] Douglas N.J., Henn L. and Sloan K *"Modelling the ability of fare to spread AM peak passenger loads using rooftops"* Paper presented at Australasian Transport Research Forum 2011 Proceedings 28 - 30 September 2011, Adelaide, Australia.

[2] The 2009 AM Illawarra timetable was modelled. The timetable was changed in October 2010).

[3] Central station was chosen because all trains (suburban and intercity) pass through or terminate at this station. By contrast, most intercity trains do not go to Town Hall and Wynyard is not directly served.

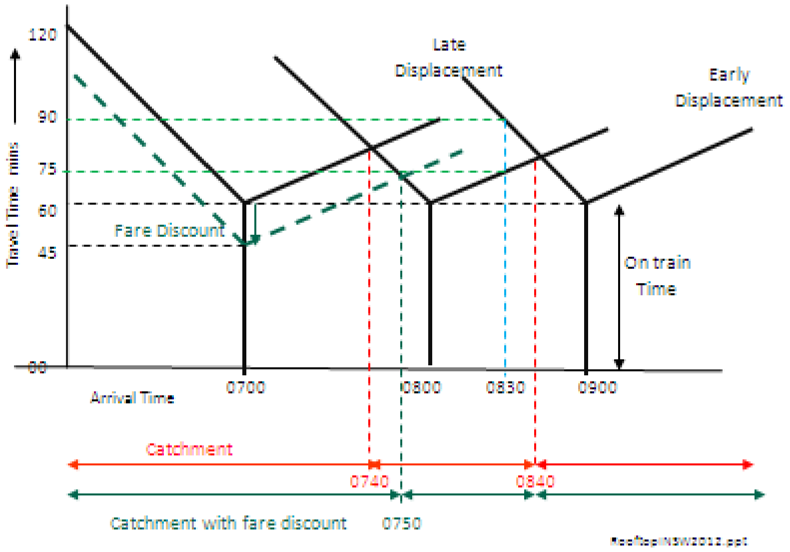
2. Model Overview

2.1 Rooftops Approach

The model uses a 'rooftops' approach that originates out of work by Hotelling in the 1920s. A half century later the technique was applied to modelling the passenger choice of train services by Tyler and Hassard in the 1970s.[4] In Australia, Ashley and McPherson used the approach in 2004 to model fast regional rail services in Victoria[5] and in Sydney, Douglas Economics used the technique in 2009 to model the Sydney rail timetable for the Independent Transport Reliability and Safety Regulator (ITSRR).[6]

Figure 2.1 shows the approach. As can be seen, the train choice graphs look like a street of roof-tops. On the horizontal axis, the arrival time of the train at the destination station is shown. There are three trains which arrive at 7am, 8am and 9am; they all take 60 minutes. The vertical axis gives the travel time for the passenger and includes the time spent on the train and the displacement time which is the difference between when the passenger wants to arrive and when the trains are timetabled to arrive.

Figure 2.1: The Rooftops Approach



A passenger who wants to arrive at 8am can catch the 8am train and arrive exactly when they desire. There is therefore no displacement time and the total travel time is the sixty minutes spent on the train.

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[4] Tyler J and Hassard R (1973) "Gravity/elasticity models for the planning of the inter-urban rail passenger business, PTRC Annual Meeting University of Sussex.

[5] Ashley D. and McPherson C (2004) *"Estimating Passenger Demand for Fast Rail Services with the Rooftop Model",* ATRF Adelaide, 2004.

6 Douglas Economics & Trainbrain "Modelling Passenger Loads and the Impact of Changes to the CityRail Timetable", Report For the Independent Transport Safety and Reliability Regulator NSW, April 2009.

However, for a passenger who wants to arrive at 8:30 there would be a displacement time. If the passenger caught the 8am train, the passenger would be 30 minutes earlier than desired. If they caught the 9am train they would be 30 minutes later than desired. The cost of displacement is shown by the sloping lines. Early displacement has a flatter slope with a minute of displacement valued the same as half a minute spent onboard the train so if the passenger caught the 8am train, the 30 minutes displacement would be worth an extra 15 minutes spent on the train. The total travel time would therefore be 75 minutes (measured as equivalent in-vehicle time).

Late displacement typically has a higher cost and in the diagram it is valued the same as onboard train time. So if the passenger caught the 9am train, the 30 minutes displacement time would be worth 30 minutes onboard the train which would make the total travel time 90 minutes. To minimise total travel time, the passenger should catch the 8am train.

The passenger catchments for the three trains are determined by the intersection of the displacement lines. The 7am train would capture all passengers wanting to arrive before 0740. The 8am train would capture passengers wanting to arrive between 0740 and 0840 and the 9am train would capture passengers wanting to arrive after 0840.

In the diagram everything else is assumed to be the same for the three services. The services are all provided by the same type of train, they offer the same chance of getting a seat and the fares are the same.

The aim of this study was to model the effect of fare discounts and surcharges. Augmenting the model to accommodate fare required the conversion of any fare differences between trains into an equivalent travel time. This is done by applying a 'value of time'. If passengers are willing to pay $12 to save an hour of travel time, a discount of $3 offered on the 7am train converts into an effective reduction of 15 minutes in the onboard travel time. The effect lowers the rooftop for the 7am train pushing out the catchment from 0740 to 0750 and attracting passengers who would otherwise have caught the 8am train.

Conventional rooftops models have used 'all or nothing' assignment. A train that offers a travel time advantage, no matter how small, captures all the patronage for that particular time interval. In this study, the probability of choosing a train service was modelled which introduced 'fuzziness' into the train catchments, reflecting the sensitivity of individual passengers to differences in travel time, displacement and fare between services.

2.2 Travel Time Profile

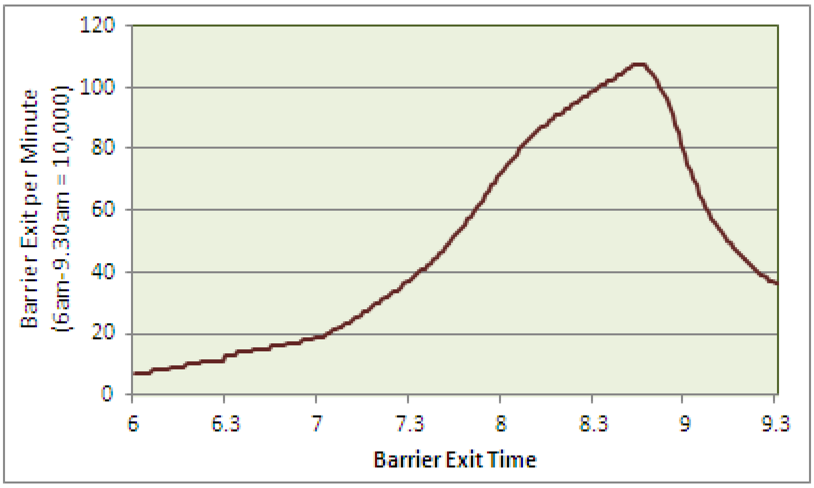
A travel time profile was developed to describe when passengers want to travel.[7] The profile, presented in Figure 2.2 was based on barrier exit data for Sydney CBD stations and gives the number of passengers wanting to exit during a particular minute.[8] The profile was multiplied by the predicted 'rooftop' catchments to allocate passengers to trains.

[7] In fact two profiles were developed: one for adult passengers and one for school children. The profile for school children, who account for 9% of total journeys, was developed to allow for their more peaked travel profile. Fare discounts and surcharges were only applied to adult passengers however.

[8] The profile has been scaled to 10,000 over the 3½ hour period. Thus if the exit profile had been constant, 48 adults would exited the ticket barrier per minute.

Barrier data can only be a 'proxy' for the ideal travel time profile. That said, the response to a self completion survey of 1,790 rail passengers on the Illawarra and ESR rail lines undertaken as part of the CRC study support the use of barrier data since 97% responded that they were travelling within 15 minutes of their ideal time.[9]

Figure 2.2: AM Peak Travel Time Profile



2.3 Model Calibration

The predicted loads were compared with observed loads and a set of calibration factors were developed to bring the model closer into alignment with observed loads.

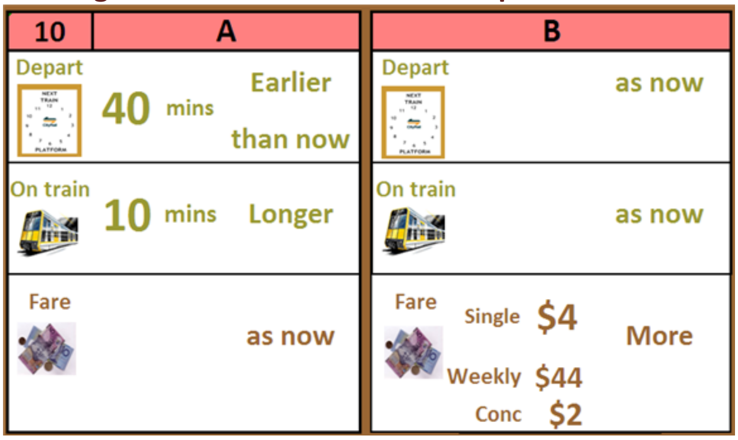
In fact, two calibration factors were calculated. The first factor was an overall factor to match the modelled patronage to the observed count for the full the AM 3.5hr period. The second factor was in fact a set of temporal factors that adjusted the desired travel time profile. The factors were calculated six times. Each successive step used the results of the previous step.

[9] The survey of 1,790 Illawarra and Eastern Suburbs Line passengers found that 80% were travelling at the 'ideal time' and a further 17%, travelling within 15 mins of their ideal time (13% preferring a train earlier and 4% a train later). Thus, 97% were travelling within 15 minutes of their ideal time and only 3% were travelling outside of 15 minutes of their ideal time. The survey is described in Henn L., Douglas N.J. and Sloan K. (2011) *"The Potential for Displacing Sydney Peak Hour Commuters"*, 34th Australian Transport Research Forum, Adelaide 2011.

3. Market Research

The demand parameters used in the train choice model were based on market research undertaken in 2010 across the Sydney suburban rail network. Passengers were presented with a series of paired journey choices and asked by interviewers which of the pair of train services they would use in each situation. An example is shown in Figure 3. In essence, the passenger is being asked whether they would pay $4 more to travel on their current train rather than travel 40 minutes earlier on a train taking 10 minutes longer but at the same fare 'as now'.

Figure 3: Market Research Example Situation



By designing a series of choices that varied the times and costs in a statistically controlled way it was possible to determine how much passengers were willing to pay to avoid having to travel an hour earlier or later than their ideal travel time and how much they were willing to pay to save onboard train time.

In total, fifty choices were designed with passengers completing eight or nine choices each. Half the fifty choices featured travelling earlier than desired. The other half featured travelling later than desired. Embedded in the design was a trade-off between onboard travel time and fare so that a value of travel time could be established.

The fares and travel times were varied around the passenger's current trip. For fares, there were five variations. Three variations featured a surcharge on the current fare and two variations featured a discount. In this way it was possible to test whether passengers were more sensitive, dollar for dollar, to a discount or a surcharge.

In total, 786 Sydney rail passengers travelling on suburban services during the peak period were interviewed. A statistical model was fitted to the data that explained the variation in response of passengers to the fifty questions in terms of the travel time, displacement and fare.

Analysis of the response found passengers to value early displacement at around half that of onboard train time but value late displacement nearly the same as onboard train time. In fact, the values would produce rooftops with similar slopes to those shown in Figure 1. Travelling an hour earlier than desired was valued the same as spending an extra 32 minutes on the train (giving the ratio of 0.53 in Table 3). Travelling an hour later was valued the same as an extra 56 minutes on the train.

The value of onboard travel time depended on the direction of the fare change. Dollar for dollar, passengers were less willing to pay a surcharge than they were willing to accept a discount. This translated into a higher willingness to accept (WTA) than willingness to pay (WTP). On average, passengers were willing to pay a fare surcharge of $13.56 to save an hour of onboard train time but required a discount of $33.80 to be willing to accept an extra hour of travel time.

Table 3: Estimated Values of Displacement & Travel Time

Valuation	Mean	Std Error	Low	High
Early Displacement/Onboard Time	0.53	0.06	0.41	0.65
Late Displacement/Onboard Time	0.93	0.08	0.77	1.09
Value of Onboard Time/Surcharge (WTP) $/hr	13.56	1.47	10.68	16.44
Value of Onboard Time/Discount (WTA) $/hr	33.80	12.52	9.26	58.34

Notes: WTP (Willing to Pay) WTA Willing to Accept (WTA)

In combination, the survey produced four values of displacement. A discount of $18 would be required to get passengers to travel an hour earlier (53% of 33.80) and a $31 discount to travel an hour later (93% of 33.80). Alternatively, a surcharge of $6 (53% of 13.56) would be required to get passengers to travel an hour earlier and $11 (93% of 13.56) to travel an hour later. Therefore dollar per dollar, surcharges were estimated to be three times more effective than discounts in getting passengers to shift their time of travel.

Table 3 also presents the statistical variability (denoted Std Error) in the mean (or average) estimate derived from the sample of passengers surveyed. The statistical variability reflects the fact that different passengers had different preferences regarding travel time and fare. Some responded strongly to a high fare and others did not. As only a sample of passengers was interviewed rather than a full census, if the survey was repeated a different mean estimate would result. The standard error provides a measure of the range in the mean estimate that could result.

As can be seen, the displacement values were estimated with reasonable precision. Early displacement ranged between 0.41 and 0.65 and late displacement between 0.77 and 1.09.[10]

At $13.85 per hour, the surcharge value of time was similar to the peak value of time of $12.85 reported in the CityRail Compendium.[11] The estimate was also relatively precise with a survey error range from $10.68 to $16.44 per hour.

By contrast, the discount value of time of $33.80 per hour was far less precisely estimated and had a wide range of $9.26 to $58.34 per hour. The response to the fare discounts across the respondents was much more varied than to the surcharge, dollar per dollar. A much larger sample would be required to reduce the range in the mean estimate to that for the fare surcharge. Given the lack of precision and the relatively high value, a lower discount value of time of $20 per hour was used in the rooftops model for the central case forecasts.

10 The low and high values are the 95% confidence lower and upper values calculated at ± 1.96 the standard error. If the survey was repeated with a different sample of passengers interviewed, there is a 95% chance that the value would lie within this range.

11 The value given in the CityRail Compendium 2010 (page 68) was estimated using similar Stated Preference research undertaken in 2004 by Douglas Economics and RailCorp. RailCorp has updated the values using economic indicators.

4. Case Study of the Illawarra Line

The Illawarra line including South Coast intercity services was used as a case study. The Illawarra suburban line carries 46,000 passengers in the AM 3.5 hour peak.[12] The total compares with 317,000 trips made on the CityRail network as a whole. Thus, the Illawarra line accounts for 15% of trips.

Figure 4.1: Illawarra Rail Line

In the AM Peak, 70% of Illawarra trips originate at an Illawarra station and 30% originate on another rail line and travel to an Illawarra line station.

Of originating trips, 60% exit at a CBD station, 20% travel within the Illawarra line and 5% travel on past Martin Place station to the remaining stations on the Eastern Suburbs Railway.[13] The remaining 15% transfer onto another rail line with the North Shore the most popular transfer destination.

South Coast intercity services operate from Bomaderry, Port Kembla and Wollongong and carry just over 5,000 passengers in the AM 3.5 hour peak. Intercity services carry around 10% of Illawarra suburban services. Of the total of 5,000 South Coast trips, two thirds originate at a South Coast station and one third travel to another South Coast station.

Intercity trains stop at larger 'suburban' stations such as Hurstville, which required the services to be included in the rooftops model.[14] Of passengers originating at a South Coast station, 40% travel to CBD stations, 35% travelling to other south coast intercity stations and 12% travel to suburban Illawarra stations. The remaining 13% transfer onto another rail line.

The Illawarra line obtains high AM passenger load factors (passengers as a percentage of seat capacity) in the AM peak. Indeed, in March 2010, Illawarra suburban services obtained the highest average passenger loadings of all lines. Table 4.1 presents the observed RailCorp loadings for the

[12] The patronage figures are taken from the Origin – Destination matrix (AM peak 3.5 hours) presented on page 50 of the "*Compendium of CityRail Travel Statistics Seventh Edition*", June 2010. The 'West' is the biggest rail line with around 50,000 using services in the AM peak.

[13] The Eastern Suburbs and Illawarra are physically one and the same. For public timetable reasons, the two services are separated. Central station is the dividing station.

[14] Passenger boarding Intercity services north of Thirroul are included in the suburban Illawarra figure.

Illawarra line.[15] Thus, in terms of the study, the Illawarra line offers a prime candidate for spreading passenger loads by introduction of fare discounts / surcharges.

Table 4.1: Average Loads on Morning Peak Illawarra Trains to Sydney CBD
RailCorp Loading Surveys March 2010

Line		One Hour Peak 0800-0859 (Central Time)				3.5 hr Peak 0600-0930 (Sydenham Time)			
(Survey Station)	Service	Trains	Seats	Pax	LF	Trains	Seats	Pax	LF
Illawarra	Cronulla	4	3,520	5,120	145%	12	10,586	11,590	110%
(Sydenham)	Waterfall/Thirroul/S'land	6	5,088	7,355	145%	13	11,086	12,490	115%
	Hurstville/Mortdale	4	3,546	4,050	115%	12	10,344	7,425	70%
	Suburban Total	14	12,154	16,525	135%	37	32,016	31,505	100%
Line		One Hour Peak 0729-0828 (Central Time)				3.5 hr Pk 0530-0900 (Helensburgh Time)			
(Survey Station)	Service	Trains	Seats	Pax	LF	Trains	Seats	Pax	LF
South Coast	Kiama/Dapto/P. Kembla	3	2,560	1,410	55%	9	5,520	3,240	60%
(Helensburgh)	Thirroul - Bondi Junction	2	1,704	50	5%	3	2,516	60	0%
	South Coast Total	5	4,264	1,460	35%	12	8,036	3,300	40%

For March 2010, RailCorp loading surveys estimated an average passenger loading of 135% for the fourteen peak hour Illawarra Suburban services measured at Sydenham. The average load factor varied by service group. For the four services commencing at Cronulla, the average passenger load reached 145% with 5,120 passengers compared to 3,520 seats. Thus at least 1,600 passengers were standing at Sydenham.[16] For the six Waterfall/Thirroul/Sutherland starters, a similar load factor of 145% was obtained with 7,355 passengers and 5,088 seats. However the four 'local' or 'all stop' Hurstville and Mortdale starters had a lower load factor of 115% at Sydenham.

Compared to other suburban services, Cronulla and Waterfall/Thirroul/Sutherland starters had the highest observed peak hour passenger loads at 145%. The next highest average load was for South services via Granville at 135% followed by Northern services with an average of 130%.

South Coast intercity services were also included in the model because the stopping pattern overlaps that of the suburban Illawarra services. All intercity services stop at Hurstville for example. Thus Hurstville passengers have the full range of suburban and also intercity services to choose from. In addition, setting different fares on intercity services compared to suburban services would also affect loadings.[17] Unfortunately, RailCorp does not survey passenger loads for South Coast intercity services at the same point as for suburban services. Instead of Sydenham, South Coast services are measured further out at Helensburgh at the end of suburban services; this makes comparison of loadings difficult since loadings will be lower than at Sydenham. In fact, in March 2010, the average loading for the 5 peak hour intercity services was only 35% at Helensburgh.

15 The loading figures are taken from page 38 of the 2010 Compendium. A full tabulation of all CityRail lines is given in section 5.1 of the Compendium.

16 Some seats will have been empty (often middle seats in three seat rows) thus the number standing will have exceeded 1,600.

17 In New Zealand, a minimum fare is set on longer distance express commuter services out of Wellington to discourage passengers who could use local services.

5. Forecast Impact on Patronage & Revenue

5.1 Fare Incentives Modelled

The model was used to predict the ability of fare discounts and fare surcharges to spread Illawarra passenger loads across the AM peak . In section 6, the results are generalised to other rail lines of interest. Nine incentives were modelled:

1. Free Travel on Trains Arriving Central before 7am
2. Free Travel on Trains Arriving Central before 7.30am
3. Free Travel on Trains Arriving Central before 8am
4. 50% Discount on Trains before 0715 & after 0915
5. 25% Discount on Trains arriving Central before 8am and after 9am
6. 25% Surcharge on trains arriving Central between 8 and 9am
7. 10% Surcharge on trains arriving Central between 8 and 9am and a 10% discount on trains arriving before 8am and after 9am
8. 10% Surcharge on trains arriving Central between 8 and 9am and a 30% discount on trains arriving before 8am and after 9am
9. 25% Surcharge on trains arriving Central before 8 and 9am and a 25% discount on trains arriving before 8am and after 9am

Tests 1 and 4 were similar to actual fares introduced in Melbourne and Sydney and Test 5 is similar to a discount fare introduced on a rail line in Wellington. These three tests allow the model forecasts to be compared with observed patronage response to actual fare initiatives. The three examples are discussed in sections 5.2 to 5.4.

A key assumption that was made in the modelling work is that the total volume of rail patronage remained unaffected. That is the discount or surcharge only affected the choice of train and did not generate or suppress any rail trips.

5.2 Melbourne Early Bird Ticket

The Early Bird ticket was trialled on two rail lines in October 2007 and rolled out onto all 15 rail lines in March 2008 and is still available as of April 2012. The Early Bird is a multi-trip pack of ten tickets offering passengers free rail travel if trips are completed before 7 a.m. Passengers are required to validate their ticket when exiting CBD station barriers.

The patronage effects of the Early Bird ticket were reviewed by Currie.[18] He estimated that in 2010, 8,000 to 9,000 passengers used the ticket each weekday. Of these passengers, 23% had shifted their time of travel (2,000–2,600 passengers) by an average of 42 min. The shift reduced demand during peak hour (8-9am) between 1.2% and 1.5% from previous levels which was considered equivalent to a maximum of five average train loads. The program cost was estimated to have cost $6 million in lost fare revenue.

[18] Currie G. (2009) *"Exploring the Impact of the 'Free Before 7' Campaign on Reducing Overcrowding on Melbourne Trains"* Paper presented at the 32nd Australasian Transport Research Forum Auckland, New Zealand 29th September 2009.

Currie considered that demand growth far outweighed this effect so that overloading had increased after the early bird program had been introduced. Its effect was to reduce the scale of increased overloading. Overall, it is unclear to what degree the early bird ticket program has acted to reduce overloading. Peak travel during the less critical 7:00 to 8:00 a.m. peak time has been reduced; however, its effect during the critical 8:00 to 9:00 a.m. peak time is low.

5.3 Sydney Smart Saver

The Smart Saver was introduced as trial on the West, Carlingford and Richmond rail lines in August 2008. The trial lasted for ten weeks.

The Smart Saver was valid on trains scheduled to arrive at Central between 4 am – 7:15 am or between 9:15 am and 10:15 am departing from Central anytime before 4 pm and after 6:30 pm.

Research by TNS[19] summarized by Henn[20] estimated that the Smart saver had led to 2% per cent reduction in peak hour rail patronage on the rail lines with the broad travel time exclusions (including those in the pm peak) being identified as a major inhibitor of ticket take-up.

5.4 Wellington Peace Monthly

A fare discount of 25% was offered on the standard monthly for travel on the Johnsonville line in Wellington during the 2000s. The discounted monthly fare was called the Peace Monthly and was available on all trains except the busiest two inbound trains (arriving 08:07 and 8:20) in the AM peak.

The Johnsonville line is a short 11km rail line which operates to a 15-20 timetable during the peak period. Tickets are inspected on trains by guards. The Peace Monthly was introduced to encourage people off the busiest two trains which suffered from overloading. The ticket was considered to have reduced patronage on the two trains by 20%.[21]

5.5 Forecast Patronage and Revenue Impacts

The impact on patronage was measured in terms of the passenger load of trains at Sydenham. Trains were aggregated according to their arrival time at Central. Three groups were defined: early peak (trains arriving between 6 and 8am), peak hour (trains arriving between 8 and 9am) and late peak (trains arriving between 9 and 9.30). The change in train load was expressed as a percentage of the base load.

The revenue impact was calculated assuming a base average adult fare of $3.30 per trip ($1.65 was assumed for school children who account for 9% of trips). The fare incentive was applied to all trips

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[19] TNS Social Research 2008, *"SmartSaver trial evaluation report of findings September – October 2008"*, report to RailCorp, Sydney.

20 Henn, Karpouzis and Sloan (2010) *"A review of policy and economic instruments for peak demand management in commuter rail", paper presented at the* 33rd Australasian Transport Research Forum Conference held in Canberra, on 29 September - 1 October, 2010.

[21] The estimate was provided by Graham Mowday Marketing Manager of Tranz Metro up until mid 2011.

on affected AM peak trains not just the passengers travelling on trains at Sydenham. The forecast impact of the incentives on passenger loads and revenue is presented in Table 5.5.

Table 5.5: Predicted Patronage and Revenue Impact

Illawarra & South Coast Services

	Fare Incentive	Peak Train Load at Sydenham Early Peak Before 0800	Peak Hour 0800-0900	Late Peak 0900-1000	Revenue Change %
1	Free Travel before 7am	3%	-2%	-1%	-11%
2	Free Travel before 7.30am	9%	-6%	-3%	-22%
3	Free Travel before 8am	19%	-11%	-6%	-37%
4	50% Discount before 0715 & after 0915	1%	-4%	7%	-15%
5	25% Discount before 8am & after 9am	4%	-4%	4%	-14%
6	25% Surcharge 8-9am	5%	-6%	6%	10%
7	10% Surcharge 8-9am & 10% Discount Before/After	4%	-4%	4%	-1%
8	10% Surcharge 8-9am & 30% Discount Before/After	6%	-8%	7%	-13%
9	25% Surcharge 8-9am & 25% Discount Before/After	9%	-11%	9%	-5%

Free travel on trains arriving Central before 7am was forecast to reduce peak hour patronage by 2%. The low response results from a combination of the average fare $3.30, a 'discount' value of time of $20 per hour and the need to travel an hour earlier. With a value of time of $20 per hour, saving $3.30 would be worth only ten minutes of onboard travel time. However, to qualify for this saving passengers would need to travel an hour earlier, which for the average customer would be equivalent to around 30 minutes of onboard train time. Nevertheless, for a minority of customers (with lower values of time) this would be worthwhile, and at 2%, the forecast peak hour reduction was of a similar magnitude, albeit slightly greater, than the 1.2-1.5% reduction estimated to have resulted from the Melbourne Early Bird ticket. In terms of ticket revenue, the model forecast a reduction of 11% which reflects the patronage share of early peak trains.

Extending free travel half an hour to trains arriving at Central up to 7.30am increased the shift out of the peak hour threefold. Peak hour loads fell 6% with early peak loads increasing by 9%. At 22%, the loss in AM peak revenue was forecast to be significant.

Offering free travel up to 8am increased the shift out of the peak hour to 11% but with a marked reduction in revenue of 37%. This fare structure could also be practically difficult to implement, as it could create large customer build up behind CBD turnstiles shortly before 8am. The remaining scenarios therefore adopt a more focussed approach to fare incentives with a lesser level of discount.

Test 4, a 50% fare discount on trains before 0715 and after 0915, matches the fare conditions of the Sydney Smart Saver. The model forecast peak hour passenger loads to reduce 4% which is double the 2% reported for the Smart Saver during its ten week trial. Revenue was forecast to reduce by 15%.

Test 5, a 25% discount on trains before 8am and after 9am produced a 4% reduction in peak hour patronage. This is much lower than the 20% reduction reported for the Peace Monthly ticket in Wellington. The Wellington ticket was less restrictive however being available on all but two peak trains arriving in a thirty minute window.

The model forecast a bigger response to a 25% fare surcharge in test 6. Peak hour passenger loads fell by 6% which was 50% greater than the 25% discount on early and late peak trains. The higher demand response reflected the lower 'surcharge' value of time estimated by the market research. The revenue impact was positive, increasing by 10% although it should be remembered that total rail demand was assumed to remain unchanged.

A 10% surcharge on peak hour trains combined with a 10% discount on early and late trains produced a more modest 4% reduction in peak hour patronage but had a near neutral revenue impact (-1%).

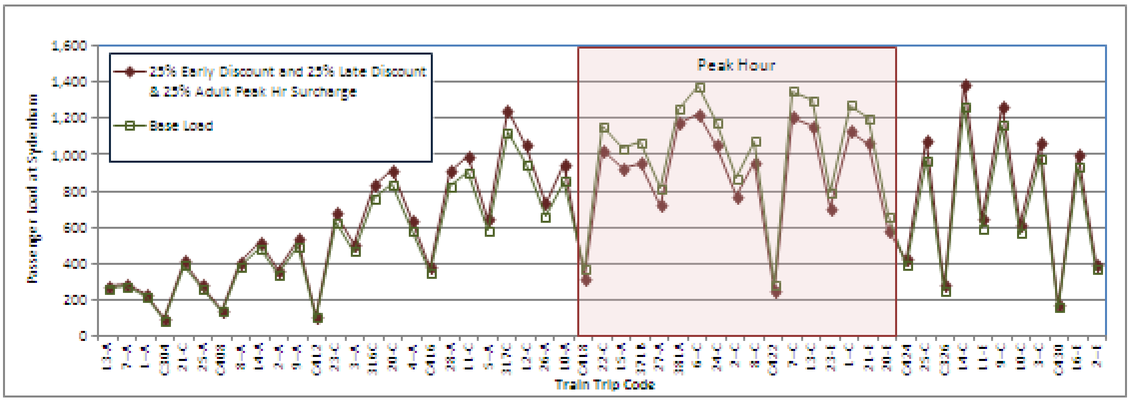
A 10% surcharge on peak hour trains combined with a 30% discount on early and late trains produced an 8% reduction in peak hour patronage but had a more substantial revenue impact of minus 13%.

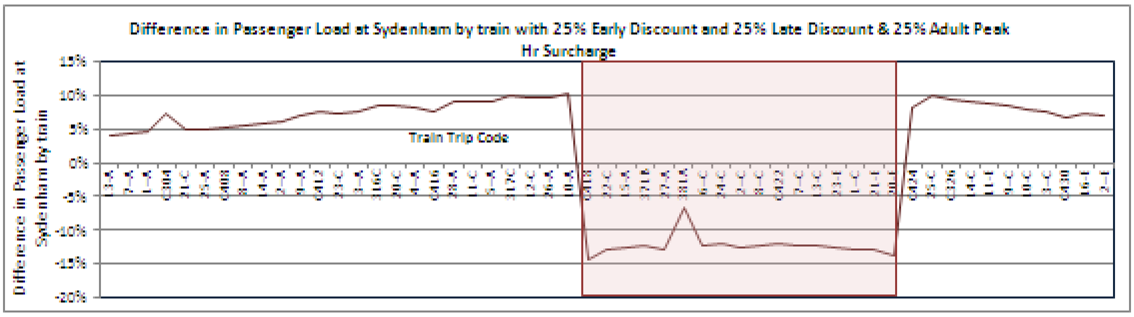
Increasing the fare difference to 25% produced the largest patronage shift out of the peak. Peak hour train loads fell 11% for a relatively small revenue loss of 5%. Figure 5.5 shows the effect of the fare policy on individual train loads (presented in chronological order).

The graphs shows passengers tend to shift to the trains closest to the peak hour that offer a fare advantage whereas within the peak hour, the shift is greatest towards the start and finish rather than at the peak of the peak.

Figure 5.5: Impact of a 25% Surcharge on Pk Hr & 25% Discount on Early & Late Pk Trains

Passenger Loads on Illawarra & South Coast Trains measured at Sydenham





5.6 Sensitivity Analysis

The parameters used in the model to measure passenger response to fare discounts and surcharges were based on market research questionnaire surveys of passengers.

To test the effect on patronage and revenue, four sensitivity tests were undertaken that varied the parameter values. The parameter values are summarised in Table 5.6.1.

Table 5.6.1: Sensitivity Tests

Valuation	Central Case	A Survey WTA	Central Case ± 20% B Low -20%	C High +20%	D CityRail VOT
Early Displacement/Onboard Time	0.53	0.53	0.42	0.64	0.53
Late Displacement/Onboard Time	0.93	0.93	0.74	1.12	0.93
Value of Onboard Time/Surcharge (WTP) $/hr	13.56	13.56	10.85	16.27	12.85
Value of Onboard Time/Discount (WTA) $/hr	20	33.80	16	24	12.85

The sensitivity analysis was undertaken for a 25% surcharge on trains arriving Central between 8-9am and a 25% discount on trains arriving before 8am and after 9am.

Table 5.6.2: Sensitivity Test Results

Predicted Patronage & Revenue Impact on Illawarra & South Coast Services
Response to a 25% fare surcharge on peak hour and 25% discount on early and late peak services

	Sensitivity Test	Early Peak Before 0800	Peak Hour 0800-0900	Late Peak 0900-1000	Revenue Change %
9	Central Case	9%	-11%	9%	-5%
9A	Survey Discount VOT of $33.80/hr	7%	-9%	7%	-5%
9B	Low Values of Displacement & Travel Time (-20%)	14%	-15%	13%	-6%
9C	High Values of Displacement & Travel Time (+20%)	6%	-8%	6%	-4%
9D	CityRail Compendium Peak Value of Time ($12.85/hr)	11%	-14%	12%	-5%

Using the survey mean estimate for the discount value of time of $33.80 per hour (test 9A) instead of the $20 per hour assumed (whilst keeping all the other parameters the same) reduced the patronage shift out of the peak hour from 11% to 9%.

Reducing the parameter values by 20% (test 9B) increased the shift out of the peak hour to 15% whereas increasing the values by 20% (9C) lowered the shift to 8%.

The final test replaced the discount and the surcharge values of time with a single value of time of $12.85 per hour as given in the CityRail Compendium for peak travel. With this value of time, the shift out of the peak increased to 14%.There was less impact on revenue with a reduction of 4% to 6% compared to 5% in the central case.

In conclusion, the value of time evidence suggests a greater likelihood for lower values of time and especially so for fare discounts. Accepting this suggest implies greater upside potential for peak spreading than downside.

6. Applying the Forecasts to Other Rail Lines

6.1 Indirect Approach

The model forecasts presented in section 5 are applied to Illawarra, Main West, North Shore and all rail lines. The forecasts are used to determine the reduction in peak hour trips to the CBD and the revenue impact of the seven fare incentives. It should be remembered that the model was developed and calibrated to the Illawarra and South Coast rail lines and although the behavioural parameters used in the model were based on market research undertaken across the suburban network, the patronage and timetable data was necessarily specific to the Illawarra and South Coast rail lines. Thus given that 'rooftop' models have not been developed for the other rail lines, the forecasts can only be indicative.

Factors likely to influence the extent of peak spreading include the average trip length from the CBD, the frequency of peak and shoulder peak services and the fare structure. In terms of shoulder peak services, if services are timetabled close to peak hour services, passengers would need to displace fewer minutes to take advantage of a fare incentive than if there was a wider service gap.

6.2 Peak Hour Patronage Reduction

The forecasts were based on patronage figures given in the 2010 CityRail Compendium. The Compendium tabulates the number of trips made to and from each rail line for the AM peak 3.5 hour period.[22] It was assumed that the fare discounts and surcharges would only apply to trips made to CBD stations. Of a total of 317,000 AM peak trips the Compendium gives a figure of 149,000 (just under one half) made to CBD stations.

The Compendium estimates that 55% of AM peak trips to the CBD are made in the peak hour. Thus the total of peak hour CBD trips is 82,000. By line, 12,700 are made on the Illawarra, 10,700 on West and 8,000 on North Shore services. These estimates are shown on the bottom line of Table 6.2.

The forecast impact of each fare incentive was determined by multiplying the number of trips by the predicted peak hour percentage reduction in Table 5.5.

Offering free travel on trains arriving Central before 7am is forecast to reduce CBD trips by 300 on Illawarra line and by 200 on both West and North Shore services. If offered on all services, a reduction of 1,600 CBD trips in the peak hour is forecast.

Three times the reduction is forecast if free travel is extended to 7.30am with 4,900 CBD trips shifted out of the peak hour if offered on all rail lines. If free fares are extended up to 8am the reduction in peak hour demand is forecast to increase to 9,000 passengers.

The same patronage shift as offering free fares on trains up to 8am is forecast with a 25% surcharge on peak hour trains in combination with a 25% discount on trains arriving before 8am and after 9am (test 9). In total, 9,000 peak hour CBD trips are forecast to shift out of the peak hour. By line, 1,400 trips are diverted from Illawarra services, 1,200 from West and 900 from North Shore services.

22 Page 51 of the 2010 CityRail Compendium.

If the discount and surcharge is lowered to 10%, the patronage shift reduces by two thirds to 3,300 trips across all lines (test 7).

Table 6.2: Predicted Peak Hour Patronage Reduction

Predicted Reduction in Peak Hour Patronage to Sydney CBD Stations

	Incentive	Peak Hour Reduction %	AM Peak Hour Reduction (Trips) Illawarra	West	N. Shore	ALL CBD
1	Free Travel before 7am	-2%	-300	-200	-200	-1,600
2	Free Travel before 7.30am	-6%	-800	-600	-500	-4,900
3	Free Travel before 8am	-11%	-1,400	-1,200	-900	-9,000
4	50% Discount before 0715 & after 0915	-4%	-500	-400	-300	-3,300
5	25% Discount before 8am & after 9am	-4%	-500	-400	-300	-3,300
6	25% Surcharge 8-9am	-6%	-800	-600	-500	-4,900
7	10% Surcharge 8-9am & 10% Discount Before/After	-4%	-500	-400	-300	-3,300
8	10% Surcharge 8-9am & 30% Discount Before/After	-8%	-1,000	-900	-600	-6,600
9	25% Surcharge 8-9am & 25% Discount Before/After	-11%	-1,400	-1,200	-900	-9,000
	Total AM Peak 1 Hour Patronage	na	12,700	10,700	8,000	82,000

6.3 Revenue Impact

A crude assessment of the impact on ticket revenue was made by multiplying the forecast percentage revenue reduction (Table 5.5) with annual AM peak (3.5 hrs) revenue.[23] Revenue was estimated assuming an average fare of $3.16 per trip.[24] For all trips to the CBD, annual AM peak revenue was estimated at $118 million and is shown in the bottom row of Table 6.3.

Table 6.3: Predicted Revenue Impact of Fare Incentives

	Incentive	Revenue Change %	Annual Revenue Change $m Illawarra	West	N. Shore	ALL CBD
1	Free Travel before 7am	-11%	-2.0	-1.7	-1.3	-13
2	Free Travel before 7.30am	-22%	-4.0	-3.4	-2.5	-26
3	Free Travel before 8am	-37%	-6.8	-5.7	-4.2	-44
4	50% Discount before 0715 & after 0915	-15%	-2.7	-2.3	-1.7	-18
5	25% Discount before 8am & after 9am	-14%	-2.6	-2.2	-1.6	-17
6	25% Surcharge 8-9am	10%	1.8	1.5	1.1	12
7	10% Surcharge 8-9am & 10% Discount Before/After	-1%	-0.2	-0.2	-0.1	-1
8	10% Surcharge 8-9am & 30% Discount Before/After	-13%	-2.4	-2.0	-1.5	-15
9	25% Surcharge 8-9am & 25% Discount Before/After	-5%	-0.9	-0.8	-0.6	-6
	Annual AM Peak 3.5hr Ticket Revenue $m	na	18	15	11	118

23 The model only models the AM peak 3.5 hr period. It is noted that CityRail already offers an off-peak return for travel after 0930. The implications of lengthening the period of analysis to, for example, midday have not been explored.

24 The average fare of $3.30 used in the rooftops model was adjusted downwards to $3.16 to allow for school children. The figure compares with an average revenue per trip of $2.81 calculated from annual ticket data in the 2010 Compendium. To calculate annual patronage, AM peak 3.5 hour patronage was multiplied by 250.

Offering free travel to passengers travelling to the CBD on trains arriving Central before 7am was estimated to cost $13 million per year. This is slightly more than double the $6 million loss in revenue estimated for the Melbourne Early Bird ticket.

Extending free travel to 7.30am doubled the revenue loss to $26 million a year and to $44 million if extended to 8 am.

Introducing a ticket similar to the 2008 Sydney Smart Saver trial offering a 50% discount on trains arriving before 7.15am and after 9.15am was estimated to cost $18 million a year.

Combining a 10% discount on early and late peak trains with a 10% surcharge during the peak hour was close to revenue neutral costing $1 million a year. A 25% discount/surcharge was estimated to cost $6 million a year. By contrast, offering a larger discount of 30% on early and late peak trains with a 10% surcharge during the peak hour would cost $15 million a year in lost revenue.

The estimated revenue losses from the discounted fare options are based on assuming passengers with non CBD destinations (45% of AM peak trips) would not receive the discount. In practice although the Airport Rail Line provides a precedent for differential station fares, there could be resistance to pricing CBD rail station fares differently to non CBD stations. Clearly, if the discounts were extended to non CBD customers, the revenue loss would be exacerabated for lesser proportional reductions in train and station crowding. Similarly, extending the discounts to cover the return evening trip would also increase the revenue loss. On the other hand, a revised peak pricing structure would probably replace the current CityRail off-peak ticket product, which may provide an offsetting revenue improvement.

7. Concluding Remarks

The rooftops approach lends itself to modelling the ability of fare to spread peak loads. The model was developed as a 'proof of concept'. Several simplifications were made in the treatment of fare and the description of passenger journeys. Further work could review and improve on these simplifications.

The model was developed for the Illawarra line. The accuracy by which the results can be generalised to other rail lines depends on the similarity of the timetables, demand and fare profiles. Ideally, individual models tailored to each rail line should be built.

The model was used to forecast the patronage and revenue effects of a range of fare incentives. The model predicted that peak hour fare surcharges, dollar for dollar, would be more effective in shifting passengers out of the peak hour than early and late peak discounts. This result reflected the behavioural parameters in the model which were based on the stated response of passengers to hypothetical situations. In general, the market research was successful in estimating values of reasonable magnitude and precision. However, the implied 'discount' value of time was considered to be too high and was replaced by a lower value in the forecasting model. Further market research could be undertaken to improve the accuracy of the 'discount' value of time.

Knowing the profile of when passengers want to travel is a key modelling requirement. The model used a profile based on CBD barrier exits. The model was then calibrated to actual loadings observed on the Illawarra line. It was also possible to validate the model predictions against the actual response to three fare discounts although no examples of introducing fare surcharges were able to be found. More work could be undertaken on understanding the factors that determine when passengers want to travel.

The model was based on travel in the AM peak and did not consider the PM peak. Further work could aim to develop an integrated AM/PM model.

The model has only been used to evaluate fare initiatives. The approach could be extended to evaluate the effect of timetable changes on train passenger loads. Changes that could be modelled include express services in the shoulder peak or an increased number of shoulder peak train services.

Finally, further work could measure the degree of displacement of peak hour passengers who shift into the early and late peak periods. If a reasonably large percentage of passengers displace, there could be opportunities to get a bigger peak reduction by introducing additional shoulder peak trains, subject to the operational feasibility of such scheduling.

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