AUSTRALIAN NON-URBAN PUBLIC TRANSPORT - PRICING PRACTICES AND ISSUES

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ABSTRACT: *With the increasing demand for public transport to become more efficient and cost effective, there is an increasing need for appropriate pricing levels and structures to be applied. Within Australia, non-urban public transport services have different pricing structures and levels. This paper makes a comparison between the various non-urban public transport operators and takes the opportunity to explain, examine, and compare the differences.*

The implications of integrating non-urban public transport Government and private operators in terms of pricing levels and revenue generation are also discussed.

When introducing fare adjustments, useful relationships for measuring revenue impacts as well as establishing the optimal maximum revenue increase for a given weighted fare increase are outlined. The maximum revenue increase is determined by specifying the situation as an optimisation problem with numerous constraints. These constraints apply to different classification of fares which have various demand and revenue levels and demand elasticities.

Finally, the paper addresses some techniques based upon previous practical experiences in estimating missing data which often occurs, so that demand elasticities and impacts of fare adjustments may be more accurately measured.

DISCLAIMER: This paper is based on work undertaken within and for V/Line. Any conclusions which could be drawn from the comments do not necessarily reflect the views and policies of V/Line Management.

1.0 PRICING PRACTICES

Pricing levels and policies are set in accordance to a number of factors including market forces, cost structures, quality of service, frequency of services, as well as the political and social environment. This section discusses the pricing practices used by Australian transport operators as well as making comparisons where appropriate.

Urban and non-urban public transport pricing practices vary considerably throughout Australia since the two types of travel are catering for different travel needs and markets. There is also significant variation from State to State in urban and non-urban public transport pricing policies.

In virtually all cases of non-urban travel, fares are set on a distance-based fare schedule regardless of mode and operator. Previous research undertaken throughout the world has concluded distance-based pricing for non-urban travel is a more effective means of optimising revenue. Distance based fares are particularly useful for relatively low populated town/cities spread across relatively large distances where the majority of travel is to a Capital City. In Australia, a significant proportion of non-urban travel is spent travelling between Capital cities and between country centres and Capital cities. Approximately 80% of country travel in Victoria by public transport is to or from Melbourne, which is in part a general reflection of travel patterns as well as most public transport is in a radial configuration of Melbourne.

The operators of public transport in Australia can be classified into one of four groups, viz :-

a) <u>Rail Dominated Government Authorities</u>

Such non-urban government bodies in each State are responsible for rail services as well as road coach services. In Australia such Authorities are V/Line, Australian National (AN), State Rail Authority of NSW (SRA), Queensland Railways (QR) and Westrail. These organisations are often referred to as Railway Systems even though they also operate or administer extensive road coach networks.

b) <u>Private Country Road Coach Operators</u>

Private country road coach operators exist in various Australian States and in Victoria's case most are subsidised by the State Government with V/Line administering the subsidy.

c) <u>Interstate Road Coach Operators</u>

Interstate coach operators exist without any direct subsidy and operate freely between States, although some set-down and pick-up conditions are controlled through government regulations.

d) <u>Domestic Airlines</u>

Domestic Airlines operate throughout Australia and the fares are controlled by the Independent Air-fare Commision

The discussion of pricing practices has been separated into country and interstate travel in the following sections :-

2.0 COUNTRY FARES

2.1 Rail Dominated Government Authorities

In Australia, non-urban distance fares are derived from distance based schedules, but even though similar principles have been applied, there seems to be a diversity in the application of the concept. In order to compare the various methodologies applied, the adult economy single fares for varying distances and operators have been compared. All fares have been converted to cents per kilometre for ease of comparison and V/Line fares are used as a basis (see Figures 1 to 6). The main points are :-

- V/Line uses two different fare scales for setting fares, one for Commuter services which cater for shorter distance travel to or from Melbourne, and another for all other services (see figure 1).

- A.N. is the only Rail System that uses a flat rate per kilometre for country travel. Current fares are set at approximately 6.0 cents per kilometre (see figure 2).

- SRA of NSW in a similar manner as V/Line use two different fare scales which are applied for varying markets. Scale 'A' applies for relatively short distance travel to or from Sydney, whilst the other scale is used for longer distance travel (see figure 3).

- Both V/Line and SRA's fares for shorter distance travel are a similar shaped function except the levels vary. V/Line fares are comparatively higher and has the same inherent problem as SRA whereby the slope of the function is positive between 40 and 200 kilometres. This means if a journey can be broken, the sum of the two fares will most likely be less than the through fare and the further one travels, the higher the rate per kilometre.

- The longer distance SRA fare scale (i.e. Scale 'B'), is a much flatter function particularly between 130 - 500 kilometres where virtually a flat rate of 6.4 cents per kilometre is used. This rate of 6.4 cents is marginally greater than A.N.'s 6.0 cents per kilometre. After 500 kilometres, SRA fares per kilometre decline quite rapidly to settle on about 3.8 cents per kilometre (see figure 4).

- Westrail country fares gradually decline from about 7.0 to 5.2 cents per kilometre over the range of 40 to 200 kilometres. Beyond 200 kilometres first class fares only apply which means the long distance fares are very similar to V/Line's economy class long distance fares (see figure 5).

- Queensland Railway fares are set in a similar manner to V/Line Commuter fares whereby a distinct dip occurs for short distance travel. However in QR's case the dip lasts much longer reaching a maximum fare of about 9 cents per kilometre at 120 kilometres, then tapering down. Queensland would also have the same problem as V/Line and SRA ('A' Scale) by having a positively sloped function which means fare anomalies will prevail (see figure 6).

Not only do the fare levels vary between country Railway Systems, but also the distance categories. In V/Line's case 10 kilometre increments are chosen for shorter distance travel which is subsequently increased to 20 kilometre increments and finally 50 kilometre increments. In AN, SRA and QR's case there are particular distance intervals which are obviously designed to capture specific travel patterns. Distance categories chosen have been set in increments of 2, 5, 7 kilometres etc. One of the reasons for using such intervals is to target particular travel patterns making the fares more market based. In fact, the finer the distance categories the more effective the fare schedules are in generating revenue.

It would appear from the comparison of Railway Systems, population densities do not necessarily dictate fare levels, as less populated States such as South Australia and Western Australia can have lower fares than more populated States.

Figure 1

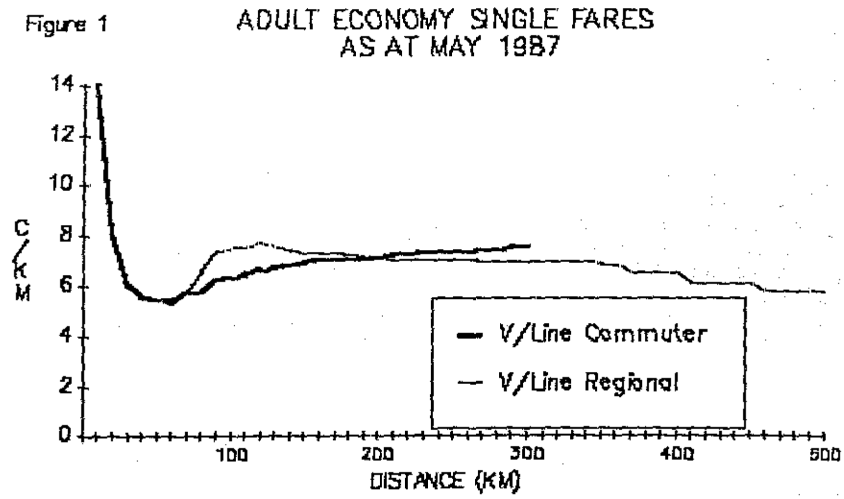

Figure 2

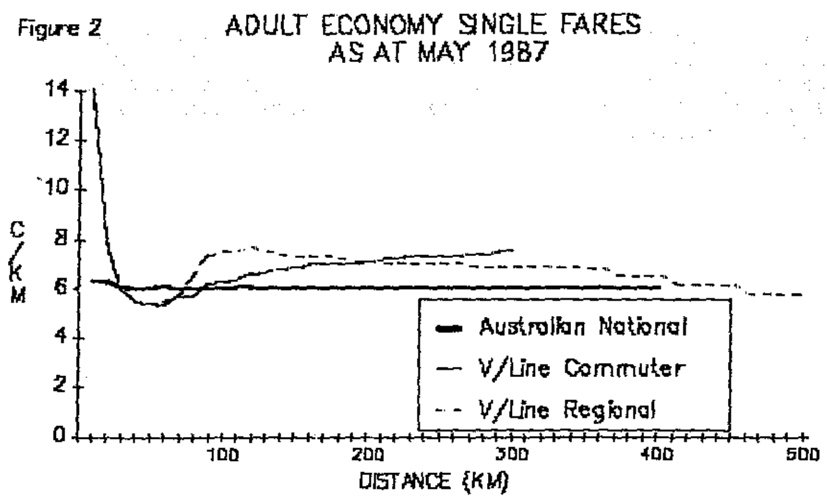

Figure 3

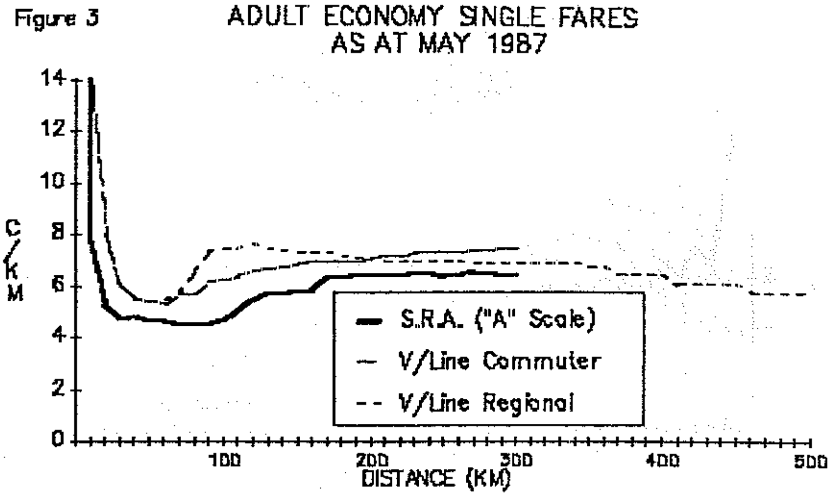

Figure 4

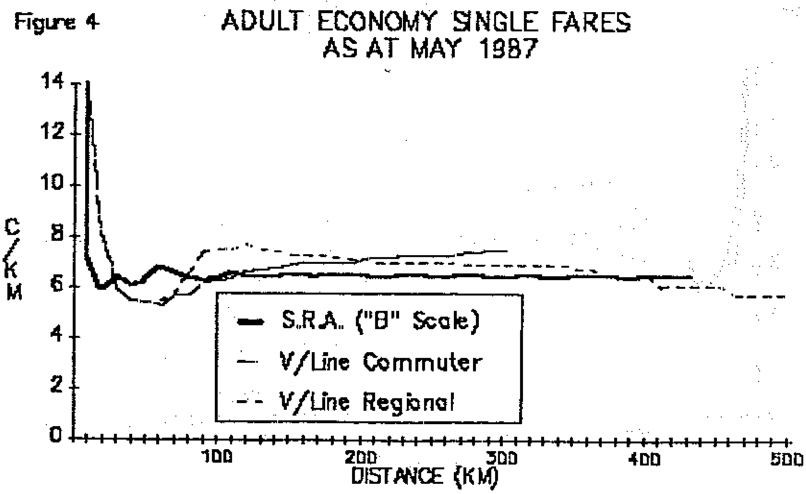

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Figure 5

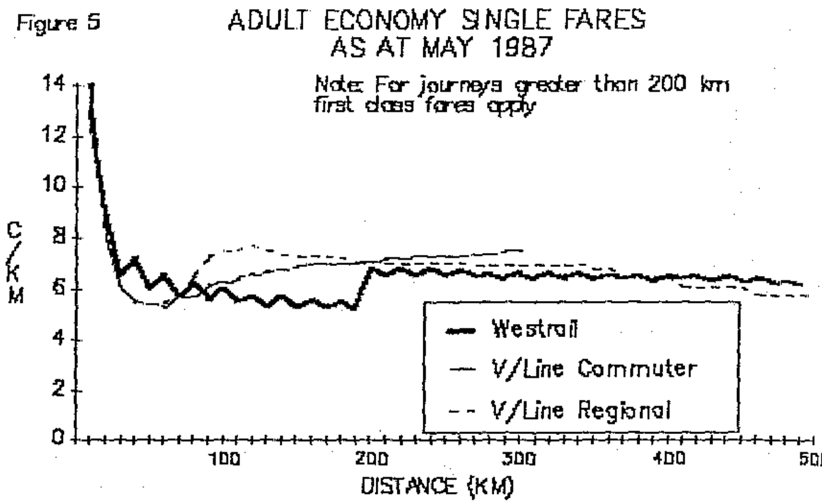
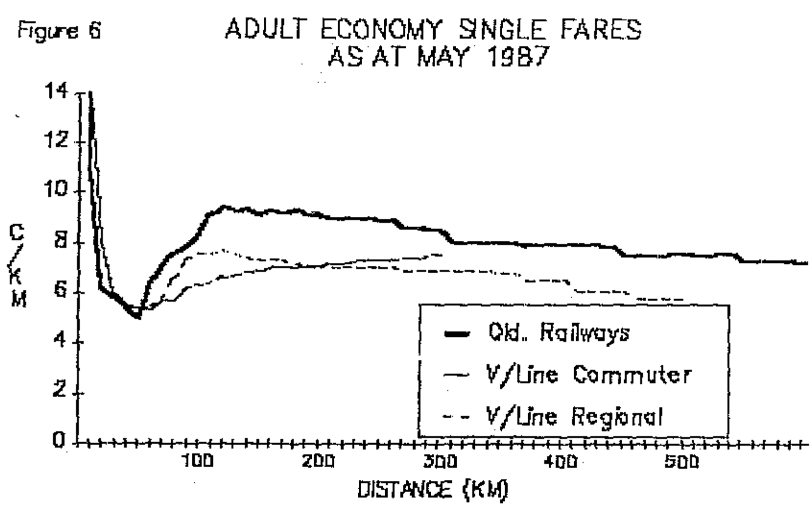


Figure 6



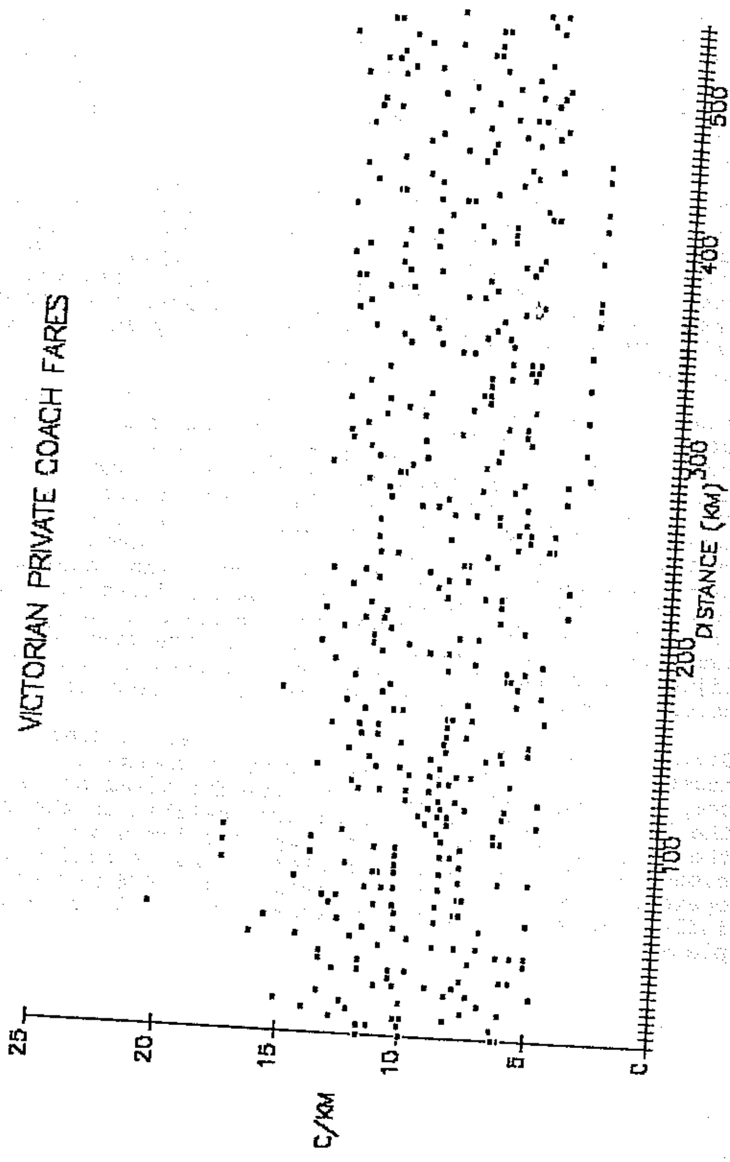
2.2 Private Country Road Coach Fares

Country private road coach fares vary considerably between operators and routes. In the case in Victoria, figure 7 depicts the cents per kilometre charged by various operators for similar distances. Even though the respective fares vary considerably for the same distance travelled, the product also widely varies as coaches vary in standard and service level.

There are a number of reasons why country Victorian road coach fares vary so widely. As mentioned, there are variations in the product delivered, as well as the market size and the market penetration. The purpose of the coach operating may also differ between routes. Some scheduled routes in Victoria are effectively operated for carrying small freight consignments and accordingly any passenger business is treated as a bonus.

Prior to 1974 all Victorian private coach fares were not subsidised which meant the operator made the business decision to increase fares or not. This led to comparative disparities between operators and routes. When the subsidy programme was introduced in 1974, current fares were adopted therefore the relativities of the fares have been maintained since all subsequent fare increases have applied to all operators. There have also been instances where the Victorian State Government has directed fares not be increased, or only increased to a certain level. In comparison, non-subsidised operators have been able to adjust fares more freely as fare-box revenue and possibly parcel revenue are there only source of revenue.

Given the wide variation in fares, it still does not necessarily mean subsidised operators charge a comparatively lower fare than non-subsidised operators, as the level of fares seem to be more related to the route and the competition. That is to say, the fares are in many cases market priced, the problem is that subsidised operators market prices are related to 1974 market influences which may not necessarily be 1987's market place.


VICTORIAN PRIVATE COACH FARES
C/KM
25
20
15
10
5
0
DISTANCE (KM)
100
200
300
400
500

2.3 Motor-Car Costs

Public transport's biggest competitor is the private motor-car, so as to provide some comparison of competitive fares these costs have also been used.

There are two main levels of motor-car costs. The first is perceived costs and secondly, real costs. Broeg (1981) showed the perceived motor-car costs are represented by lubricants only, hence the perceived costs could be assumed to be in the range of 5.5 to 6.0 cents per kilometre for a medium size vehicle.

The full real costs of maintaining a medium size vehicle as derived by the Royal Automotive Club of Victoria is approximately 32.5 cents per kilometre (i.e. as at March, 1987). This costing includes such items as depreciation, scheduled and unscheduled maintenance etc.

Whilst Broeg proved the perception of costs is equivalent to lubricants, it is expected if a vehicle was committed to regular travel such as commuter travel, then the perceptions of cost would increase with usage. For example, the need for more regular servicing, tyre replacement costs, parking fees etc.

In the case of V/Line, commuter travellers can purchase a periodical ticket (e.g. weekly) which is a substantial discount from the adult economy fare and therefore only pay about 2.5 to 3.5 cents per kilometre for peak travel in the distance range of 50-100 kilometres. Accordingly the perceived motor-car costs are higher than the V/Line commuter fares which is inducing significant demand and placing pressure on peak resources. On existing fares, at least three regular commuters would need to establish a car pool arrangement for the perceived motor car costs per head to be less than a V/Line commuter fare.

Perceived motor-car costs will be spread across all passengers and this means for any trip in Australia, the perceived price of operating a vehicle for two or more passengers will most likely be less than the equivalent adult economy single fare. However many public transport users are eligible for some form of discount, and secondly not all users have a motor-car available.

3.0 INTERSTATE FARES

3.1 Rail Systems

Railways of Australia (ROA) is the co-ordinating body of all interstate rail services. ROA has representatives from each of the Railway Systems which then set the interstate fares. ROA fares are set as a flat cents per kilometre between respective cities and the rates vary between 5.6 and 8.1 cents per kilometre.

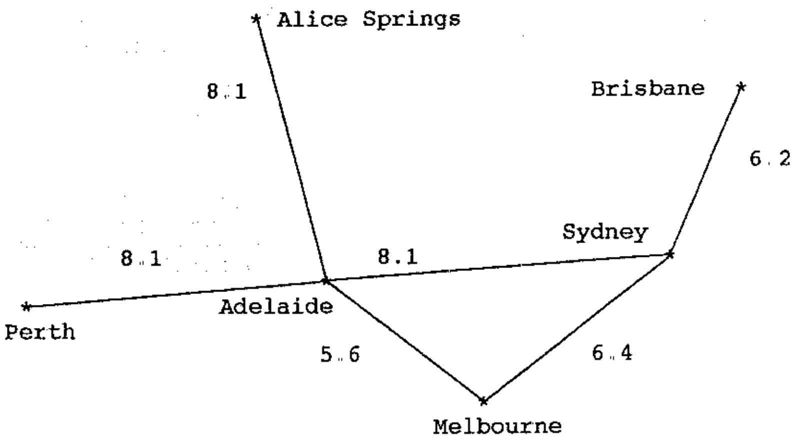
The Melbourne-Adelaide corridor has the lowest ROA fare of 5.6 cents per kilometre on the network, followed by the Sydney-Brisbane and Melbourne-Sydney corridors of 6.2 and 6.4 cents per kilometre respectively. Other corridors across Australia and into Alice Springs are set at 8.1 cents per kilometre which is much higher than other corridors. Figure 8 diagrammatically shows the ROA fares on the major interstate rail corridors.

The more recent ROA negoiations undertaken in setting the rates have led to ROA fares being more market based. There have been instances over the last few adjustments including planned future adjustments, that various corridor fares be increased differently. To complement the base fares, other promotional fares (e.g. Standby fares on the Melbourne-Adeladide corridor etc.), have also been introduced.

The level of ROA rates also tend to be similar with the respectitive local State Railway System's fares. For example on the Melbourne-Sydney corridor, ROA fares are 6.4 cents per kilometre which compares with the long distance country fares in each State of 7 and 5 cents per kilometre in Victoria and NSW respectively.

FIGURE 8

RAILWAYS OF AUSTRALIA CENTS PER KILOMETRE FARES



Fares as at May 1987

3.2 Airline Fares

In April 1981 economy (jet) fares were set using a linear equation based on the distance travelled. This equation was implemented based on the recommendations of the Holcroft report. The actual formula on the trunk routes was set at :-

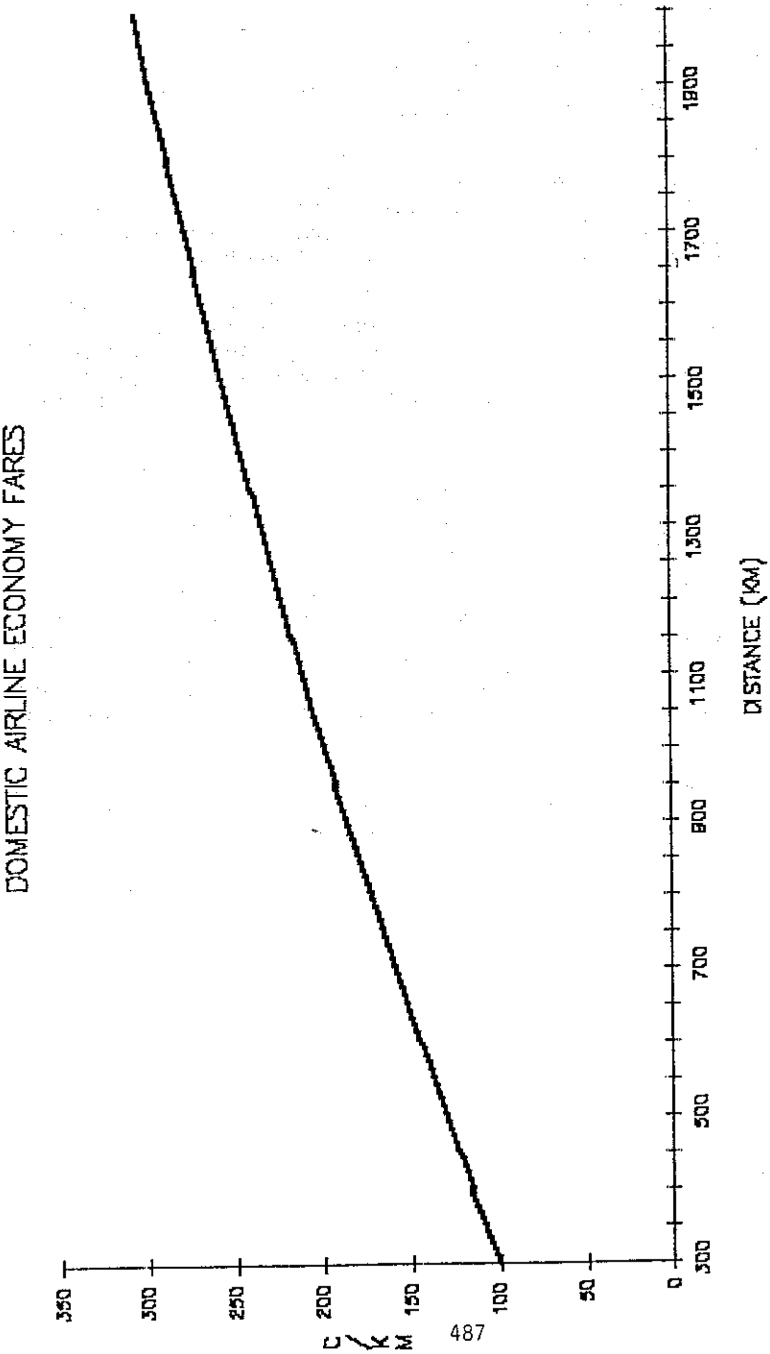
$$fare = 40 + 86.48 x$$

where x = distance travelled
fare = economy fare expressed in dollars

This formula was subsequently revised in September 1982 by a polynomial function which meant for trips under 571 kilometres, the fare increased, whilst for trips over 571 kilometres the fares decreased. As at the December quarter 1986 the formula stood at :-

$$fare = 50.15 + 171.81 x - 27.31 x^2 + 2.6 x^3$$

One of the benefits in using such an equation is no definition of distance categories is required as virtually every distance will generate a different fare (depending upon rounding). The same comment also applies to a flat cents per kilometre function. The shape of the airlines fare function is shown in figure 9.


DOMESTIC AIRLINE ECONOMY FARES
C/KM
350
300
250
200
150
100
50
0
300
500
700
800
1100
1300
1500
1700
1800
DISTANCE (KM)

3.3 Interstate Road Coach Operators

Four of the major interstate operator's fares have been analyzed and these operators are Greyhound, Deluxe, Ansett Pioneer and VIP. A sample of the major routes have been included in the analysis and are shown the attached table. The route and the associated competition appears to be the criteria for dictating the fare rate. The main points to be made from the analysis are :-

- The most common level of fares for interstate road coaches is between 3.7 and 5.7 cents per kilometre. As expected the variation in the prices appear to be related to the level of competition. Figure 10 presents the cents per kilometre rates for various distances.

- Ansett Pioneer have some exceptionally high rates for travel between Brisbane-Long Reach, Cairns-Mt Isa and Canberra-Dubbo. Such services are priced at between 8.4 and 10.0 cents per kilometre and once again are expected to be set so high due to the lack of competition and volume of business.

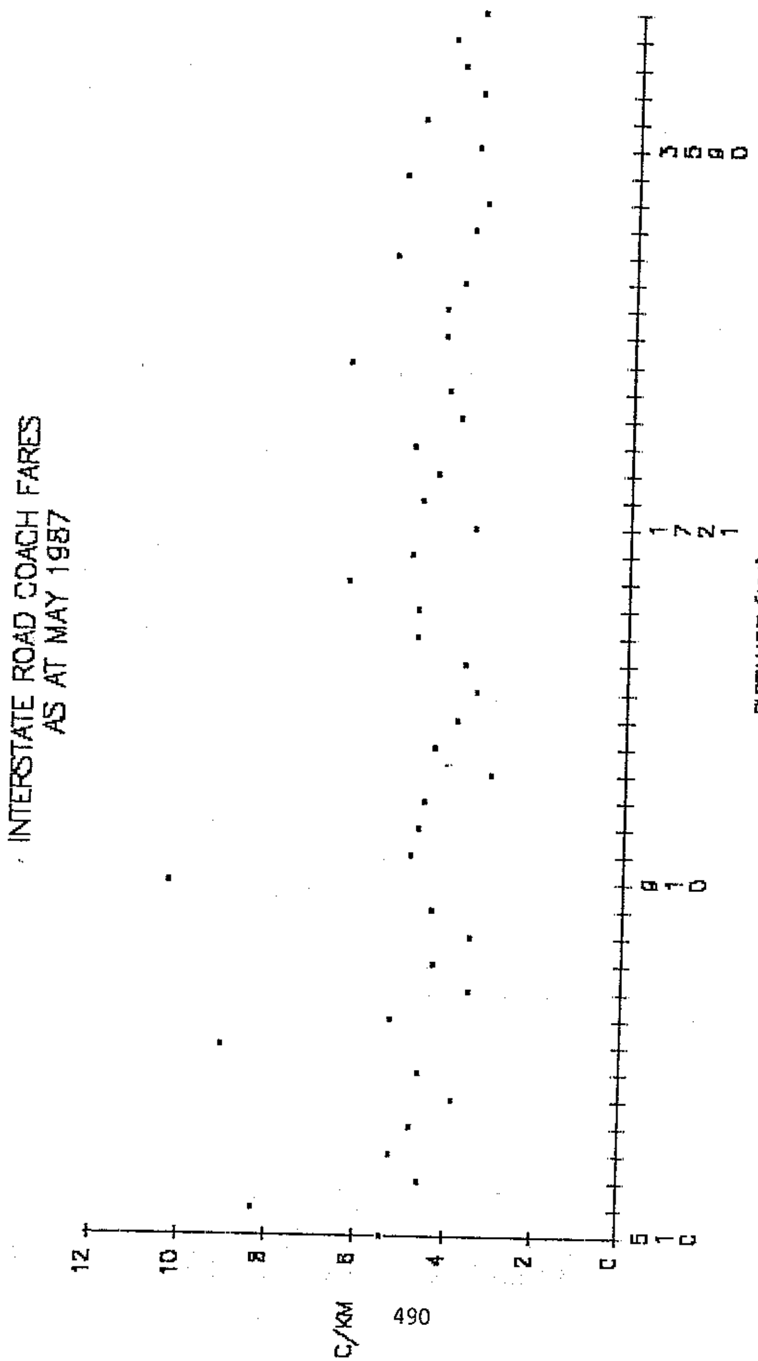
- Out of the four operators analyzed, VIP offer the lowest fare per kilometre in Australia. The fare occurs on the Melbourne-Sydney corridor with a fare of $30, which is equivalent to 3.2 cents per kilometre.

Compared to rail fares, interstate road coach fares are generally less with some exceptions, however both rail and interstate road coach operators often offer promotional fares which are cheaper than the adult economy single fare (e.g. Advanced purchase fares, Standby fares etc.), and hence the difference between the operators is often only marginal.

The recently introduced Greyhound twin-deck coach which operates on the Melbourne - Adelaide corridor has on-board catering with a lounge and the fare is $45 (single). This is equivalent to 5.2 cents per kilometre which is higher than all other Greyhound fares, but the service quality is obviously superior.

INTERSTATE COACH OPERATORS FARES

ORIGIN-DESTINATION	DISTANCE	FARES GREYHOUND	FARES DELUXE	FARES ANSETT	FARES VIP	CENTS PER K.M. GREYHOUND	CENTS PER K.M. DELUXE	CENTS PER K.M. ANSETT	CENTS PER K.M. VIP
BROKEN HILL-ADEL	510	27.00				5.29			
CANBERRA-DUBBO	530			43.50				8.21	
MELB-BEGA	630	28.10				4.46			
MELB-ADEL	745		38.00				5.10		
MELB-ADEL	800	37.50			30.00	4.69			3.75
MELB-ADEL	820			37.00				4.51	
BRIS-LONGREACH	820			74.00				9.02	
MELB-SYD	870	45.00			30.00	5.17			3.45
MELB-ADEL	880	37.50	38.00		30.00	4.26	4.32		3.41
CAIRNS-TWNS-MT.ISA	910			93.00				10.22	
MELB-CANB-SYD	935	45.00	43.00			4.81	4.60		
SYD-BRIS(PACIFIC)	1000	45.00	43.00	38.00	30.00	4.50	4.30	3.80	3.00
SYD-BRIS(NEW ENG.)	1175	39.90	43.00			3.40	3.66		
SYD-CANB-ADEL	1550	73.00		73.00		4.71		4.71	
ADEL-ALICE	1570		99.00				6.31		
MELB-BRIS	1721	84.00	80.00	75.00	60.00	4.88	4.65	4.36	3.49
PERTH-PORT HEDLAND	1820			75.00				4.12	
CAIRNS-BRIS	1820	89.00			70.00	4.89			3.85
BRIS-MT.ISA	1900	120.50				6.34			
CAIRNS-BRIS	1950	83.00	83.00			4.26	4.26		
MELB-BRIS	1985	77.00				3.88			
MELB-ADEL-ALICE	2520			135.00				5.36	
ADEL-PERTH	2730		99.00				3.63		
SYDNEY-CAIRNS	2940				100.00				3.40
BRIS-ALICE	3070	159.50				5.20			
MELB-ADEL-PERTH	3590			130.00				3.62	
BRIBANE-DARWIN	3600	174.00				4.83			
MELB-CAIRNS	3650				130.00				3.56
SYD-PERTH	3980		159.00				3.99		
DARWIN-PERTH	4305		180.00				4.18		
SYD-CANB-PERTH	4320			152.00				3.52	
					AVERAGE	4.72	4.45	5.59	3.49


INTERSTATE ROAD COACH FARES
AS AT MAY 1987
DISTANCE (KM)
C/KM
12
10
8
6
4
2
0

4.0 INTEGRATION OF PRIVATE AND GOVERNMENT OPERATORS FARES

In Victoria, all non-urban public transport operations are under the administrative responsibility of V/Line. In some cases the services operate without State Government funding, and in most cases there is some form of subsidy provided for the operation of the services.

Most recent developments in Victoria have led to V/Line entering into joint arrangements with private bus companies. That is, a business contract is agreed to by both parties for the operation of a particular service. In effect this means the operator generally provides the cost of operating the service and an agreement is then made regarding the allocation of fare-box revenue and subsidy according to a negotiated 2 year contract.

The benefits of such a scheme are for example:-

(i) improvement in the financial performance of the service given the awareness and demand for the services improves significantly. This gain in financial performance means less Government subsidy.

(ii) services throughout Victoria are being better co-ordinated and duplication is being reduced.

(iii) when re-vamping services, a feeder policy in some cases is applied whereby road coach services feed rail services and vica-versa.

(iv) frequency of road coach services can often be improved given the feeder policy.

(v) a greater range of services can be provided.

(vi) through ticketing is introduced which is simpler for the user.

The through ticketing of fares means an amalgamation of the previous fares and V/Line fares is undertaken. As discussed in the previous section, at times private road coach fares can be greater than V/Line fares which leads to the situation of reducing fares or having specialized fares. In practice, a compromise is often applied, whereby when existing fares are close to V/Line fares - the V/Line fare for the respective distance travelled is adopted.

However when current fares are in far excess of a V/Line fare that particular fare is maintained. Reducing the fare substantially will only lead to a reduction in revenue even though this would be off-set by new business. If the current users of the service are a reflection of the total market, and they currently pay such a fare level, then it is better to charge what the market will bear. This practice is particularly followed when such a price inelastic market prevails.

5.0 MAXIMISING REVENUE GAINS THROUGH PRICING

5.1 Differential Pricing

Differential pricing is the concept of setting fares at different levels for different markets given each market reacts differently to fare changes and price levels (i.e. price elasticity).

There are numerous examples of the technique in practice within Australian public transport operators. For instance, off-peak pricing aims at attracting business to travel at times of spare capacity. Off-peak business is often represented by passengers transferring from peak services as well as new business, however the released peak capacity is then re-sold. The net effect of the changes is a gain in revenue and patronage.

When operating off-peak differential pricing, a balance is made between offering a suitable discount to attract new business versus reducing fares for existing patrons. For this reason various off-peak discounts are currently being applied within the non-urban public transport industry which range from 5% (e.g. VIP) to 40% (e.g. V/Line). V/Line is the only Rail System to offer off-peak fares, and the most interstate coach operators do not.

Other examples of differential pricing include surcharges for various classes of travel, promotional discount fares and specialised fares. Some of the first class surcharges adopted are as follows:-

OPERATOR	FIRST CLASS DIFFERENTIAL (Added to economy fare)
V/Line	40%
SRA	40%
QR	50%
AN	50%
Westrail	35%
ROA	40%
Australian Airlines	50%
Ansett Airlines	50%

5.2 Optimising Fare Adjustments

When increasing fares it is important to maximise the revenue impact of the fare adjustment for a nominated fare inccrease.

For operators which base their fares on a flat cents per kilometre, the target fare increase would simply be applied across all fares. However for operators using a non-linear fare function, a weighted fare increase is a more efficient means of generating revenue rather than a flat increase across all fares. The question arises as to how can the revenue impact be maximised, patronage loss be minimised and the target weighted increase be satisfied.

When attempting to determine the optimal mix of a fare increase across various fare types so as to satisfy the objectives mentioned above, a number of factors need to be considered by the operator :-

- (i) demand distribution across ticket types
- (ii) revenue distribution across ticket types
- (iii) price elasticity distribution across ticket types
- (iv) demand distribution across distances
- (v) revenue distribution across distances

This particular problem has been attempted to be solved by V/Line by treating the problem as a non-linear optimisation problem. However it was found the problem requires details of cross elasticities between modes, classes of fares, peak to off-peak travel, as well as induced travel. Such a requirement means the specifications of the problem become very complicated, very quickly. Therefore at the time of writing this paper a solution had not been found but it was still considered interesting and worthwhile to raise at this Conference.

5.3 Measuring Revenue Impacts

When determining the impact of a fare adjustment in an inelastic market the revenue gain is often of more concern than the effect on patronage. That is, if the patronage loss is going to be relatively little, then the primary concern to Management is the revenue impact. A very useful formula for directly estimating the impact of a fare increase on revenue is :-

$$Rn = Ro\,(1+f)\,(1+f.Ed)$$

where :- Rn = New Revenue
Ro = Old Revenue
f = fare increase, expressed as a decimal
Ed = elasticity of demand, signed negatively

The derivation of the formula is shown in Appendix A.

e.g. Suppose existing revenue equals 100 units, and the fare increase is 7% with a price elasticity of -0.3, this means the revenue yield will equal :-

$$Rn = 100\,(1+0.07)\,(1+(0.07)(-0.3))$$
$$= 104.8$$

i.e. an increase of 4.8%

Using the revenue formula as shown, means for a given price elasticity the optimal fare increase can be derived for maximising revenue. The relationship between revenue gains and fare increases for an elasticity of -0.4 is shown in figure 11.

The optimal fare increase for a given elasticity is found by simply finding the turning point in the relationship between revenue and fare increases. That is, at what point will the fare increase have driven away so much of the business, that there are not enough patrons left paying the increased fares to maintain the revenue. The solution to this problem is as follows (see Appendix B for details) :-

$$\text{Optimal } f = -\frac{(1 + Ed)}{2Ed}$$

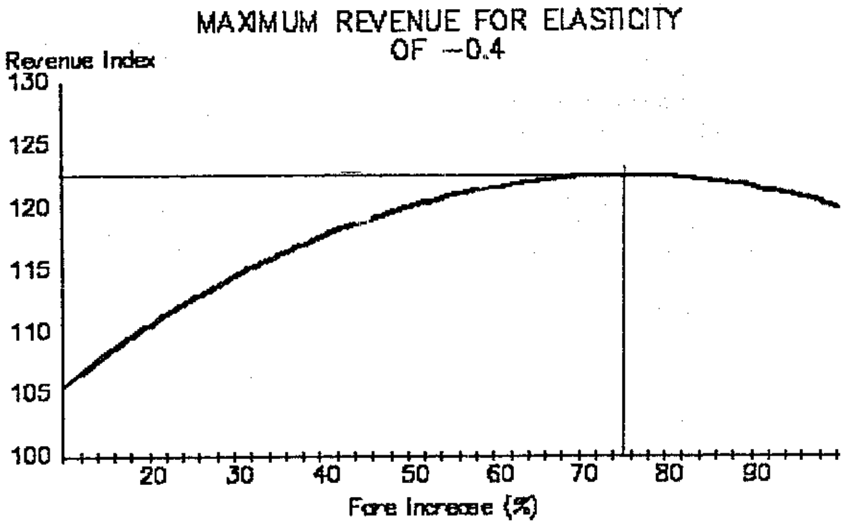
where f = fare increase expressed as a decimal
Ed = elasticity of demand, signed negatively

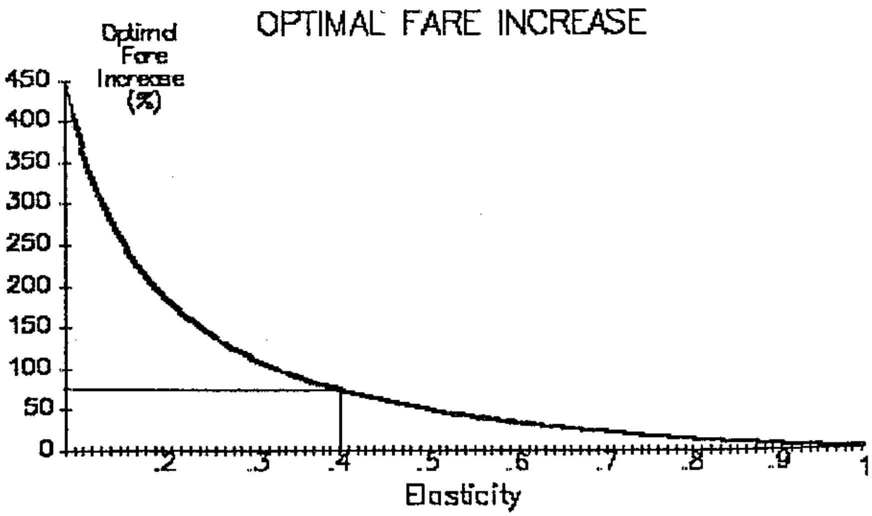
Figure 12 shows the optimal increase for various elasticities. As shown, for elasticities close to zero the fare increase for maximising revenue is enormous whereas for elasticities closer to unity, the optimal increases are only marginal. However it should be noted cross elasticities have not been used in the analysis which means for large increases the results are void.

5.4 Consecutive Fare Increases

If a target market is price-homogeneous by all patrons being price sensitive to the same level, then the price elasticity will hold constant for consecutive fare increases. However this is often not the case which means the impact of consecutive fare adjustments will vary according to the sub-components of the target group.

For instance, upon the introduction of the first fare increase, the most price sensitive patrons will react, leaving the less price sensitive patrons behind. This means the weighted elasticity for the remaining patrons will move closer to zero. Similarly, for the second fare increase, the process will occur and once again the weighted elasticity will alter and move closer to zero. So for each fare adjustment, assuming no new business and fare relativities between competitors are maintained, means the target market will become less and less responsive to fare changes.


MAXIMUM REVENUE FOR ELASTICITY
OF -0.4
Revenue Index
130
125
120
115
110
105
100
20
30
40
50
60
70
80
90
Fare Increase (%)


OPTIMAL FARE INCREASE
Optimal
Fare
Increase
(%)
450
400
350
300
250
200
150
100
50
0
.2
.3
.4
.5
.6
.7
.8
.9
1
Elasticity

6.0 MEASURING ELASTICITIES WITH MISSING DATA

Measuring demand elasticities is a difficult process at the best of times as the process requires isolating price factors versus other market forces, trends and randomness of data. The task becomes even more difficult when data is missing. In order to overcome the problem of missing data an iterative convergence technique has been developed and tested by V/Line in conjunction with the Mathematics and Operations Research Department, Footscray Institute of Technology, Melbourne. The technique is briefly discussed below:-

Before and after studies are a common means of attempting to understand the impact of fare changes. If the data being analysed can be formulated as a block then this iterative convergence technique can be applied. For instance, suppose demand data can be formulated as follows :-

Day of Week

Week	Mon	Tue	Wed	Thu	Fri	Sat	Total
1	39	36	?	41	49	19	184
2	38	38	31	41	29	?	177
3	34	42	32	32	?	16	156
4	36	43	37	32	37	23	208
Totals	147	159	100	146	115	58	725

where ? = missing values

For the missing passenger count on the first Wednesday in the block the element can be estimated using the algorithm :-

$$\text{Missing Value} = \frac{(Nw \,.\, W) + (Nd \,.\, D) - G}{(Nw-1) \,.\, (Nd-1)}$$

where Nw = Number of weeks in block (i.e. 4)
W = Sum of available counts in week containing missing value (i.e. 184)
Nd = Number of weekdays in block (i.e. 6)
D = Sum of available counts in the weekday containing missing value (i.e. 100)
G = Sum of all available data points in block

What this means is the missing data point is substituted by an estimate which is related to the demand level for values in the same week, and similar days of the week, and because of this the technique has some appeal.

The process can then be extended for more than one missing value, and after each missing value is estimated, the column, row, and grand totals are updated. Once all missing values have been estimated, the process is repeated until all missing value estimates equal the previous estimates (i.e. converge).

Using the technique generates the following estimates for each of the missing days as follows :-

Estimates at Each Iteration

Missing Day	Iteration Count		
	1	2	3
Wednesday	41	37	37
Saturday	19	17	17
Friday	35	35	

Given the last estimates equal the previous estimates, the problem has converged and a solution has been found.

V/Line was using the technique to provide estimates of passenger loads on individual short distance services. Such services were not seat reserved services, and hence the on-board conductor was responsible for recording counts of the passenger loads. However due to manning practices, a conductor is not available everyday on every service. After using the technique which has it's origins from Random Block Design in Experimental Survey Design, the technique has been extensively tested using V/Line data. Some of the more interesting results from the testing were :-

1. Whilst a single estimate has worthy statistical properties such as Best Linear Unbiased Estimator (BLUE), it is not clear whether all estimates have the same property.

2. The final solution was not dependent upon the original values chosen for the missing element, however the solution converged more quickly using the average as the initial estimate.

3. The solution would generally be found in less than four iterations

4. There was no pattern regarding the errors as a function of the number of missing values. This means the errors appeared to be random.

5. Estimates were significantly effected by extreme values.

6. In the particular application tested, the optimal block size was 6 weeks.

7. The estimates generated proved to be no better than any other central location measure (e.g. mean, median etc), given in this particular case the data was random between days.

In V/Line's case the data used only consisted of Monday-Friday train loads, hence the association between the load data and days of week was not as strong as if all days including weekends were considered.

The purpose in presenting the technique was to alert other researchers involved in modelling, the technique exists and depending upon the characteristics of the data for the application, will dictate the appropriateness of the technique. The technique is valuable when there is a significant association between the data and the rows and columns of the block and days of week and weeks in the year.

7.0 CONCLUSION

Throughout Australia there are similar quality services charging different rates for a similar service. The variations in pricing levels seem to be related to the decision-makers involved, market influences including competition, and historical reasoning.

Non-subsidised road coach operators (i.e. interstate and country) are examples where fares fluctuate primarily due to market forces and satisfactory financial performance. Country Rail System's fares vary throughout Australia and do not seem to be related to population densities, or market forces. Rail System's fares tend to be set in accordance to the previous fare levels so the relativity between System's and the market forces is dependent upon the original levels.

Interstate surface transport fares tend to be more market driven than country fares as such operators have more autonomy in their pricing.

Perceived motor-car costs are generally lower than public transport fares, except in the case of commuter travel (e.g. Victoria), where the traveller is offerred a substantial discount from the ordinary full-fare.

Taking the opportunity to maximise revenue is obviously of paramount importance and this can be achieved by applying differential pricing, using distance-based fares for non-urban travel, and carefully setting fare increases. For operators who use a non-linear fare function, the same weighted average fare increase can generate different revenue gains.

For non-urban transport operators who must consult with a Government body before adjusting fares, have the responsibility to identify where fares are below market based levels and present a clear case for adjusting the fares accordingly. The Government body should in turn be responsible for validating the proposal and feel encouraged to implement the proposal based on social equity and economic reasoning.

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APPENDIX A

DERIVATION OF REVENUE FORMULA

To measure the impact of a fare increase on demand, the standard relationship used is :

Demand is given by :

$$Dn = Do\ (1 + f.Ed)$$

where Dn = New demand
Do = Old demand
f = fare increase, as a decimal
Ed = Elasticity of demand, signed negatively

After a fare adjustment the resultant reveue will be :-

New Revenue = New Demand . New Average fare

$$= Dn \cdot \frac{Ro}{Do} \cdot (1 + f)$$

Therefore substituting the demand equation into the revenue equation gives :-

$$Rn = Do\ (1 + f.Ed) \cdot \frac{Ro}{Do} \cdot (1 + f)$$

given $\frac{Do}{Do} = 1$, then

$$Rn = (1 + f.Ed) \cdot Ro \cdot (1 + f)$$

$$= Ro\ (1 + f)\ (1 + f.Ed)$$

APPENDIX B

DERIVATION OF OPTIMAL FARE INCREASES

Using the revenue formula :-

$$Rn = Ro\ (1 + f)\ (1 + f.Ed)$$

where Rn = New revenue
Ro = Old Revenue
f = fare increase, as a decimal
Ed = Elasticity of demand, signed negatively

Expanding the expression gives :-

$$Rn = Ro\ (1 + f + f.Ed + f^2.Ed)$$

dividing both sides by Ro,

$$\frac{Rn}{Ro} = (1 + f + f.Ed + f^2.Ed)$$

Differentiating both sides with respect to Rn/Ro will give the turning point of the expression, hence

$$\frac{d\ R}{d\ f} = 1 + Ed + 2.f.Ed$$

Set $\frac{d\ R}{d\ f} = 0$

$$0 = 1 + Ed + 2.f.Ed$$

Solving for f,

$$f = -\frac{(1 + Ed)}{2\ Ed}$$