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DEMAND FOR INTER-CITY AIR TRAVEL IN N.S.W.

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ABSTRACT: *This paper evaluates the estimation results for aggregate cross-sectional models of the demand for inter-city air travel in New South Wales. A feature is the specification of income as an independent variable within the framework of a cross-sectional model. The results indicate that income contributes substantially to the explanatory power of the models. It is also concluded that air travel demand is sensitive to competition from other modes. It was not possible to isolate satisfactorily the relative roles of the money and time costs of travel. However, evidence is provided to demonstrate that travel time is an important determinant of the demand for air travel.*

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INTRODUCTION

The purpose of this paper is to assess the relative roles of the money and time costs of travel and of travellers' income in determining the distribution of air trips between Sydney and towns in New South Wales. The models that have been estimated are variations on the basic trip distribution model, with Sydney as a common origin or destination. In the first section we evaluate the results for conventional trip distribution models. A shortcoming of these models is the omission of income as an explanatory variable. In the second section, income is incorporated as an explanatory variable by specifying trip rates by income group as the dependent variable. In the third and fourth sections, two overseas studies are replicated in an attempt to provide evidence on the value of time in air travel. Although the estimates obtained for the value of time are generally unacceptable, it is concluded nevertheless that travel time is an important determinant of the demand for air travel.

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*This is a revised version of Chapter 3 of a thesis entitled "Travel Demand Modelling And The Valuation of Travel Time", Macquarie University 1976.

This study originated from a brief undertaken by the author for the Bureau of Transport Economics on inter-city passenger travel demand.

I would like to acknowledge the assistance and advice provided by the Bureau and members of its staff. Andrew Smith in particular played a valuable part in formulating the original study. David Rutledge of Macquarie gave numerous comments on the empirical work. This paper has also benefited from the critical suggestions of Richard Bullock, Colin Gannon and David Hensher.

TRIP DISTRIBUTION MODELS

Models of the demand for air travel by Sydney residents[1] have been estimated for the following trip purposes[2]:

i) Business
ii) Leisure
iii) Visiting Friends and Relatives (i.e. VFR)
iv) Holiday

The estimation results are tabulated by trip purpose in tables 1-4 respectively. The models, which are denoted by the numerals I - V, are variations on the basic trip distribution model :

$$X_j = \alpha_0 P_j^{\alpha_1} F_{Aj}^{\alpha_2} T_{Aj}^{\alpha_3} F_{Rj}^{\alpha_4} T_{Rj}^{\alpha_5} \qquad (1)$$

where X_j = air travel between Sydney and town j by trip purpose
P_j = population of town j
F_{Aj} = air fare to town j
T_{Aj} = air travel time to town j
F_{Rj} = rail fare to town j
T_{Rj} = rail travel time to town j

The essential differences among the alternative models arise because of the inclusion of different combinations of the cost and time variables and because of the specification of alternative proxies for the attraction variable.

One of the difficulties associated with the models is that the explanatory variables are highly collinear. Not only are the fare and time variables positively related to each other, but in turn each is negatively related to population, a measure of attraction. This is because the larger airport towns are generally located closer to Sydney.

The presence of multicollinearity makes it extremely difficult to isolate the relative effects of population, fares and times upon the distribution of trips among alternative destinations. Furthermore care must be taken in interpreting the estimates

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1. Models of the demand for air travel by destination town residents were also estimated. The results are not given, however they are similar to the results presented for Sydney residents.
2. The data source was an air passenger survey conducted for the Department of Transport in 1973 as part of the study for a proposed second airport in Sydney.

TABLE 1

BUSINESS AIR TRIPS TO TOWNS IN N.S.W. BY SYDNEY RESIDENTS

	I	II	III	IV	V
CONSTANT	-5.7655	-6.1742	-6.1990	-3.0552	-5.6862
	(-2.8431)	(-3.2131)	(-2.8270)	(-1.1410)	(-2.7798)
POPULATION	+1.3815	+1.3174	+1.1455		+0.9325
	(+10.1314)	(+9.9746)	(+6.1193)		(+4.7200)
AIR FARE	-0.4311	-2.7170	-2.3887	+2.6561	-0.3236
	(-1.0148)	(-2.3633)	(-1.6272)	(+1.2895)	(-0.1973)
AIR TIME			+0.1378	-1.6750	-0.2936
			(+0.1775)	(-1.7980)	(-0.3943)
RAIL FARE		+3.0838	+4.7449	+2.9426	+2.2555
		(+2.1212)	(+2.6242)	(+1.0805)	(+1.1238)
RAIL TIME			-1.6048	-2.4758	-0.7343
			(-1.5231)	(-1.8506)	(-0.6902)
REGIONAL DUMMY				-2.1193	-1.0596
				(-3.7749)	(-2.2557)
R^2	0.8056	0.8334	0.8477	0.7578	0.8744
F	58.0165	45.0216	27.8299	15.6441	27.8471
N	31	31	31	31	31

TABLE 2

LEISURE AIR TRIPS TO TOWNS IN N.S.W. BY SYDNEY RESIDENTS

	I	II	III	IV	V
CONSTANT	-1.3013 (-0.4494)	-1.9399 (-0.7189)	-3.9365 (-1.3728)	-2.4797 (-0.8536)	-3.7629 (-1.2853)
POPULATION	+1.0841 (+5.5165)	+0.9739 (+5.2511)	+0.5269 (+2.1524)		+0.4548 (+1.6086)
AIR FARE	-0.9067 (-1.4947)	-4.4781 (-2.7738)	-2.2539 (-1.1741)	-0.1019 (-0.0456)	-1.5552 (-0.6625)
AIR TIME			-1.1416 (-1.1246)	-1.9614 (-1.9408)	-1.2876 (-1.2082)
RAIL FARE		+4.8181 (+2.3600)	+7.6279 (+3.2259)	+7.1207 (+2.4102)	+6.7856 (+2.3623)
RAIL TIME			-3.2015 (-2.3236)	-3.7564 (-2.5882)	-2.9069 (-1.9339)
REGIONAL DUMMY				-0.8754 (-1.4374)	-0.3585 (-0.5333)
R^2	0.5835	0.6547	0.7264	0.7005	0.7296
F	16.3352	17.0640	13.2750	11.6945	10.7928
N	31	31	31	31	31

TABLE 3

V.F.R. AIR TRIPS TO TOWNS IN N.S.W. BY SYDNEY RESIDENTS

	I	II	III	IV	V
CONSTANT	-5.6911 (-1.5368)	-6.8185 (-2.1910)	-7.7024 (-2.1747)	-5.3784 (-1.3928)	-7.9901 (-2.2202)
POPULATION	+1.3127 (+5.2713)	+1.1357 (+5.3097)	+0.8062 (+2.6665)		+0.9257 (+2.6632)
AIR FARE	-0.3880 (-0.5002)	-6.6933 (-3.5949)	-5.4708 (-2.3072)	-3.6711 (-1.2359)	-6.6290 (-2.2971)
AIR TIME			-0.3853 (-0.3073)	-1.5146 (-1.1274)	-0.1433 (-0.1094)
RAIL FARE		+8.5063 (+3.6128)	+11.0366 (+3.7789)	+13.1150 (+3.3392)	+12.4329 (+3.5210)
RAIL TIME			-2.6553 (-1.5603)	-4.8723 (-2.5254)	-3.1435 (-1.7013)
REGIONAL DUMMY				-0.4576 (-0.5652)	+0.5943 (+0.7191)
R^2	0.5279	0.6817	0.7108	0.6332	0.7169
F	15.6548	19.2753	12.2890	8.6315	10.1292
N	31	31	31	31	31

TABLE 4

HOLIDAY AIR TRIPS TO TOWNS IN N.S.W. BY SYDNEY RESIDENTS

	I	II	III	IV	V
CONSTANT	-2.2557 (-0.5339)	-2.6011 (-0.6087)	-6.1334 (-1.3272)	-5.3188 (-1.1975)	-5.7718 (-1.2282)
POPULATION	+1.0170 (+3.5798)	+0.9628 (+3.2782)	+0.3107 (+0.7876)		+0.1605 (+0.3537)
AIR FARE	-0.8307 (-0.9387)	-2.7619 (-1.0803)	+0.9222 (+0.2981)	+2.8913 (+0.8463)	+2.3782 (+0.6311)
AIR TIME			-2.1466 (-1.3121)	-2.6885 (-1.7399)	-2.4507 (-1.4326)
RAIL FARE		+2.6053 (+0.8059)	+6.2196 (+1.6321)	+4.5827 (+1.0145)	+4.4644 (+0.9683)
RAIL TIME			-4.3584 (-1.9628)	-4.0445 (-1.8226)	-3.7446 (-1.5520)
REGIONAL DUMMY				-0.9295 (-0.9982)	-0.7471 (-0.6923)
R^2	0.3693	0.3841	0.4946	0.5019	0.5045
F	8.1970	5.6124	4.8930	5.0380	4.0726
N	31	31	31	31	31

obtained for the coefficients of the related variables. For example, in Model II the air and rail fare variables both have significant coefficients, which supports the policy conclusion that air travel is sensitive to competition from other modes.[3] However, the direct and cross fare elasticities are best regarded as combined fare and time elasticities because the fare variables would appear to capture the effects of both fares and travel times in this model. It is significant from a policy viewpoint that these elasticities are higher for non-business than they are for business travel.

Reference to model III shows that attempts to incorporate travel time variables are not particularly encouraging. For business travel, it is noticeable that the air time variable is insignificant and takes an implausible sign. In the case of leisure travel, the air time variable does take the expected sign, although it too is insignificant. The rail travel time variable consistently takes an implausible sign. However, it cannot be concluded from these results that travel time is an irrelevant variable. This is because of the presence of multicollinearity, which simply implies that there may be insufficient variation within the data to isolate the effects of the money and time costs of travel

An attempt has been made to circumvent the problems of multicollinearity by substituting alternative measures of attraction for the population term in models IV and V. An analysis of the air travel market in N.S.W. had revealed that the growth of air travel to the north-west region of the state was sluggish.[4] Accordingly, each airport town in the state was allocated to either the north-west region or to the remainder of the state, and a regional dummy variable was used in lieu of, and in conjunction with, the population variable. Unlike the population measure of attraction, this regional dummy variable is not correlated with the fare and travel time variables, and for this reason it was to be expected that the problems of multicollinearity would be less severe. It can be seen from the results for model IV in tables 1-4 that the regional dummy variable captures much of the explanatory power contributed by the population variable, and that for holiday travel, there is even an improvement in explanatory power.

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3. The rail fare variable may well be acting as a proxy for car travel as an alternative to air.
4. Air Passenger Survey, Sydney 1973, Department of Transport.

A notable result which holds across all models is that the population coefficient is larger for business than for leisure trips. This is not surprising since business activity is associated with larger towns and cities. As a result, for business trips, population proves to be a good proxy for attraction. On the other hand, the population of a potential destination need not necessarily enhance its attraction to the leisure traveller. This applies in particular to holiday trips. An examination of table 4 reveals that when the regional dummy variable is included in conjunction with the population variable as in model V, the population coefficient is insignificant.

MODELS OF TRIP RATES BY INCOME GROUP

To incorporate income as an independent variable and derive income elasticities of travel demand, it was necessary to redefine the dependent variable as a trip rate.(5) This required the use of data cross classified by destination and income.

The estimation results obtained for business and leisure trips by Sydney residents are presented in tables 5 and 6. The models, which are denoted by the numerals I - VI, are again variations on the trip distribution model :

$$x_{ij} = \beta_0 P_j^{\beta_1} F_{Aj}^{\beta_2} T_{Aj}^{\beta_3} F_{Rj}^{\beta_4} T_{Rj}^{\beta_5} Y_i^{\beta_6} \qquad (2)$$

where $x_{ij} = X_{ij}/N_i$ is the trip rate of the ith income group to destination town j.

X_{ij} = the number of business/leisure trips between Sydney and town j by Sydney residents in the ith personal/household income group.(6)

N_i = the number of persons/households in the ith personal/household income group.

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5. A trip rate is defined as the total number of air trips by Sydney residents belonging to a given income group divided by the total number of Sydney residents in that income group. It was necessary to restrict the analysis to Sydney residents since data on the distribution of income was not available for NSW country towns.

6. Personal income was the income measure adopted for business trips, while household income was used for leisure trips.

TABLE 5

BUSINESS AIR TRIP RATES TO TOWNS IN NSW BY SYDNEY RESIDENTS IN EACH PERSONAL INCOME GROUP

	I	II	III	IV	V	VI
CONSTANT	-5.1650 (-1.0561)	-28.2578 (-9.0366)	-22.0043 (-8.2603)	-28.2578 (-9.0366)	-29.3354 (-9.4557)	-28.7296 (-10.9114)
POPULATION	+1.4065 (+4.2804)	+1.4065 (+8.0237)	+1.6173 (+9.2702)	+1.4065 (+8.0237)	+1.3227 (+7.2588)	+1.3866 (+8.2667)
INCOME		+2.5265 (+13.3969)		+3.2592 (+3.3154)	+4.3561 (+3.0147)	+3.5924 (+7.9093)
AIR FARE	-0.3522 (-0.2009)	-0.3522 (-0.3765)	-3.1026 (-6.7224)	-0.3522 (-0.3765)	-3.0537 (-1.8071)	
AIR TIME	-0.7326 (-0.4051)	-0.7326 (-0.7594)				
INCOME X AIR TIME			+2.4066 (+12.1739)	-0.7326 (-0.7594)	+0.1131 (+0.1140)	
RAIL FARE					+5.4776 (+2.7117)	
INCOME X RAIL TIME					-1.9427 (-1.7374)	
AIR FARE + INCOME X AIR TIME						-0.9287 (-1.3464)
RAIL FARE + INCOME X RAIL TIME						-0.1388 (-0.2426)
R^2	0.2702	0.7952	0.7631	0.7952	0.8152	0.7950
F	8.7626	67.9460	76.2458	67.9490	49.9800	21.3780
N	75	75	75	75	75	75

TABLE 6

LEISURE AIR TRIP RATES TO TOWNS IN NSW BY SYDNEY RESIDENTS IN EACH HOUSEHOLD INCOME GROUP

	I	II	III	IV	V	VI
CONSTANT	+1.0426 (+0.3465)	-3.2307 (-0.9200)	+3.2924 (+1.1110)	-3.2307 (-0.9200)	-4.4704 (-1.2994)	-2.6247 (-0.8880)
POPULATION	+0.4720 (+2.3350)	+0.4720 (+2.3979)	+0.6920 (+3.5651)	+0.4720 (+2.3979)	+0.3777 (+1.8691)	+0.5053 (+2.6833)
INCOME		+0.4675 (+2.2075)		+3.3997 (+3.0795)	+4.5993 (+2.8702)	+2.8420 (+5.5738)
AIR FARE	+0.5798 (+0.5375)	+0.5798 (+0.5520)	-2.2891 (-4.4583)	+0.5798 (+0.5520)	-2.9485 (-1.5734)	
AIR TIME	-2.9322 (-2.6354)	-2.9322 (-2.7063)				
INCOME X AIR TIME			+0.3424 (+1.5569)	-2.9322 (-2.7063)	-1.8547 (-1.6845)	
RAIL FARE					+6.8081 (+3.0392)	
INCOME X RAIL TIME					-2.2771 (-1.8363)	
AIR FARE + INCOME X AIR TIME						-2.7335 (-3.5302)
RAIL FARE + INCOME X RAIL TIME						+0.3543 (+0.5517)
R^2	0.3707	0.4116	0.3319	0.4116	0.4823	0.4116
F	13.9440	12.2413	24.1668	12.2413	10.5550	18.1995
N	75	75	75	75	75	75

Y_i = the average income[7] of the ith personal/household income group.

Income has been specified multiplicatively with the travel time variables, and as a separate independent variable. The multiplicative specification recognises that the perception of time costs may be a function of income. The rationale for specifying an additional income variable is that income denotes a budget constraint on travel expenditure.

A comparison of the estimation results indicates that the specification of an income variable generally improves the explanatory power of the models. For example, model I which omits the income variable, has a lower coefficient of determination (i.e. R^2) than model II, which specifies income additively in logs. In model III, the multiplicative income and travel time variable takes an unexpected (i.e. positive) sign. It would appear that this model is mis-specified, for when a separate income variable is specified along with the multiplicative variable, the latter now takes the expected sign. This can be seen from models IV and V for leisure trips and from model IV for business trips.

It is difficult to pass judgment on the alternative specifications for the income variable because model II, which excludes the multiplicative variable, cannot be formally distinguished from model IV, which contains both specifications for the income variable. Clearly statistical tests of these alternative model forms cannot be undertaken. However, on *a priori* grounds, a strong case can be made out for formulations such as model IV, which include the composite variable and a separate income variable.

From the results for model IV it can be seen that both variables containing the income term are significant for leisure trips. However, for business trips, the multiplicative income and travel time variable is not significant. For model V, which introduces competing modes, none of the composite income and time variables are significant. This is not surprising due to collinearity among the independent

7. It was not feasible to distinguish more than 3 income groups because of the unacceptably high sampling errors associated with the joint distribution of trips by income class and destination.

variables. Problems of multicollinearity are less severe in model VI due to the specification of generalised cost of travel variables for the alternative modes. The results here are quite encouraging even though the generalised cost variable for rail is not significant for either business or leisure travel.

Overall, the estimation results are plausible and have significant policy implications. For example, it would appear that the estimated income coefficient is higher for business than for leisure air travel. On the other hand, leisure air travel is much more responsive to changes in the generalised cost of travel than is business air travel.

Estimates of the income elasticities must be treated with particular caution. One reason for this is that the range of incomes within each group is quite high because it was not feasible to distinguish more than three income groups. Consequently the average income of the group may not be representative of the whole group.

An additional complication that must be considered when comparing the income elasticities of business and leisure travel is that different income measures have been used. The adoption of different measures was justified on the grounds that income captures the influence of different factors for business and leisure travel. For example, for business travellers, personal income acts as a proxy for trip purpose because of the value placed on a passenger's skills by his employer. This is borne out by the higher participation rate of professionals (and higher incomes) in business travel. On the other hand, for the leisure traveller, income acts as a measure of the passenger's ability to pay for a trip, and household income would appear to be a better measure of this ability to pay.

A shortcoming of the generalised cost formulation of model VI in tables 5 and 6 is that the respective influences of fares and travel times cannot be determined. This makes it difficult to infer estimates for the value of saving time in air travel. Some form of sensitivity analysis based upon alternative estimates for the value of time is required, and this is the approach to be pursued in the following section.

A MODEL OF THE GENERALISED COST OF AIR TRAVEL

An attempt has been made by Gronau[8] to estimate the value of time from the demand function for air passenger travel using the following model:

$$x_{ij} = \gamma_0 P_j^{\gamma_1}(F_j + kW_iT_j)^{\gamma_2} Y_i^{\gamma_3} \qquad (3)$$

where F_j = the air fare to destination j.
T_j = the air travel time to destination j.
W_i = the average wage rate of the ith income group
k = a value of time factor which expresses the value of time as a proportion of the wage rate.

The subscripts i and j denote the ith income group and the jth destination respectively, whilst all other variables are as defined in (1) and (2).

The approach adopted by Gronau in his empirical analysis was to arbitrarily select values for k and obtain estimates of γ_1, γ_2, and γ_3 (the population, generalised cost and income elasticities of demand respectively) on the basis of that value for k yielding the highest R^2. Thus the value of k is chosen indirectly.

Equation (3) has been estimated for a range of values of k for business and leisure trips using data on intrastate air travel in N.S.W. The results are presented in tables 7 and 8.

It can be seen that for business trips in table 7, R^2 is at its maximum when k=3.5. However, for leisure trips, in table 8, k>10.0 because R^2 does not achieve a maximum in the range of values selected for k. These results are implausible for they imply time values considerably greater than the wage rate.[9]

It is also apparent from tables 7 and 8 that the population and income elasticities are greater for business than they are for leisure travel. This result is consistent with Gronau's findings. On the other hand, the results suggest that leisure travel is more responsive to changes in the generalised cost of travel than

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8. R. Gronau, The Value of Time in Passenger Transportation: The Demand for Air Travel, NBER Occasional Paper No. 109, 1970

9. Gronau found that for business trips, the value of air travel time was approximately equal to average earnings (i.e. k=1) whilst for leisure trips, the value of time was unrelated to hourly earnings (i.e. k=0)

TABLE 7

A GENERALISED COST MODEL FOR BUSINESS AIR TRIPS BY PERSONAL INCOME GROUP (3 GROUPS)

	CONSTANT		POPULATION		INCOME		GENERALISED COST			
	COEFFICIENT	't'RATIO	COEFF.	't'RATIO	COEFF.	't'RATIO	COEFF.	't'RATIO	R^2	N
K=0	-27.0543	-10.0664	+1.4557	+8.9642	+2.5265	+13.4370	-0.9941	-2.4893	0.7935	75
K=0.5	-27.7170	-11.1861	+1.4378	+8.9354	+2.6881	+13.8428	-1.1418	-2.8498	0.7986	75
K=1.00	-28.4301	-12.0312	+1.4255	+8.8975	+2.8242	+13.5207	-1.2169	-3.0366	0.8013	75
K=1.50	-29.0600	-12.6303	+1.4168	+8.8585	+2.9338	+13.0403	-1.2573	-3.1369	0.8028	75
K=2.00	-29.5906	-13.0451	+1.4103	+8.8215	+3.0219	+12.5774	-1.2794	-3.1905	0.8037	75
K=2.50	-30.0325	-13.3296	+1.4054	+8.7875	+3.0934	+12.1711	-1.2911	-3.2172	0.8041	75
K=3.00	-30.4008	-13.5238	+1.4017	+8.7566	+3.1521	+11.8226	-1.2966	-3.2278	0.8042	75
K=3.50	-30.7091	-13.6553	+1.3987	+8.7289	+3.2009	+11.5243	-1.2982	-3.2285	0.8043	75
K=4.00	-30.9687	-13.7434	+1.3963	+8.7039	+3.2418	+11.2675	-1.2974	-3.2231	0.8042	75
K=5.00	-31.3763	-13.8378	+1.3928	+8.6611	+3.3060	+10.8500	-1.2916	-3.2022	0.8038	75
K=6.00	-31.6755	-13.8702	+1.3905	+8.6261	+3.3537	+10.5261	-1.2832	-3.1755	0.8034	75
K=7.00	-31.8995	-13.8717	+1.3888	+8.5972	+3.3900	+10.2677	-1.2738	-3.1473	0.8030	75
K=8.00	-32.0698	-13.8580	+1.3876	+8.5730	+3.4184	+10.0568	-1.2644	-3.1196	0.8026	75
K=10.00	-32.3026	-13.8136	+1.3861	+8.5349	+3.4592	+ 9.7331	-1.2466	-3.0686	0.8018	75

TABLE 8.

A GENERALISED COST MODEL FOR LEISURE AIR TRIPS BY HOUSEHOLD INCOME GROUP (3 GROUPS)

	CONSTANT		POPULATION		INCOME		GENERALISED COST			
	COEFF.	't'RATIO	COEFF.	't'RATIO	COEFF.	't'RATIO	COEFF.	't'RATIO	R^2	N
K=0	+1.5862	+0.5021	+0.6690	+3.5046	+0.4675	+2.1153	-1.9891	-4.2374	0.3501	75
K=0.50	-0.2274	-0.0778	+0.6440	+3.3900	+0.7623	+3.3255	-2.0833	-4.4046	0.3605	75
K=1.00	-1.6736	-0.5987	+0.6267	+3.3063	+0.9896	+4.0046	-2.1342	-4.5018	0.3666	75
K=1.50	-2.8204	-1.0357	+0.6137	+3.2422	+1.1697	+4.3927	-2.1678	-4.5679	0.3708	75
K=2.00	-3.7443	-1.3954	+0.6035	+3.1912	+1.3166	+4.6321	-2.1928	-4.6226	0.3741	75
K=2.50	-4.5019	-1.6910	+0.5952	+3.1494	+1.4390	+4.7916	-2.2126	-4.6660	0.3768	75
K=3.00	-5.1326	-1.9351	+0.5882	+3.1144	+1.5430	+4.9049	-2.2290	-4.7029	0.3791	75
K=3.50	-5.6646	-2.1381	+0.5823	+3.0845	+1.6326	+4.9896	-2.2429	-4.7349	0.3811	75
K=4.00	-6.1182	-2.3086	+0.5771	+3.0586	+1.7107	+5.0554	-2.2549	-4.7631	0.3829	75
K=5.00	-6.8471	-2.5759	+0.5686	+3.0160	+1.8403	+5.1518	-2.2746	-4.8104	0.3859	75
K=6.00	-7.4022	-2.7732	+0.5619	+2.9823	+1.9437	+5.2196	-2.2900	-4.8486	0.3883	75
K=7.00	-7.8343	-2.9228	+0.5564	+2.9548	+2.0282	+5.2703	-2.3024	-4.8802	0.3903	75
K=8.00	-8.1762	-3.0385	+0.5518	+2.9321	+2.0986	+5.3097	-2.3125	-4.9066	0.3919	75
K=10.00	-8.6721	-3.2024	+0.5447	+2.8965	+2.2091	+5.3675	-2.3278	-4.9482	0.3495	75

TABLE 9

A GENERALISED COST MODEL FOR BUSINESS AIR TRIPS BY PERSONAL INCOME GROUP (7 GROUPS)

	CONSTANT		POPULATION		INCOME		GENERALISED COST			
	COEFF.	't'RATIO	COEFF	't'RATIO	COEFF.	't'RATIO	COEFF.	't'RATIO	R^2	N
K=0	-21.94	-5.15	+0.98	+3.04	+2.47	+9.36	-1.11	-1.61	0.375	182
K=1.00	-23.12	-5.96	+0.98	+3.13	+2.97	+9.58	-2.06	-2.95	0.397	182
K=2.00	-25.05	-6.57	+0.97	+3.10	+3.37	+9.10	-2.36	-3.38	0.407	182
K=3.00	-26.51	-6.91	+0.95	+3.06	+3.65	+8.69	-2.48	-3.55	0.411	182
K=4.00	-27.57	-7.10	+0.93	+3.02	+3.84	+8.37	-2.53	-3.60	0.412	182
K=5.00	-28.33	-7.21	+0.92	+2.98	+3.98	+8.11	-2.54	-3.60	0.412	182
K=6.00	-28.89	-7.26	+0.92	+2.95	+4.08	+7.89	-2.54	-3.58	0.411	182
K=10.00	-30.02	-7.29	+0.89	+2.88	+4.29	+7.29	-2.47	-3.44	0.408	182

is business travel. This confirms our earlier findings, although it does contradict Gronau's results. One final result to emerge from tables 7 and 8 is that when the model is mis-specified by omitting the time costs of travel from the analysis (this is the case when k=0), both the generalised cost and income elasticities are underestimated whilst the population elasticities are overestimated.

Gronau's procedure can be subjected to a number of criticisms. The first concerns the validity of the R^2 test. Since the estimating equations revealed virtually no differences among the R^2 values, it is difficult to justify selecting the value for k on the R^2 criterion.

A second criticism concerns the methodology of Gronau's approach to the valuation of savings in travel time. Clearly the assumption that the value of time is proportional to the wage rate (i.e. k is a constant) is too restrictive. Constraints upon the allocation of time to various activities, and preferences for or attitudes towards time spent in alternative activities are undoubtedly important determinants of the value of time.[10] The assumption of a proportional relationship to income abstracts from these considerations.

Apart from these criticisms, there are two further problems which arise because of shortcomings in the data used to estimate these models. The first concerns measurement errors in the wage rate for leisure travellers. Household income was used as the income measure for leisure travel. Consequently the wage rate, and hence the time cost component of the generalised cost of air travel, may have been overestimated for leisure travellers from households with more than one income earner. This could explain why the analysis of the demand for leisure trips failed to produce a plausible value for k.

The second data problem is also attributable to measurement errors. It will be recalled that only thee income groups were distinguished because of the larger sampling errors associated with smaller classes.

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10. For a discussion of the determinants of the value of time and empirical evidence on its relationship with the wage rate for commuting trips in Sydney, refer to A.T. Whitehead, Travel Demand Modelling and the Valuation of Travel Time, M.A.(Hons) Thesis, Macquarie University, 1976.

Unfortunately, the larger the range of incomes within a particular income class, the less representative is the mean as a measure of income, and the more likely it is that there will be measurement errors in the income and generalised cost variables. In order to minimise this measurement error, the generalised cost model was re-estimated for business trip rates in seven income groups. The results are presented in table 9. A comparison with table 7 reveals a sizeable reduction in the explanatory power of the model. The maximum value of R^2 occurs when k=4.5. It is concluded that due to data sampling errors, it is not advisable to distinguish more than three income groups.

AN ALTERNATIVE GENERALISED COST MODEL

In an attempt to circumvent the problems of inter-correlation between income and the generalised cost of travel implicit in Gronau's approach, De Vany[11] devised an alternative procedure for estimating a generalised cost model of the demand for air travel. This involved omitting the value of time from the estimation equation :

$$X_{ij} = Af_{ij}^{\,a+bM_{ij}} t_{ij}^{\,c+dM_{ij}} M_{ij}^{\,e} P_j^{\,f} Y_i^{\,g} \qquad (4)$$

where X_{ij} = travel by air between towns i and j.
f_{ij} = the air fare per km between i and j.
t_{ij} = the travel time per km between i and j.
M_{ij} = the route distance between i and j
P_j = the population of destination town j.
Y_i = the average income of the ith income group

De Vany's model has been estimated using the data on intrastate air travel by Sydney residents to towns in N.S.W. The results for business and leisure trips are presented in tables 10 & 11 respectively. Models I - III do not allow for competing modes. However, it can be seen from the results for models IV-VI that there is little improvement in explanatory

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11. A. De Vany "The Revealed Value of Time in Air Travel". Review of Economics and Statistics Vol. 66, Feb 1973, pp 72-82.

TABLE 10

ALTERNATIVE GENERALISED COST MODELS FOR BUSINESS AIR TRIPS

	I (1)	II (2)	III (3)	IV (1)	V (2)	VI (3)
CONSTANT	-17.8365 (-2.7858)	-42.1472 (-5.9455)	-43.4030 (-3.3019)	-22.0503 (-1.6439)	-63.0564 (-3.0420)	-52.8123 (-1.3322)
LOG POPULATION	+1.4601 (+9.8917)	+1.5078 (+8.0530)	+0.7720 (+1.8543)	+1.1861 (+4.9187)	+1.5572 (+5.7026)	+1.0883 (+2.0459)
LOG INCOME		+2.5265 (+14.6198)	+2.4698 (+9.4743)		+2.5265 (+14.7474)	+2.4698 (+9.4859)
LOG DISTANCE	+0.3604 (+0.2360)	-0.8372 (-0.4800)	+3.0029 (+0.7510)	-0.0906 (-0.0527)	-1.1597 (-0.5652)	+2.1962 (+0.4627)
LOG AIR FARE PER KM	+9.5722 (+1.9892)	-5.0406 (-0.7586)	+13.7544 (+0.8297)	+6.6090 (+1.2489)	-10.6959 (-1.3530)	+15.7537 (+0.9461)
DISTANCE X LOG AIR FARE PER KM	-0.0205 (-2.8305)	-0.0026 (-0.2369)	-0.0134 (-0.5180)	-0.0170 (-2.1626)	+0.0055 (+0.4191)	-0.0134 (-0.5156)
LOG AIR TIME PER KM	-6.7449 (-2.6567)	-0.3523 (-0.0961)	-8.3276 (-1.0465)	-8.1280 (-2.8069)	-2.8013 (-0.7063)	-10.1407 (-1.1327)
DISTANCE X LOG AIR TIME PER KM	+0.0116 (+2.9488)	+0.0019 (+0.3099)	+0.0084 (+0.5774)	+0.0135 (+2.8531)	+0.0068 (+1.0340)	+0.0136 (+0.7770)
LOG RAIL FARE PER KM				+5.1518 (+1.5772)	+1.2525 (+0.2889)	-8.7593 (-1.4123)
DISTANCE X LOG RAIL FARE PER KM				-0.0083 (-1.2889)	-0.0132 (-1.2331)	+0.0036 (+0.1765)
LOG RAIL TIME PER KM				-2.8571 (-0.8314)	+0.5514 (+0.1219)	+5.9142 (+0.9192)

TABLE 10 (Cont'd)

ALTERNATIVE GENERALISED COST MODELS FOR BUSINESS AIR TRIPS

	I[1]	II[2]	III[3]	IV[1]	V[2]	VI[3]
DISTANCE X LOG RAIL TIME PER KM				+0.0023 (+0.3667)	-0.0001 (-0.0088)	-0.0105 (-0.7126)
R^2	0.8901	0.8354	0.4038	0.9130	0.8479	0.4202
F	32.3968	48.5779	15.4811	20.9886	31.9273	14.2477
N	31	75	168	31	75	168

1. Estimated from data on business air trips.
2. Estimated from data on business air trip rates by personal income group (i.e. 3 groups).
3. Estimated from data on business air trip rates by personal income group (i.e. 7 groups).

TABLE 11

ALTERNATIVE GENERALISED COST MODELS FOR LEISURE AIR TRIPS.

	I (1)	II (2)	III (3)	IV (1)	V (2)	VI (3)
CONSTANT	-33.2891 (-3.4511)	-25.8157 (-3.1539)	-8.4859 (-1.1658)	-22.1729 (-1.0243)	-21.6639 (-0.8772)	-5.1067 (-0.6224)
LOG POPULATION	+1.2947 (+5.8232)	+0.7901 (+3.6548)	+1.1644 (+2.9459)	+0.9174 (+2.5043)	+0.6938 (+2.1328)	+1.0500 (+2.4028)
LOG INCOME		+0.4675 (+2.3430)	-1.1768 (-3.2019)		+0.4675 (+2.2906)	-1.1683 (-3.1713)
LOG DISTANCE	+4.8422 (+2.1053)	+2.1852 (1.0850)	-3.8113 (-3.4782)	+3.7734 (+1.3597)	+2.7327 (+1.1178)	-2.8461 (-1.4064)
LOG AIR FARE PER KM	+7.3833 (+1.0186)	-5.3880 (-0.7023)	+1.6799 (+0.7545)	+6.2604 (+0.7330)	-2.7868 (-0.2959)	-4.3528 (-0.8327)
DISTANCE X LOG AIR FARE PER KM	-0.0099 (-0.9052)	+0.0098 (+0.7756)	-0.0000 (-1.8308)	-0.0099 (-0.7766)	+0.0041 (+0.2579)	+0.0065 (0.7870)
LOG AIR TIME PER KM	-4.4351 (-1.1598)	+1.0975 (+0.2592)	-6.0749 (2.4856)	-5.9477 (-1.2727)	+1.1176 (0.2365)	-5.9745 (2.0333)
DISTANCE X LOG AIR TIME PER KM	+0.0071 (+1.1970)	-0.0041 (-0.5844)	+0.0000 (+1.8321)	+0.0091 (+1.1933)	-0.0046 (-0.5830)	+0.0030 (+0.9001)
LOG RAIL FARE PER KM				+4.7585 (+0.9027)	+3.3760 (+0.6536)	+0.9572 (+0.1244)
DISTANCE X LOG RAIL FARE PER KM				-0.0015 (-0.1391)	-0.0000 (-0.0005)	+0.0055 (+0.5325)

TABLE 11 (Cont'd)

ALTERNATIVE GENERALISED COST MODELS FOR LEISURE AIR TRIPS

	I (1)	II (2)	III (3)	IV (1)	V (2)	VI (3)
LOG RAIL TIME PER KM				-0.5337 (-0.0962)	-3.3688 (-0.6252)	+6.0321 (+0.9542)
DISTANCE X LOG RAIL TIME PER KM				-0.0026 (-0.2642)	-0.0051 (-0.4960)	-0.0150 (-1.1355)
R^2	0.7381	0.5001	0.2150	0.7619	0.5082	0.2301
F	11.2732	9.5753	6.2606	6.3988	5.9180	4.2389
N	31	75	182	31	75	182

1. Estimated from data on leisure air trips.
2. Estimated from data on leisure air trip rates by household income group (i.e. 3 groups).
3. Estimated from data on leisure air trip rates by household income group (i.e. 7 groups).

where D is a dummy variable signifying multiple destination routes.[12]

Fare and time elasticities and the value of time were calculated for the mean trip distances for business and leisure travel. The resulting estimates are presented in table 12.

It is concluded from an analysis of the results in tables 10, 11, and 12 that models I and IV for business trips are the most satisfactory. Not only

TABLE 12

ESTIMATES OF ELASTICITIES

(a) BUSINESS

MODEL	ε_f	ε_t	ε_π	V
I	-1.2108	-0.6433	-1.8541	7.94
II	-6.4082	+0.6509	-5.7625	-
III	+6.7060	-3.9092	+2.9769	-
IV	-2.3330	-1.0270	-3.3600	6.58
V	-7.7919	+0.7891	-7.0028	-
VI	+8.6785	-2.9599	+5.7187	-

(b) LEISURE

MODEL	ε_f	ε_t	ε_π	V
I	+2.4333	-0.8851	+1.5482	-
II	-0.4380	-0.9525	-1.3905	32.32
III	+1.6799	-6.0749	-4.3950	-
IV	+1.3104	-1.3977	-0.0873	-
V	-0.7368	-1.1821	-1.9189	23.84
VI	-1.1028	-4.4725	-5.5773	60.29

12. On multiple destination routes there are flights with one or more stopovers at intermediate destination towns. The inclusion of the multiple destination dummy variable in the air travel time regression equation resulted in a considerable improvement in explanatory power.

do these two models exhibit the highest R^2 values (13) but have more estimated coefficients that are statistically significant. More importantly the estimates obtained for the fare and time elasticities at mean trip distances are plausible in the case of models I and IV.

In order to demonstrate the policy implications of models I and IV, fare, time, and generalised cost elasticities have been calculated for alternative trip distances. The resulting estimated elasticities are presented in table 13, where it can be seen that the fare elasticities rise whilst the time elasticities fall with distance. The reason for this result is that the air fare becomes a larger fraction of generalised cost as distance increases. The higher price elasticities on longer routes signify a greater scope for fare reductions on such routes. Conversely, the higher time elasticities on shorter routes emphasize the importance of adhering to departure schedules and of minimising airport access and egress and baggage search times as route distance decreases.

TABLE 13

RELATIONSHIP BETWEEN FARE AND TIME ELASTICITIES AND TRIP DISTANCE

DISTANCE (KMS)	FARE ELASTICITY	TIME ELASTICITY	GENERALISED COST ELASTICITY
	(a) MODEL 1 (V = $7.94/hour)		
200	-1.16	-0.69	-1.85
400	-1.20	-0.66	-1.85
526	-1.21	-0.64	-1.85
750	-1.23	-0.63	-1.85
1000	-1.23	-0.62	-1.85
	(b) MODEL IV (V = $6.58/hour)		
200	-2.24	-1.12	-3.36
400	-2.31	-1.05	-3.36
526	-2.33	-1.03	-3.36
750	-2.36	-1.00	-3.36
1000	-2.38	-0.98	-3.36

13. The data sets differ across models and for this reason the results cannot be strictly compared on this criterion.

Despite the attractive features of De Vany's demand model for air travel, his approach is subject to a number of shortcomings. The first concerns the valuation of travel time. Conceptually it is possible to measure the value of time directly from the demand function for trips. However, there are certain methodological problems to be overcome before an unbiassed measure of the value of time is obtained empirically.(14) Moreover, it is doubtful whether the value of time can be measured accurately because of the nature of constraints upon the allocation of time among activities. For example, when a business traveller is constrained by an airline departure schedule to arrive at his destination prior to his preferred arrival time, savings in travel time which necessitate an even earlier arrival for appointments may not be valued very highly at all. Failure to take time-of-day constraints into account in the model specification may lead to biased estimates of the value of time.

A second criticism of De Vany's model is that estimates for the price and time elasticities, and consequently for the value of time itself, are subject to a wide margin of error. Not only are the parameters a,b,c and d subject to error, but so also are the estimates for fares and travel times calculated from regressions on distance.

One disappointing feature of all models is the failure to obtain a significant coefficient for the distance variable. Furthermore, when the model incorporates an income variable and competing modes are allowed for, there is little improvement in explanatory power. As was argued previously, this could be attributed to multicollinearity in the data.

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14. A.C. De Serpa, "A Theory of the Economics of Time" Economic Journal, Vol. 81, Dec 1971 pp. 828-846 demonstrates the nature of the theoretical bias implicit in value of time measures such as are given by equation (7).

15. D.A. Hensher and R.C. Carruthers, Resource Value of Business Air Travel Time, (Pergamon 1974) demonstrate that the relative disutility of time spent in air travel vis-a-vis work is pertinent to the valuation of savings in the travel time of business travellers. Their study provides evidence for the value of air travel time.

CONCLUSIONS

In view of policy recommendations for new air passenger pricing structures(16) and public interest in lower air fares, the results obtained in this paper are of some significance. However it is difficult to translate the empirical results into a policy context, other than in the most general terms.

It is apparent that the demand for air passenger travel in N.S.W. is sensitive to changes in fares. However, because of the high correlation of both fares and travel times with distance, it was not possible to isolate fare elasticities. This paper has, however, provided some evidence concerning generalised cost (incorporating both money and time costs of travel) and income elasticities. It was concluded that the generalised cost elasticity of air travel demand was higher for non-business than for business trips whilst income elasticities were highest for business trips. Given the assumption of a constant generalised cost elasticity model, fare elasticities increase and time elasticities decrease with distance.

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16. P.J. Forsyth and R.D. Hocking, "Economic Efficiency and the Regulation of Australian Air Transport", Seventh Conference of Economists, Sydney 1978.