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A review and assessment of fare capping as a passenger incentive mechanism for Australia and New Zealand

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Abstract

Globally, there has been a tendency over the last decade towards simplifying fare structures and automating fare payment and ticketing systems. This trend has been supported by the advent of smartcard ticketing systems, which are now used by virtually all public transport systems in Australia and New Zealand.

The deployment of smart ticketing technology has provided an opportunity for public transport authorities to introduce more innovative fare products, such as fare capping. This paper discusses the key features of fare capping and the principles that govern its design and functions. The paper also provides a framework for evaluation of the appropriateness of a fare capping or reward system based on a range of objectives and performance measures, including equity, simplicity, cost recovery, affordability and patronage impacts.

1. Introduction

One of the key goals for public transport authorities in Australia and New Zealand is to increase demand for public transport, which needs to be balanced against affordability and other objectives (Litman, 2014; Currie and Delbosc, 2010; Wang, Li and Chen, 2015). This effectively means that public transport authorities need to maximise demand within a given funding envelope. Amongst other things, this requires a consideration of fare levels and products that incentivise travel for different market segments (Paulley et al., 2006).

The advent of smartcard ticketing systems has provided an opportunity for public transport authorities to consider more innovative fare products, including fare capping which is the subject of this paper. The majority of public transport systems in Australia and New Zealand now have smartcard ticketing systems. These systems have generally demonstrated a positive effect on demand and have significantly improved the quality and quantity of data available for planning purposes, (Puhe, 2014; Matas, 2004; Mezghani, 2008; Lübeck, Wittmann and Battistella, 2012; Currie and Wallis, 2007).

This paper seeks to provide some insights into what fare capping is, how it is applied in Australia and New Zealand and a methodological framework to assist in evaluating the appropriateness of fare capping and reward options.

2. Concepts and application of fare capping

The concept of fare capping to reward frequent and/or regular users of public transport has been around for some time and was documented about a decade ago (Streeting and Charles, 2006). Our review of the literature, however, identified very little in-depth discussion of the principles and mechanisms behind the concept of fare capping.

2.1. What is fare capping?

Fare capping is built upon the concept of a guaranteed lowest fare. This ensures that users will only be charged the lowest fare for which they are eligible based on their travel behaviour, which can be especially useful where the fare structure is based on a complex mix of distance and time-based products. The concept of fare capping is consistent with the move towards simplified fare structures as the complexity of the required calculations are hidden from passengers (e.g. passengers only need to know that their fare is capped at $5, not how the cap is calculated).

We define fare capping as a policy instrument or a reward scheme where the total fare paid by each passenger within a specified time period is “capped” after a certain number or value of trips as a reward for frequent and/or regular use. The resulting capped fare is a distinct fare product, with specific marketability and implications on user travel behaviour, demand and revenue. Fare capping encourages users to make more trips by inducing a perception of free or highly discounted travel after a threshold defined by the cap. We note, however, there is also a significant revenue implication for the public transport authority as any revenue currently received from trips made above any proposed cap would be lost (assuming free travel once a cap has been reached).

We have identified two broad approaches to applying fare caps:

- **Trip based caps –** where fares are capped at a specified number of trips within a specified period, irrespective of the fare paid.
- **Value based caps –** where fares are capped at a specified dollar value within a specified period. The dollar value may vary for different passenger types, or be based on a number of zones or stages travelled or time/day periods.

Some variations or combinations of the two approaches can also be applied. For example, a capping scheme can be designed so that a reduced fare is charged for each trip or journey above a certain minimum number of trips or journeys during a specified time period. This type of capping provides multiple threshold levels. A cap can also be set at a specified number of longest distances travelled or at the equivalent price of the most frequently travelled number of zones or stages. Likewise, a capping scheme can apply differentiated fares by mode, service or groups of services and operators. A capped fare can also be differentiated by time of day or week.

Taken to an extreme, capping schemes may result in a range of various capping levels and can result in a complex set of fares and fare calculations. Complexity in fare structure can bring about undesirable outcomes such as inconvenience for users, inefficiency for operators and significant costs for public transport authorities. The need for simplicity, or at least the appearance of simplicity to the passengers, is increasingly an objective for fare systems. Taking this into consideration two broad capping approaches can be identified:

- **Universal fare caps** - where one capped fare applies to the entire system for one or more passenger groups, or
- **Graduated fare caps** - where caps may increase on a graduated basis e.g. by distance/fare zone or time/day period for one or more passenger groups.

The impact of these different approaches to fare capping is influenced by the overall fare structure. Within a flat fare structure, trip and value based approaches are the same and would generally be applied as a universal fare cap (assuming that fares do not vary by time/day period). Within a graduated fare structure, where fares reflect the distance travelled or vary by time of day, the effect of a capping approach will depend on the individual trips and whether the fare cap is trip or value based.

We note that there is a need for a degree of vigilance with respect to the factor of “time”. A fare structure may differentiate fares by time or day period (e.g. peak/off-peak or weekday/weekend). However within the same fare structure, a capped fare may be independent of time resulting in varying incentive levels that may or may not be intentional.

2.2 Perceived benefits of fare capping

Fare capping provides generally the same benefits that traditional period or multi-trip tickets offer to users. Period passes have been popular mostly because many users perceive them as being convenient and offering better saving options (Graham & Mulley, 2012; Mc Collom and Pratt, 2004). The popularity has also been driven by supply-side benefits including guaranteed revenue and significant reduction in boarding time and cash handling (Graham & Mulley, 2012).

Generally, fare capping offers an easy, flexible and relatively affordable alternative for regular/frequent passengers (e.g. commuters) by ensuring that they pay no more than the fare associated with the traditional pass products they use. This depends on policies and the level of initial discounts offered by pass products. Traditional pass products are generally deeply discounted and providing the same level of discount may not be financially viable in some system, given that fare capping does not secure the same amount of revenue as the legacy pass products do. The flexibility though can attract new customers and increase loyalty of committed users (Mezghani 2008).

A key benefit of fare capping is that users are not required to estimate their potential travel for a period in order to pre-purchase any specific product and do not need to be concerned about when to renew their pass; although users still need to ensure a sufficient balance in their accounts. This feature of capping means that the benefits of a capped product can extend to a wider demographic than, for example, just commuters. In this sense, fare capping improves equity and consistency in allocation of benefits across users with different purchasing powers.

Fare capping schemes can be introduced using existing smartcard systems without the need for additional separate fare media (e.g. additional paper tickets). Therefore, compared to conventional period products, a capping scheme is normally easier to administer and less costly to maintain. However, a capping scheme may incur significant costs for its design, development, testing and deployment. This depends on the parameters that define pricing structure, network complexity and other fare policies and rules.

A capping scheme is also more extensible than a conventional period pass, and can easily cope well with various pricing policies and fare structures. The complexity is hidden from the passenger who instead is presented with a simple marketable fare product (e.g. pay no more than $5). Fare capping can also reduce fraud and revenue dilution if properly designed and validated.

This was only a brief overview of the perceived benefits of fare capping schemes. A more detailed assessment of economic benefits and effectiveness of existing capping schemes would help confirm and better quantify these benefits. A proper understanding of the potential benefits of fare capping would help public transport authorities identify and develop appropriate sets of outcomes and performance indicators to monitor effectiveness of their capping schemes.

2.3. How fare capping is implemented?

Fare caps are similar in concept to period passes but require a significantly more sophisticated ticketing system to implement. The ability to provide fare capping products arises from the data processing and computational capabilities of smartcard ticketing systems. To implement fare capping, a smartcard ticketing system needs to track the time and value of individual transactions in order to compute the number and value of each passengers' boardings towards the cap. Once the fare cap threshold is met, the system stops charging for additional trips. Further detail on the technology and implementation of smartcard ticketing systems is beyond the scope of this paper.

3. Fare capping in Australia and New Zealand

3.1 Fare capping schemes

As shown in Table 1, a number of public transport systems currently provide fare capping products. Daily fare caps are the most common but week and monthly caps are also available in some areas. Daily caps are often set at the same level as a cash day pass (available in most regions). Weekly caps are assumedly targeted for commuters making at least 10 trips per week (five return trips). Some fare caps also accommodate different time periods (e.g. peak/off-peak) and days of the week (e.g. weekday/weekend).

Fare caps either replace or complement other fare products and are often applied in conjunction with period passes. Fare caps, in combination with other smartcard fares, can also completely replace traditional fare products, for example in Melbourne where cash fares are no longer available.

Table 1 Summary of urban fare products offered in New Zealand and Australia

Country	System	Day pass	Day cap	Week pass	Week cap	Month pass	Month cap
NZ	Auckland	Y	-	-	-	Y	-
	Christchurch	-	Y		Y	-	-
	Dunedin	-	-	-	-	-	-
	Hamilton	Y	-	-	-	-	-
	Invercargill	-	-	-	-	-	-
	Napier/Hastings	-	-	-	-	-	-
	Nelson	Y	-	-	-	-	-
	New Plymouth	-	-	-	-	-	-
	Palmerston North	-	-	-	-	Y	-
	Rotorua	Y	-	-	-	-	-
	Tauranga	Y	-	-	-	-	-
	Timaru	-	-	-	-	-	-
	Wanganui	-	-	-	-	Y	-
	Wellington	Y (OP)	-	-	-	Y	-
	Whangarei	-	-	-	-	-	-
AUS	Adelaide	Y	-	-	-	-	-
	Brisbane/SE Queensland	-	-	-	Y	-	-
	Bunbury (WA)	-	-	-	-	-	-
	Cairns (Queensland)	Y	-	Y	-	-	-
	Canberra	Y	Y (P/OP/ WE)	-	-	-	Y
	Darwin	Y	-	Y	-	-	-
	Geelong (Victoria)	Y	-	Y	-	-	-
	Melbourne	Y (SC)	Y	Y	Y (WE)	-	-
	Perth	Y (OP)	Y (OP)	-	-	-	-
	Sydney	Y	Y	Y	Y	-	-
	Shepparton (Victoria)	Y	-	Y	-	Y	-
	Tasmania (urban)	Y	Y	-	-	-	-

Key: T=Train only, OP=Off-peak only, WE=Weekend and Public Holidays only, SC=Seniors daily caps apply to smartcard trips only

3.2. Common objectives of fare capping

Our literature review was unable to identify any objectives in current policy documents in Australia and New Zealand that are specific to fare capping (as opposed to general fare policies). Nonetheless it is clear from fare capping schemes that the objective is principally to reward users who engage in repeated (frequent) or regular use of public transport.

A key objective behind fare capping has been to replace or complement time-based fare products (including daily, weekly and monthly passes). This can be seen when reviewing the status of weekly capped fares in relation to their traditional equivalents. In Brisbane and Christchurch a weekly cap has replaced monthly passes. In Sydney and Melbourne some multi-trip and period passes including weekly and bi-weekly passes still coexist with a weekly cap. Except for Christchurch, where a daily cap has completely replaced legacy tickets, in almost all other cases some form of daily cap is available along with day period passes. In some cases (e.g. in Sydney and Melbourne), different types of capping have been designed to match the different incentives that are normally offered by traditional period passes.

The fare capping scheme in Christchurch was introduced as part of the restructuring of the fare system. The primary intention behind the daily and weekly maximums that were introduced was to remove the traditional return tickets and period passes due to their inconsistency with the new fare structure (pers comms). The daily maximum is set at the price of a return trip and was introduced to spread the peak demand by encouraging non-commuters to travel outside peak hours (Douglas, 2009). The weekly maximum was also intended to provide an affordable option to encourage frequent travel.

In recent years, Wellington has developed policies to introduce a fare capping scheme as part of its multi-year integrated fares and ticketing programme, with an intention to simplify the fare structure partly by replacing existing multi-trip and period passes with daily and weekly capped fares, as well as to remove existing inconsistencies and to provide flexible and affordable options for frequent and regular users. The ultimate objective is to increase patronage in a cost-effective manner.

These instances of fare capping indicate that various reasons could drive a decision to introduce a fare capping scheme. A key consideration is to align the specific reasons behind fare capping with the overall objectives of the public transport authority and to ensure that a capped fare does not undermine other objectives.

4. Principles and mechanisms of fare capping

The underlying principles and mechanisms behind fare capping follow nearly the same principles that govern the typical concept of ‘frequent user incentive’ commonly implemented in service businesses such as airlines, retail market, hotels and car rental agencies (Pride, Hughes, & Kapoor, 2011). There are also similarities between the discounting mechanism for fare capping and the conventional multi-use period passes.

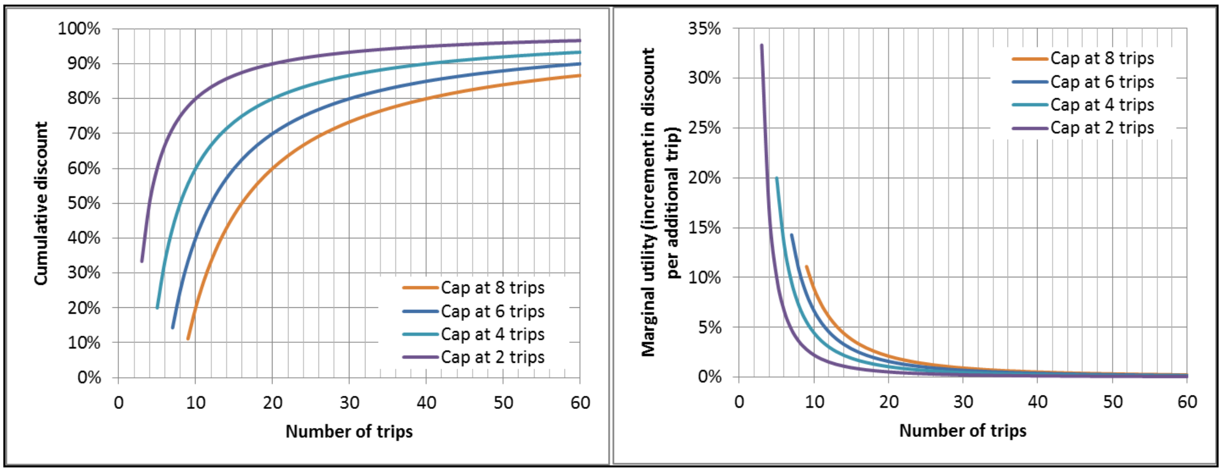
A fundamental principle with any fare capping scheme is that users are rewarded only if the sum of their individual trip payments or the number of trips they have made passes the level of the specified cap. This rule first drives users to trigger the cap and then encourages them to make more trips and benefit from the free travel rewards or discounts on additional trips (and in the case of public transport ultimately reduce reliance on private car). Capping schemes are generally designed so as to provide 100 percent discount on any travel beyond the cap. The marginal utility that a user gains from each additional free trip depends on the degree of change to the total discount as a result of an additional trip after the cap, which is also a basic parameter to determine the cost breakeven point and revenue impact of a capped fare.

In principle, the degree of incentive provided by a capping regime depends primarily on the level at which the cap is set, the type and frequency of trips made by users (users’ travel habit) and willingness to take advantage of savings or sensitivity of users to cost (measured using fare elasticities), and availability of alternative products. The basic mechanism behind fare capping may result in different outcomes, primarily depending on the fare structure in which the capping is implemented. These differences are discussed below:

4.1. Flat fare systems with time-invariant caps

Within a flat fare structure, the marginal passenger fare is generally the same as average fare. Therefore the utility of a cap at a certain number of trips or the equivalent fare value is principally a function of the level of fare and distance travelled. Regardless of the fare level, a flat fare system always advantages long distance travellers over those who travel short distances. The effect is more pronounced in large networks where greater distances can be travelled for the same fare. As the number of trips made by an individual increases, the increment in discount per additional trip decreases. We refer to this as marginal utility, which is illustrated in Figure 1 (a) and (b). The graphs provide a basis to understand effectiveness of a capping regime in terms of its impact on demand and revenue.

Figure 1 Cumulative discount (a) and marginal utility (b) by caps set at different number of trips

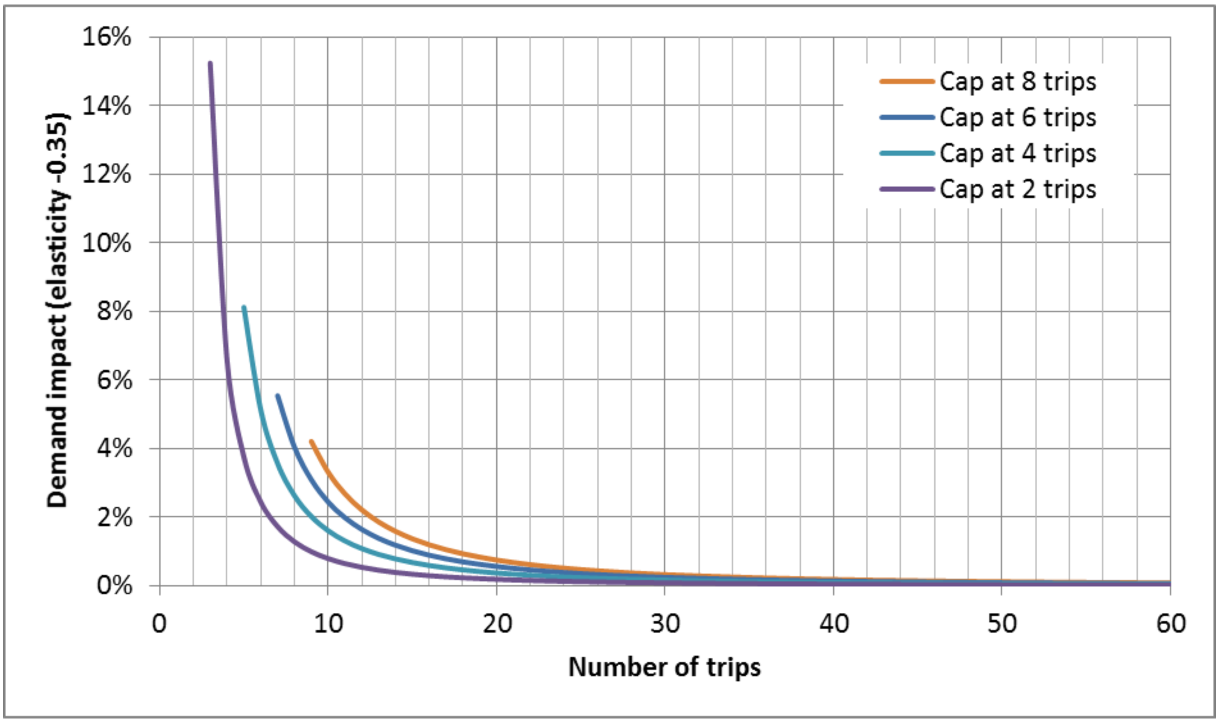


The impact of various trip caps on patronage can be estimated by applying a relevant fare elasticity to the marginal utility for each additional trip. Additional trips reduce the average fare by a diminishing margin for each passenger resulting in a smaller increase patronage.

Figure 2 indicates that when considering universal caps, setting a cap at a lower number of trips within a defined period of time may provide a greater incentive to users than setting caps based on a higher number of trips, especially for less frequent travellers. This would indicate that fare caps that apply over shorter periods (e.g. daily caps) can be more incentivising than fare caps over longer periods (e.g. weekly caps). However, the actual incentive and impact on demand depends on a number of factors, including rules around transfers, passenger travel behaviour and level of dependency on public transport.

We note that only a certain number of trips can be undertaken during a particular period of time which limits the potential increase in trips based on margin utility. For example, transfer rules will generally limit the total number of potential trips per day (e.g. a service span of 18 hours and two-hour transfer rule would limit the maximum number of trips per day to 9) and will need to be considered when setting a specific fare cap. Furthermore, many commuters only use public transport for a single return trip per day and therefore a cap at two or more trips per day does would not provide any incentive for these passengers.

Figure 2 Effects of discounts by different capping regimes on demand for additional trips



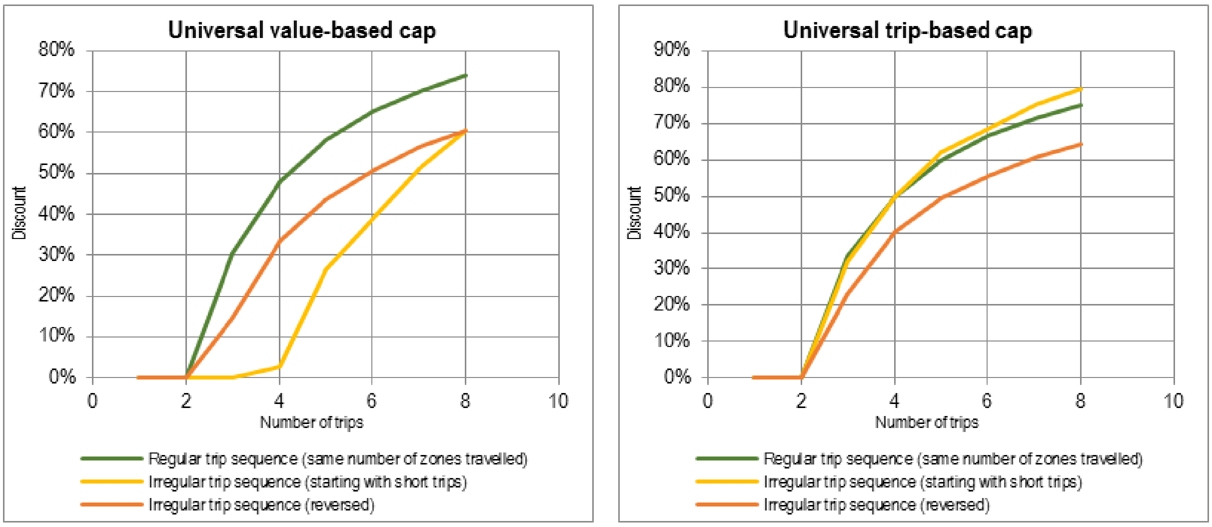
4.2. Graduated fare systems with time-invariant caps

In graduated fare systems, each journey does not necessarily have the same fare. This means that in order to apply a fare capping scheme there is a need to consider how fares vary based on the distance (e.g. number of zones) travelled.

Universal fare cap

The impact of a universal fare cap depends on whether it is value or trip based. Figure 3 shows the total discount that would result if applying a fare cap of 2 trips to a random pattern of trips within a zone based system. The discount will vary depending on the sequence of trips and distance travelled as not all trips have the same fare.

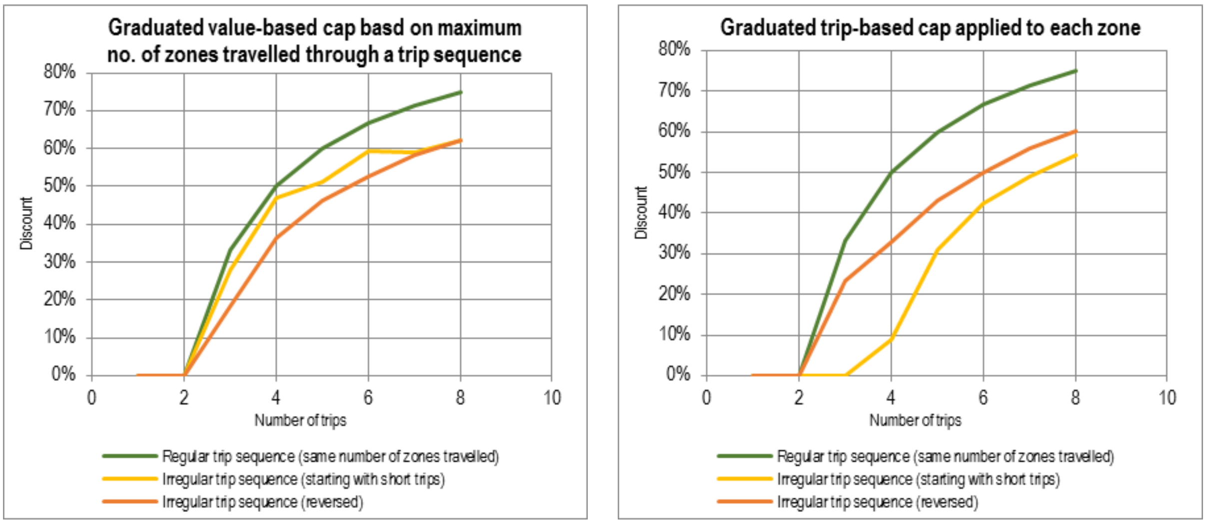
Figure 3 Example effects of universal capping regimes within a graduated fare system



Graduated fare caps

In a graduated system, different combinations of trips are made by individual passengers over a given period of time and can result in different overall fares for equivalent travel. For example, the incentive provided by a cap based on the maximum number of zones or distance travelled is identical across all types of travel. However, if a direct trip between two points is broken into several shorter distance trips or if the order of trips is changed for the same total number of trips this will generate a different discount, as shown in Figure 4. It is important to consider this effect when considering fare capping schemes within a graduated fare structure (e.g. zone based system).

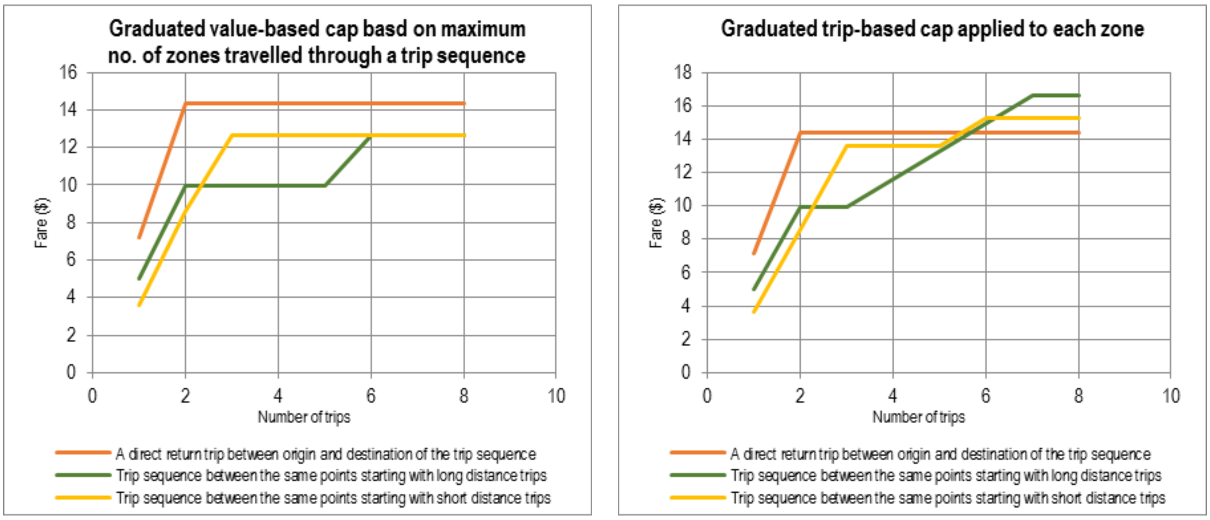
Figure 4 Effects of graduated capping regimes within a graduated fare system



Trip and value based fare caps

Both trip and value based capping approaches can influence fare levels if the trip pattern between two points changes. For example, a cap set at two trips per zone in a zonal system makes a direct trip between two points cheaper than if the same trip was broken into several short distance one-way trips. In the same example, if a cap is set based on the maximum number of zones travelled, a trip between two points generally generates higher fares than if the same trip is broken into several shorter distance trips. These effects are illustrated in Figure 5.

Figure 5 Effects of graduated capping regimes on fare levels within a graduated fare system



4.3. Fare systems with time-variant caps

These capping approaches may also apply to systems with fares that differ by time of day or day of week. The rules are similar to graduated fare caps but include the parameter of time (e.g. time of day) in addition to distance (for zone/distance based fare systems). This type of time-variant universal or graduated cap can be applied to both flat fare and graduated fare systems.

Fare caps are generally applied as daily, weekly or monthly caps and can be further broken down by time of day or week. Melbourne has one of the most comprehensive systems of “layered” fare caps with different caps triggered depending on a number of factors. This approach will ensure the passenger pays the minimum fare possible but can be difficult to understand and requires some degree of trust that the system will calculate the correct fare. In contrast the daily cap in Perth is much simpler and applies only to off-peak periods.

A time-variant cap may be applied to incentivise travel at the specified time of day or during specified days of week. However, the time-based fare caps need to take account of other agency objectives such as encouraging off-peak travel (e.g. shifting passengers from peak to off-peak so that services cost less to deliver and reduce peak vehicle requirements).

4.4 Patronage and revenue impacts of fare capping

A relatively simple approach to estimating the impact of a fare capping scheme on patronage and revenue is to carry out an analysis based on average fare. The only data requirements are total boardings and fare revenue by number of boardings per card for each market segment, along with appropriate elasticity estimates. This boarding and revenue data should be readily available from most smartcard ticketing systems.

Some key assumptions are needed for any modelling exercise. A 100% discount can be assumed for all trips after the cap is triggered (i.e. free travel). Modelling can also assume other level of discounts (e.g. 50%). In the absence of actual travel data or where some data are missing, there is a need to develop robust assumptions to enable estimations with acceptable level of reliability. These assumptions can use survey data or other sources that provide some indication of the trip types and market segmentation by ticket usage.

The methodology for estimating the impact of a universal fare cap on revenue and patronage is relatively straight forward and can be calculated in two steps:

Step One - Calculate revenue impact

$$REV_{lost} = \sum_{TRIPS=1}^{n} \left[\frac{(TRIPS \times FAR_{avg} - CAP) \times PAX}{TRIPS} \right] \quad (1)$$

Where:

$TRIPS \times FAR_{avg}$ is greater than CAP

$TRIPS$ is the number of trips undertaken by each passenger during the specified period (day) which can be aggregated by total number of trips per smartcard per period.

CAP is the dollar value fare cap to apply. This is often specified using a multiplier on the standard smartcard fare (e.g. cap might be 2.5 x adult single fare of \$3 = \$7.50). The following steps should be repeated to test the impact of multiple fare caps.

FAR_{avg} is total revenue divided by patronage (REV / PAX) for the relevant number trips per smartcard per period.

Step Two - Calculate patronage impact

$$PAX_{inc} = \sum_{TRIPS=1}^{n} \left[PAX \times \left(\left(1 - \frac{REV_{lost}}{REV} \right)^{ELAS} - 1 \right) \right] \qquad (2)$$

Where:

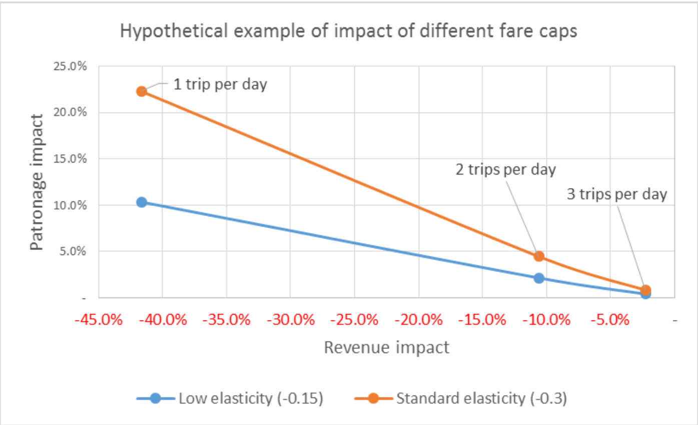
REV_{lost} calculated first as per above

$ELAS$ is the fare elasticity (default could be –0.3)

The calculations should be repeated for each market segment (e.g. adult, child, senior) which. The percent change in revenue and patronage is given by and respectively.

To compare the impact of different fare caps for passengers with various numbers of trips per period the variables and can be plotted against the number of trips. This approach can also be applied to compare different fare cap values on the same chart, as demonstrated in the example in Figure 6.

Figure 6 Example of impact of difference fare caps and elasticity assumptions



The above approach is most suitable for cities with a flat fare structure as all trips are charged the same fare, but in cities with multiple zones/sections, the average fare per boarding does not necessarily reflect the marginal cost of each additional trip. For example, a person might make a long trip with a higher fare followed by two short trips with lower fares and a final long trip with a higher fare. If the cap is set at three trips, the marginal cost (revenue foregone by the agency) would be much higher than the average.

Within a graduated fare system, the methodology for analysis of a graduated capping scheme in terms of its revenue and patronage impacts is similar to that set out above and could provide a useful first approximation of impacts. But a more detailed analysis is required to account for different fare caps for each zone/distance band and/or time period, including the following data requirements for modelling and estimation of revenue and demand implications of a proposed capping scheme and appropriate capping level:

- Frequency of trips or journeys by user and ticket types
- Fares per journey and average fares by mode or geographic area
- Levels of discount on equivalent multi-trip and time-based tickets
- Boarding data by market segments and ticket types

We note that often modelling of a capping scheme is limited by lack of data and information on travel patterns. The data requirements are not very onerous for analysing the universal fare cap and this approach could be used as a first pass when looking at graduated fare caps (by using average fares). However estimates could be less accurate. Unlike the universal fare capping approach, the data requirements for modelling of a graduated fare capping approach are more onerous, especially in systems where the traditional passes are paper-based and the existing data may be less reliable. Systems with paper-based tickets generally suffer from proper travel pattern data, which is necessary to model impacts of a fare capping approach.

To model impacts of a graduated fare cap, individual trips need to be examined to identify the actual fare paid per trip. This level of data is recorded by all smartcard ticketing systems but often custom reports are required to obtain this level of disaggregate data from reporting systems.

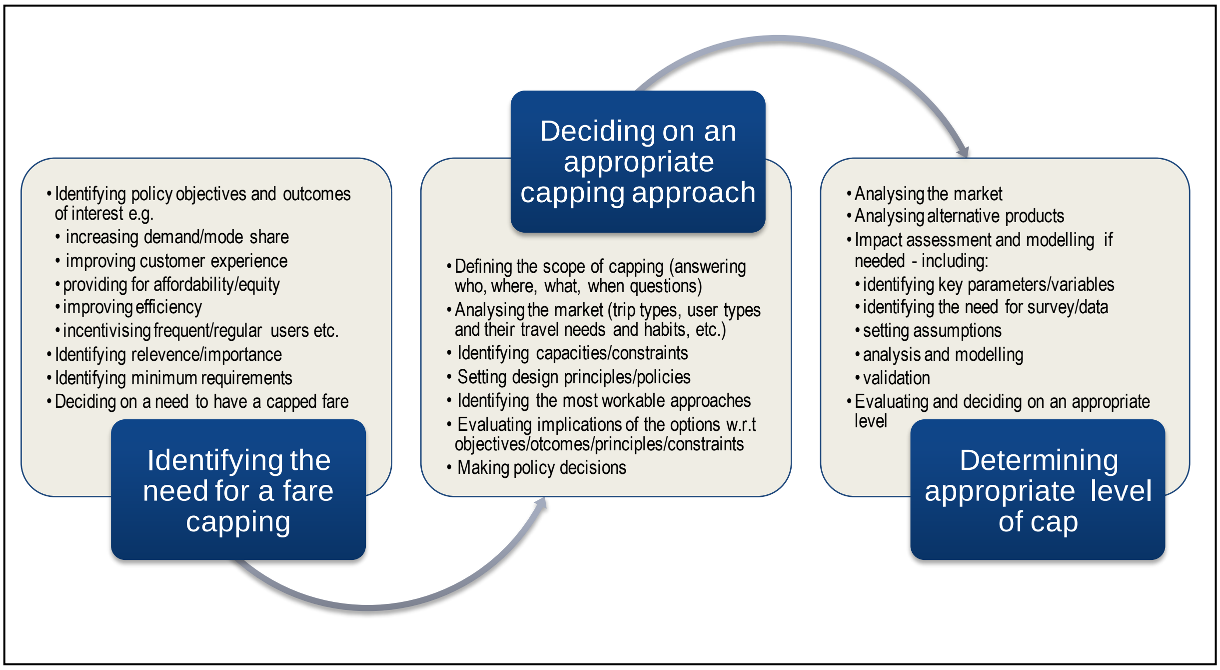
5. Appropriateness of fare capping

A decision on appropriateness of a capping scheme needs to balance various competing objectives and outcomes of interest. The design of a capping scheme includes at least three interrelated steps, with each step answering a number of key questions and may feedback to other steps. These are illustrated in Figure 7.

The need for fare capping will depend on the policy drivers and market factors for each public transport system. An appropriate capping regime primarily requires a knowledge and understanding of the pricing structure and needs to consider a number of key parameters and variables. The most defining parameters include:

- Types and purpose of trips or journeys
- Types of users (market segments) and their travel habits within the market
- Demand elasticity (and cross-elasticity) of fares and discounts for different user types
- Complexity of pricing structure and availability of differentiated fares (by time, area, mode or service or operator)
- Level of integration of fares and ticketing (especially transfer arrangements)
- Capabilities and limitations of the electronic ticketing system
- Strategies and policies for revenue protection
- Key objectives of public transport in general and capping scheme in particular

Figure 7 Key stages of a fare capping design process



When deciding on an appropriate capping approach the following list provides an outline of common objectives, principles and constraining factors:

- **Equity** (strategic) – does the approach treat users equally?
- **Simplicity** (strategic/product specific) – is the approach potentially easy to communicate to customers, convenient to use and relatively simple to design, implement and administer?
- **Consistency** (strategic/product specific/design principle) – does the approach provide for a capping scheme that allocates fares consistently and can be consistently applied to zones, services, operators and modes across the network?
- **Flexibility** (strategic/product specific) – does the capping approach provide flexibility for users to change between allowed modes or services and benefit from the discount offered?
- **Reliability** (design principle) – how does the capping approach guarantee a minimum fare for customers and creates confidence and trust?
- **Capability to incentivise** frequent/regular use (strategic/design principle) – how effective is the capping approach in encouraging usage and regulating travel patterns? Does it offer discount comparable to legacy products and how competing is it with car?
- **Targeting specific market segments** (strategic/product specific) – what is the suitability of approach in relation to different user types e.g. frequent, regular or occasional users?
- **Revenue impact** (strategic/constraint) – is there any potential significant revenue loss as a result of introducing the approach? Or how much revenue loss can the agency tolerate?
- **Revenue protection** (strategic/design principle) – is the capping approach prone to fare avoidance?

- **Cost effectiveness** (strategic/design principle) – is the capital and operational cost of the capping approach worth its benefits?

Some other objectives and principles may emphasise on various other dimensions of a capped fare product such as potential marketability, technical compatibility, targeting specific market segments, encouraging off-peak trips, removing limitations of traditional passes (e.g. potential revenue dilution or the need for pre-payment), gaining operational and administrative benefits (e.g. reducing cash handling), supporting integration of fares and improving data integrity.

A simple qualitative multiple criteria assessment can assist in evaluating different approaches to capping. This approach can be refined by assigning appropriate weights to the assessment criteria and quantifying the impacts of each approach with respect to the weighted criteria. A more systematic approach may further require classification of the criteria into distinct groups of (i) strategic objectives, (ii) product specific objectives and (iii) a set of agreed principles; as each group of criteria may have different degrees of importance for the agency. A set of product specific objectives essentially defines the desirable outcomes or the benefits that an agency seeks to provide by introducing a capping scheme. Some strategic and product specific objectives may overlap. Principles basically specify the key constraints and may include an agency's business rules or standard protocols for the design, procurement or delivery of a service or product.

When evaluating capping options, it is worth to make a distinction between different user types or market segments especially based on their travel habits, as it influences decisions on which approach best suits what target groups and eventually defines what combination of capping approaches best suits the specific needs of a system (e.g. daily + weekly or simply weekly). The two defining factors for this type of analysis are frequency and regularity of trip sequences. This requires consideration of cross-consistency or compatibilities between capping approaches to ensure that capping approaches can coexist with each other.

6. Conclusions

Fare capping is a policy instrument to meet the strategic public transport objectives including encouraging demand and improving affordability of fares particularly for captive users of public transport. A main intention behind fare capping is to provide a product with functionality and benefits similar to period passes while eliminating many of the disadvantages of the pass products. A fare capping by its nature could potentially provide multiple benefits including flexibility, cost and time efficiency (by removing the need for a paper ticket, reload, etc.), equity (anyone can benefit from a capping scheme), extensibility, and data benefits.

Despite these perceived benefits and the growing tendency to apply this instrument especially in Australia and New Zealand, the principles and basic mechanisms behind fare capping are not well-documented and there is an obvious need for expansion of knowledge in this area of policy and practice. In this paper we discussed some of the fundamental principles and functionalities of different types of fare capping, although we have not attempted to undertake a detailed review of existing fare capping schemes. The impacts are often difficult to isolate from other changes but would nonetheless be a useful area for further research.

A key finding is that various capping schemes may result in different outcomes, which are primarily influenced by the fare structure in which the capping is implemented. Therefore design of a capping scheme needs to take into account sources of fare differentiations and users' potential response and willingness to take advantage of the discounts provided by fare capping. This requires a good knowledge of the market and users' travel habits.

It is also important to note the specific order and patterns of trip sequences when analysing effects of different capping schemes, as these factors influence the fare levels and are sources of variations in discount increments which may consequently affect the revenue generated by various combinations of trips. Knowledge of the marginal utility by an additional trip over a cap combined with an understanding of trip frequencies and fare elasticity of demand also provides a basis to estimate the potential revenue impacts of various capping regimes.

When evaluating capping options, it is worth to make a distinction between different user types or market segments especially based on their travel habits, as it influences decisions on which approach best suits what target groups and eventually defines what combination of capping approaches best suits the specific needs of a system. The two defining factors for this type of analysis are frequency and regularity of trip sequences. This requires consideration of cross-consistency or compatibilities between capping approaches to ensure that capping approaches can coexist with each other.

In terms of the effects, trip-based and value-based capping would result in significantly different outcomes, as order or pattern of trip sequence influences total fare paid for a trip chain. A universal fare cap generally incentivises longer distance travel over shorter distance travel due to a greater discount for long-distance travel. While a value-based cap within a graduated fare structure generates the same fares within a set distance irrespective of the sequence and order of trips, the cap is sensitive to patterns of trips within the same distance. This can potentially discourage direct return trips and may encourage multiple un-linked trips to get from an origin to destinations. In comparison, a trip-based cap within a graduated fare structure is generally sensitive to order, sequence and trip patterns, and therefore generally incentivises longer distance travels. These types of effects are often not desirable outcomes but could be deliberately applied to incentivise specific types of travel behaviours depending on goals of the organisation.

The concept of fare capping is consistent with the move towards simplified fare structures as the complexity of the required calculations are hidden from passengers (e.g. passengers only need to know that their fare is capped at $5, not how the cap is calculated).

In conclusion, a decision on appropriateness of a capping approach needs to follow a set of systematic steps and carefully consider and assess a proposed capping approach against various objectives and constraints, and capacity of the agency to bear the costs and accommodate new demand. A capping scheme should also be analysed in relation to the discounts that other alternative pass products and make a clear map of the migration path from legacy products to a fully operational capping scheme.

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