BRANDOW DEMAND FUNCTIONS

FOR

AUSTRALIAN LONG DISTANCE TRAVEL[1]

by

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ABSTRACT:

This paper discusses the fares by mode of travel and the mode shares on Australia's seven major long distance travel corridors; it reviews econometric results on the demand elasticities for long distance travel in Australia and then it derives a matrix of Brandow cross elasticities associated with the Brandow Demand Functions for the Australia long distance travel market.

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INTRODUCTION

Early in 1985, the Market Analysis Division of the Australian Railways Research and Development Organization (ARRDO) was preparing itself for a major study of long distance travel in general and in particular, of the Indian-Pacific, a long distance passenger service in the Sydney-Perth corridor. As part of this preparation, Lubulwa (1985) an ARRDO document presented a methodological review of long distance passenger demand research in Australia, examining and assessing the functional forms the data and estimation methods used in Australian econometric studies of long distance travel demand.

This paper on Brandow demand functions has three objectives namely: (i) to briefly discuss two features of the Australian long distance travel market (ii) to identify the estimates of elasticities from a number of major studies of long distance travel carried out in Australia and (iii) to present some results on Brandow demand functions for Australian long distance travel

THE AUSTRALIAN LONG DISTANCE TRAVEL MARKET

The purpose of this section is to put the discussion on Brandow demand functions for long distance travel in context by a brief discussion (hinged on seven major Australian long distance passenger travel corridors) of two of the main characteristics of the Australian long distance travel market, namely the fares and the mode shares on these seven selected major routes.

FARES ON SEVEN MAJOR CORRIDORS

Table 1 presents information on fares on seven major long distance travel corridors.

Table 1: Passenger Transport Fares on Selected Major Routes (at 1 January 1985)

Route	Fare Class[a]	Passenger mode, $ Air	Rail	Road
Townsville-Brisbane	1st	280.50	93.50	83.90
	Economy	187.00	62.30	72.85
	Discount	121.55	-	50.00
Brisbane-Sydney	1st	218.60	79.00	39.00
	Economy	145.70	56.00	36.00
	Discount	94.70	-	25.00
Brisbane-Melbourne	1st	321.00	158.00	79.00
	Economy	214.00	112.00	69.50
	Discount	139.10	-	50.00
Sydney-Melbourne	1st	211.40	79.00	39.50
	Economy	140.90	56.00	36.00
	Discount	91.60	39.00	25.00
Melbourne-Adelaide	1st	199.70	59.00	39.00
	Economy	133.10	42.00	36.00
	Discount	86.50	29.00	25.00
Adelaide-Perth	1st	420.90	315.00	-
	Economy	280.60	241.00	104.00
	Discount	182.40	105.00	60.00
Sydney-Perth	1st	548.40	476.50	-
	Economy	365.60	366.50	149.00
	Discount	237.65	-	110.00

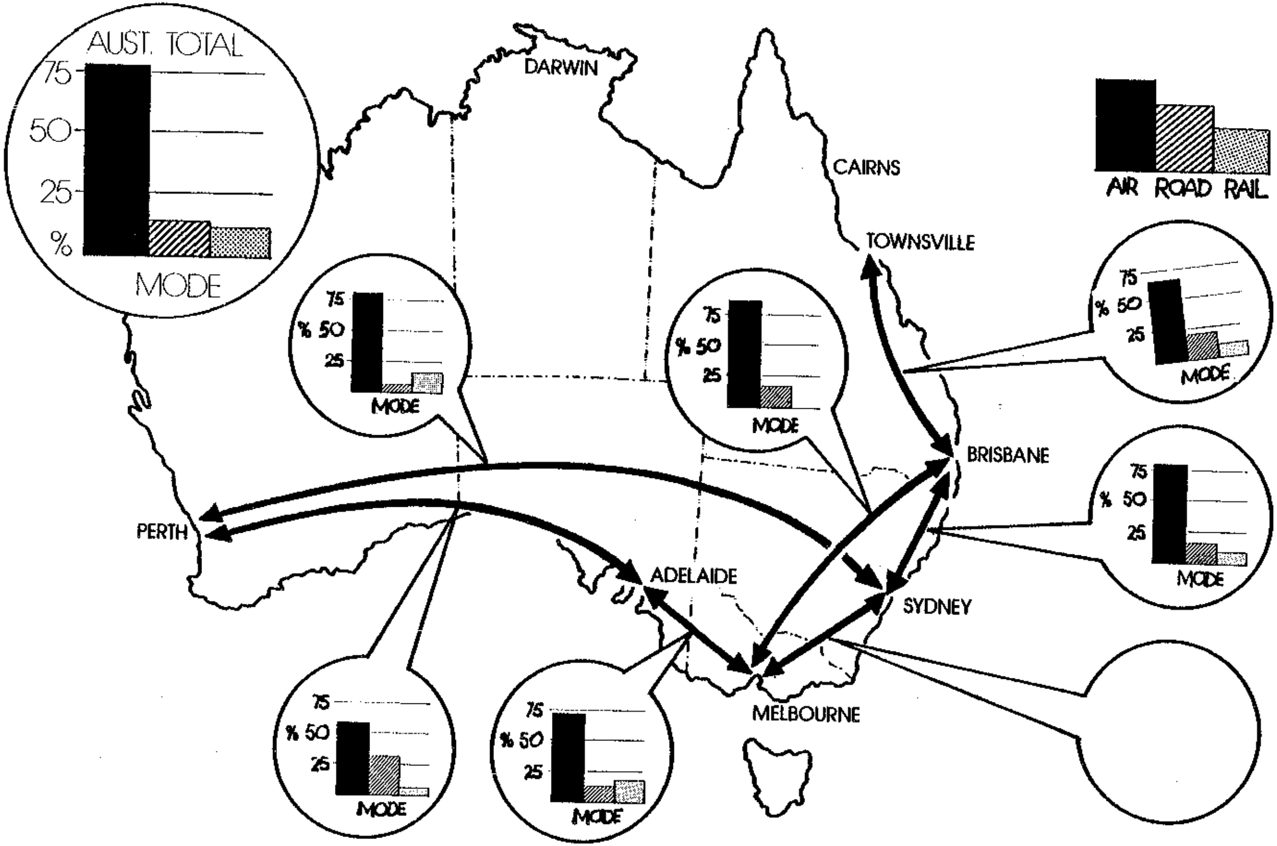
(a) For comparative purposes, fares for each class are based on the minimum price for a seat on a scheduled service. 'Stand-by', 'flexi-fares' and other like fares which do not guarantee travel on a specified service, and 'special' or temporary 'promotional' fares have been excluded. Railway fares do not show berth or meal charges where these are an extra cost option. Road fares do not include meal and refreshment costs. Discount fares for all modes may have special conditions attached to purchase.

Source: Lubulwa, Michael and Smith (1985, p.33)

It is clear from table 1 that apart from the Economy class on the Townsville-Brisbane route road is the cheapest mode of long distance travel on the routes under consideration. This intermodal price differential seems to be one of the major explanatory variables of the difference on most routes in mode shares between road and rail which are land based transport modes. The dominance of air travel on these routes is obviously due to non price factors since air travel is the most expensive of all the modes on all the routes under consideration.

MODE SHARES ON SEVEN MAJOR CORRIDORS

Mode shares have been estimated for 1983-84 on seven long-distance passenger routes. These routes, shown in Fig. 1, were selected largely for their volume although the Sydney-Perth route has been included because of its current pertinence to railway decision-making particularly regarding the Indian-Pacific. Mode shares analysed in this context are for the commercial fare-paying services of all rail, air and road coaches only, with private vehicles and hire cars excluded. These results suggest that rail transport holds a little over 11% of the total commercial market of more than 6.2 million passenger journeys per annum on these routes. Air transport dominates with around 76% of total commercial passenger journeys, but it is apparent that road-coaches have a strong market penetration that is currently around 13%. The competition between road coaches and rail services appears to be favouring road transport on the longer routes, perhaps because road coaches enjoy not only a price advantage but also a time advantage. The dominance of air transport on the day Brisbane-Sydney-Melbourne routes is partly due to the large numbers of same-day business travellers for which the other modes find it hard to compete.


AUST. TOTAL
75
50
25
%
MODE
DARWIN
CAIRNS
TOWNSVILLE
BRISBANE
PERTH
ADELAIDE
SYDNEY
MELBOURNE
AIR
ROAD
RAIL
% 50
MODE

As noted above that these mode shares exclude the traveller using a private car as a means of transport it is worth examining separately the share of the 'private car' in long distance travel.

Since the inception of the Domestic Tourism Monitor in 1978, the survey indicators have shown that most trips within Australia are undertaken by means of private car - in fact, private car travel accounted for around 82%, of total trips in the period 1978-79 to 1983-84, despite fluctuations in the economy and changes in the real costs of private motoring. Thus only 18% of all travellers in this period were fare-paying travellers which suggests that, there are substantial commercial rewards for transport operators who can convert some private car travellers to their mode

The successful development of a strategy that will lead to a substantial increase in the mode share of any given transport mode in the long distance travel market requires a lot of information on the demand characteristics of long distance travel. The next section summarises the various quantitative research efforts directed at identifying the major factors that impinge on the demand for long distance travel in Australia.

LONG DISTANCE TRAVEL: MODELLING EXPERIENCE IN AUSTRALIA

This section summarises the estimates of Australian demand elasticities in the long distance travel market. Table 2 deals with the estimates for rail long distance travel

Table 2: Rail: Long distance travel demand elasticities.

Author (Date)	Dependent Variable/ Corridor	Income Elasticity	Own price elasticity	Cross price elasticity	Other	Type of Model
BTE (1971)	Yass-Canberra	-	-		1.0[a]	Gravity
Smith-BTE (1977)	Perth-Sydney					
	Total Trips	n.e.	-0.43	1.12[e]	0.35 [d]	Time Series
	First class	n.e.	-0.67	1.56[e]	0.35 [d]	Time Series
	Economy	n.e.	-0.14	0.68[e]	0.35 [d]	Time Series
			n.e.			
BTE (1980a)	Sydney-Canberra	n.e.	n.e.	4.87[b]	0.512[d]	Cross Section
Tulpule and Powell (1978)	All Australia	0.40[c]	n.e.	n.e.	n.e.	Time Series
Meagher, Parmenter, Rimmer & Clements (1983)	All Australia	0.38[c]	-0.21	n.e.		Time Series

(a) this value was not estimated but assumed from overseas studies.
(b) this value is for the price of air travel relative to rail travel
(c) this is an expenditure elasticity defined as the percentage change in the expenditure on railway transport for a 1% change in total expenditure
(d) this is the elasticity of rail travel demand with respect to frequency of service
(e) the elasticity of rail travel demand with respect to airfares.
n.e. denotes not estimated

Though it is not clear from Table 2, Smith-BTE (1977) included population and income variables in their initial specification of the demand functions but these were excluded later on because their coefficient estimates were not significant and their inclusion made the coefficient estimates of other variables less significant Table 2 shows that there are lots of gaps one needs to fill in with respect to the cross elasticities of rail demand for long distance travel.

Long distance travel by air has been extensively studied and thus there is more information about the requisite elasticities but this is not to say that there are no information gaps as Table 3 below shows. It is clear from table 3 that none of the results in all these tables yield any information on elasticities with respect to travel time, frequency, other modes (except for the car). There are some useful general conclusions that one can draw from table 3 though namely: that the elasticities for long distance travel by air (i) change depending on whether the trip is a business or non-business trip with the non-business trip being more elastic;

Table 3. Air: Long Distance Travel Demand Elasticities[a] with respect to

Author and CORRIDOR	Income	Own Price	Car or Sea Cost	Other
BTE (1978a)				
To overseas				
Leisure(to O/S)	2 36	-1 78[b]	n e	0 55[i]
Business(to O/S)	n e	-1 23[b]	n e.	0 83[g]
BIE (1978b)				
Total Interstate	0.446	-0 284	-0 144[c]	-0.137[j]
Non-business	n e	-1 264	n e	-0.444[j]
Business	n e.	-0.855	n e.	0.948[j]
Hutton-BIE (1979)				
Australia	1 22	-1 45	n.e	
BIE (1982)				
Short Haul[d] (less than 500 km)	-1 039*	-0 728	0 239	0 385[k]
			-0 132++	1 30**[l]
Medium Haul[e] (up to 2000km)	1 592	-0 712	0 313	1 723[l]
				1 087[k]
Long Haul[f] over 2000km	3 074	-0 849	0.459	2 544[l]
SAAD et al (1983)				
Business	n e	-0 543	n e	0 336(Exports)
				0 235(Imports)
non-business	0 827	-0 687	n e	0 403(Immigrants)
Trunk:				
:Summer Holiday	3 846	-1 087	0 030	
:winter	2 565	-1 120	n e	
BIE (1984)				
Sydney/Brisbane	n e.	-0 09	n e.	1 32[h]
Perth/Adelaide	2 16	-1 65	0 69	
Melbourne/Brisbane	n e	-1 02	n e.	8 0[j]
				0 79[h]
Sydney Adelaide	0 82	-0 91	0 35	4 5[j]
Melbourne/Adelaide	n e	-0 46	0 11	1 71[h]
Milloy et al (1985)				
Melbourne Perth	n e	-0 85	n e	1 50 [h]
Sydney/Melbourne				
Sydney/Brisbane				
Business	n e	-1 1 +OR-0 3	n e	
Non Business	n e	-3 2 +OR-0 6	n e	
1st class	n e	-0 6 +OR-0 4	n e	

Notes to Iable 3.

n.e. denotes not estimated

(a) all the results in this table were derived from logarithmic demand functions so that the estimated coefficients could be directly interpreted as elasticities

(b) these are elasticities with respect to real equivalent air fares which is the sum of the actual fare paid and the notional monetary penalty attached to any conditions associated with a particular air ticket type

(c) this is the elasticity with respect to the ratio of real air fare plus access and egress cost to the percieved cost of car travel in real terms. Otherwise figures in this column give the elasticities with respect to the perceived cost of car (or sea) travel in real terms. The only elasticity with respect to sea cost is denoted by ++.

(d) the elasticities associated with 'short haul' except for those marked++ or * or ** are averages of elasticities over 4 corridors namely: Canberra-Sydney, Cairns-Townsville, Canberra-Melbourne and Launceston-Melbourne. * is for Canberra-Sydney, ++ is for Launceston-Melbourne while ** is for Cairns-Townsville.

(e) elasticities in this row are averages over 17 corridors.

(f) elasticities in this row are averages over 7 corridors.

(g) the elasticity with respect to trade volume which is the sum of exports to and imports from Australia's major trading partners.

(h) elasticity with respect to Australia's gross domestic product.

(i) the elasticity with respect to the exchange rate index.

(j) the elasticity with respect to the product of the populations in the origin - destination pair.

(k) the elasticity with respect to the availability of tourist accommodation (i.e. hotel and motel rooms) in the origin and destination of the corridor under analysis

(l) the elasticity with respect to the number of people employed;

(ii) elasticities of long distance travel vary according to length of haul with the long haul trips more elastic than the short haul trips;

(iii) long distance travel elasticities are route dependent changing from one corridor to another possibly because of the differences in the socio-economic characteristics of travellers on different corridors and due to the specific nature of each corridor as a result geographical climatic conditions and the availability of amenities (e g motels and service stations) for corridor road travellers.

Unfortunately the literature is not very informative about the elasticity relating to long distance travel by sea One study by the Bureau of Transport Economics (1980b) examined this submarket but the highly non-linear functional forms do not easily yield information about elasticities. Similarly the only study on the road long distance travel demand is by the Bureau of Transport Economics (1984) whose results are presented in table 4 below.

While on some corridors certain modes are just not available, more than one mode is available on most long distance corridors. A pricing decision in one mode will always have consequences for other modes, for although all transport modes are not perfect substitutes of one another, there is a feasible region within which intermodal substitution is possible.

Without some knowledge of cross elasticities the outcome of pricing policies can be unpredictable even when good estimates are available of own-price elasticities. While it is true that under ceteris peribus conditions there would be no need to know the cross-elasticities in order to predict the effect of a fare change, it

Table 4. Estimates of elasticities of the number of passenger cars on register with respect to purchase price, income and operasting costs by state of registration

State of Registration	Purchase price	Income	Operating costs	$\bar{R}^2$	Durbin-Watson
New South Wales	-0.66 (-3.16)	0.75 (7.51)	0.05 (0.23)	0.99	1.93
Victoria	-0.48 (-2.44)	1.02 (7.80)	-0.27 (-1.31)	0.99	1.58
Queensland	-1.12 (-3.78)	0.63 (4.35)	0.14 (0.48)	0.98	2.16
South Australia	-0.59 (-3.79)	0.76 (8.90)	-0.06 (-0.41)	0.99	1.71
Western Australia	-0.92 (-4.77)	0.76 (6.67)	-0.32 (-1.56)[(a)]	0.99	1.76
Tasmania	-0.89 (-3.41)	0.90 (7.73)	-0.17 (-0.66)	0.98	1.80

(a) Significant at the 90% level.

Note: t values are in brackets

Source: Bureau of Transport Economics (1984).

is also true that the real world is one where the ceteris paribus conditions rarely if ever hold. The problem often is that these cross elasticities are often not available The next section suggests a way of somehow over coming this problem

Brandow demand functions

These are demand functions named after an economist, Brandow (1961) who pioneered a method of deriving values for missing cross elasticities of demand using those elasticities which are available from emperical/econometric work on the one hand and some well known economic theoretic consistency constraints Though this method was developed in the context of consumer demand for food products, this paper extends Brandow's method to the Australian long distance travel distance market.

In the studies of Australian long distance travel detailed above, there is an abundance of parameter estimates of the elasticities with respect to income and to the fare of the transport mode in question. This is mainly because estimation has generally been limited, by the data available, to fairly simple equations in which demand for a particular type of travel on a given corridor is some function of the fare, income and possibly the fare on one other mode which is a close substitute Thus other modes and estimates of the inter modal cross elasticities are lacking and probably cannot be obtained directly from the data due to the inadequacy of both the econometric techniques and the data.

The Brandow method for generating cross elasticities is well documented in Brandow (1961) and Taplin (1980) and will not be detailed here. It suffices to note that the Brandow method is a method of information synthesis which brings together and interrelates scattered bits of valuable information into a coherent and comprehensible package. It is used here to bring together and interrelate the information about long distance demand elasticity which is scattered in the above mentioned econometric studies into one whole and to generate the missing cross-elasticities while preserving coherence.

The most difficult elasticities to find were the elasticities of demand with respect to changes in travel time, associated with various modes of transport. The only comprehensive elasticities available were from BIE (1979) and these were adopted since there were no other available

THE MATRIX OF BRANDOW ELASTICITIES

The matrix of Brandow elasticities is presented in Table 5 below. The sources from which the elasticities are derived are given at the bottom of the table. Reading across the row labelled 'air cost' for example, reveals that when the cost of air transport increases by 1% that demand for air travel by business travellers declines on average by 0.86% while the demand by non-business travellers declines on average by 1.26%. Similarly for the same increase in the cost of air travel the demand for long distance travel by rail increases by 1.12% while that by bus and car respectively increases on average by 0.9% and 0.03%. For each numbered row of Table 5 one can give similar interpretations of the figures. In row five, the negative income elasticity of demand for long distance travel by rail is embodying the assumption that long distance travel by rail is an inferior good, so that a 1% increase in disposable income is on average likely to lead to 1.11% drop in demand.

In the column labelled 'Air' it is worth noting that if λ_A is some positive constant less than 1 then if all travel times are multiplied by λ_A then the demand for air travel will be multiplied by λ_A to the power α_A

$$\alpha_A = -0.50 + 0.06 + 0.06 + 0.05 = -0.38$$

That is the demand function for long distance travel by air is not homogeneous of degree zero in travel times of all modes. Similarly for travel by rail, bus and car taking positive constants $\lambda_R, \lambda_B, \lambda_C$ where $0 < \lambda_R < 1, 0 < \lambda_B < 1, 0 < \lambda_C < 1$ associated with the modes R for rail, B for bus and C for car that λ would be raised to the power α_R, α_B, α_C respectively

where

$$\alpha_R = 0.06 - 2.25 + 0.30 + 0.04 = -1.85$$

$$\alpha_B = 0.06 + 0.04 - 2.25 + 0.04 = -1.75$$

$$\alpha_C = 0.06 + 0.04 + 0.04 - 2.50 = -2.36$$

Table 5. Brandow long distance travel demand functions for Australia

Elasticity of demand with respect to the number variable	The demand for long distance travel by mode				
	Air		Rail	Bus	Car
	Business	Non-Business			
1 Air cost	-0.86[a]	-1.26[a]	+1.12[f]	-0.9[d]	+0.03[h]
2 Rail cost	+0.02[h]	+0.02[h]	0.43[f]	+0.50[h]	+0.02[h]
3 Bus cost	+0.02[h]	+0.02[h]	+0.40[h]	-2.22[h*]	+0.02[h]
4 Car cost	+0.02[e]	+0.03[h]	+0.02[h]	+0.02[h]	-1.27[h*]
5 Income	+1.89[b]	+1.19[b*]	-1.11[h*]	+1.00[h]	+1.20[h]
6 Population	+0.95[a]	+0.44[a]	+1.00[h]	+1.00[h]	+1.00[h]
7 Air time	-0.50[h]	-0.50[h]	+0.06[h]	+0.06[h]	+0.06[h]
8 Rail time	+0.06[h]	+0.06[h]	-2.25[h]	±0.040[h]	+0.04[h]
9 Bus time	+0.06[h]	+0.06[h]	+0.30[h]	-2.25[h]	+0.04[h]
10 Car time	+0.05[h]	+0.05[h]	+0.04[h]	+0.04[h]	-2.50[h]
11 Tourist accommodation	+1.41[c]	+1.41[c]	n.a.	n.a.	n.a.

Sources: (a) Bureau of Transport Economics (1978a)
(b) Saad, Dao, McAndrew and Watt (1983)
(b*) Denotes an elasticity from Saad et al (1983), modified to satisfy the homogeneity of degree zero condition.
(c) Francki and Eyland (1983)
(d) Milloy, Douglas and Sullivan (1985).
(e) Taplin (1980).
(f) Smith - BIE (1977).
(g) Bureau of Transport Economics (1980)
(h) Bureau of Transport Economics (1979).
(h*) Denotes an elasticity from BIE (1979) modified to satisfy the homogeneity of degree zero condition
n.a. Denotes not available.

Thus if travel times for all modes are reduced by the same proportion the demand for travel by car is assumed to increase by the largest amount, followed by rail, bus and air in that order.

THE USE OF THE BRANDOW FUNCTIONS

Table 5 is useful in that it helps the policy maker realise the interrelationships between the long distance travel submarkets Nevertheless the table can only be treated as indicative of orders of magnitude The deficiencies of the Brandow demand functions are partly due to the need for more estimation work, though it is probable that many of the cross elasticities will remain inaccessible to econometric techniques. Finally, it is worth noting that these demand functions give average elasticities over the whole of Australia BTE (1982) has shown though that the elasticities for air travel vary significantly from one corridor to another

There is no apriori justification for the elasticities for other modes of travel to remain constant across corridors Thus, in corridor specific applications the elasticities in Table 5 would need to be adjusted to reflect the special demand features of the corridor in question.

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