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DEMAND FOR RAIL TRAVEL TO AND FROM AIRPORTS

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1. INTRODUCTION

This paper is concerned with explaining the number of air travellers who use rail to get to and from the airport and investigating the extent to which their sensitivity to rail fare and service quality differs from rail travellers in general. The context is that of inter-urban journeys, with rail travel to and from Manchester and Stansted Airports the subject of this study.

Air travel in Britain, as elsewhere, is growing at a fast rate. Between 1988 and 1998, the volume of passengers at British airports grew by 5½% per year, compared with 0.8% for national rail passengers and Y% for car travel (DETR, 1999). There has been particularly strong growth at some smaller airports, such as Edinburgh achieving 10% per year in the 1990's. Official forecasts are for air travel to increase by XXXXX (REF), although growth forecasts have traditionally been exceeded.

Currently, XX of Britain's YY airports have direct rail access. Some airport rail stations are well established, such as at Gatwick and Birmingham, yet several significant connections are much more recent, such as Heathrow (19XX), Manchester (19XX) and Stansted (19XX), and there remains considerable scope both for adding further airport rail connections and for improving the quality of existing rail links. The pattern of rail services to airports varies considerably. Heathrow Airport is served by a fast and frequent shuttle to London Paddington whilst Glasgow Airport is served as part of a suburban network. In contrast, Birmingham and Gatwick Airports benefit from direct inter-urban and long distance services as well as local services and, for the latter, a fast and frequent dedicated link to Central London. The market shares of rail for airport access vary considerably. GIVE FIGURES. These market shares depend not only on the quality and cost of the rail service but also on competitive factors, with road congestion benefiting rail market share at the main London airports.

The significance of analysing rail access to airports stems from train operators desires to exploit revenue opportunities by offering the most appropriate fare and service quality levels and to assess longer term revenue trends in this growing, distinct and in some cases important market segment. In Great Britain, the dedicated rail link to Gatwick is a separate train operating company with a turnover in 1997/98 of £39m (TAS, 1999), whereas the Heathrow Express was built and is operated by British Airports Authority and (TURNOVER). Of the revenue earned by the top 100 flows of Northern Spirit, a train operating company whose franchise covers inter-urban and suburban services in the North of England, 15% accrues to Manchester Airport. SOME FIGURES ON RAIL GROWTH TO STANSTED?

There are also other bodies, such as local authorities and the airports themselves, who have an interest in increasing not only airport use but also the proportion of airport users accessing and egressing by train. For example, Manchester Airport has a target of (SEE PAUL). HEATHROW TARGETS.
In addition to improving existing services, there is also the issue of forecasting the demand for proposed new links, with connections to XXX and XXX currently under scrutiny.

The findings reported in this paper are based on analysis of rail ticket sales. In Great Britain these are recorded by the CAPRI system which details the volume of sales and associated revenue for journeys between specific stations for the full range of ticket types. Within the industry it is widely regarded to provide an accurate account of travel between stations where, as in this inter-urban context, pre-paid multi-ride tickets are not common. It has for many years supported the development of robust rail demand models yielding plausible parameter estimates for investigations into a wide range of issues (OR, 1989; Steer Davies Gleave, 19XX; TCI, 1997; Wardman, 1994, 1997, 19GW). OR fare elasticity

Whilst there have been a number of studies in Great Britain which have developed disaggregate mode choice models in order to forecast rail demand to airports as the proportion of the total market that rail can capture (OR, 1986; Oscar Faber, MASAM, HASAM, SDG, Buchanan, Harrison, 2000), we are not aware of studies that have exploited rail ticket sales data to examine behaviour in this market segment. Although analysis of ticket sales data has its limitations, such as being unable to distinguish between business and leisure travel or to examine the impact of socio-economic, it does complement the findings obtained from more disaggregate models and, as we shall see, has proved capable of proving important insights into demand sensitivities for airport rail access. Indeed, the findings allow the demand parameters contained in the forecasting framework widely used in the railway industry in Great Britain (ATOC, 1997) to be tailored to this unique market segment.

2. SHORTCOMINGS OF CURRENT RAIL DEMAND FORECASTING PROCEDURE

The forecasting procedure set out in the Passenger Demand Forecasting Handbook (ATOC, 1997) is essentially that which was used by British Railways and it remains the approach adopted by many of the private sector train operating companies in Great Britain. It is an incremental approach which forecasts changes to base flows of rail travel using recommended elasticities. It can be specified as:

$$\frac{V_f}{V_b} = \left(\frac{GDP_f}{GDP_b}\right)^{\alpha} (1+t)^n \left(\frac{F_f}{F_b}\right)^{\beta} \left(\frac{GT_f}{GT_b}\right)^{\gamma}$$

V denotes the volume of rail demand in the base (b) and forecast (f) period which is a function of external factors, represented by gross domestic product (GDP) and a time trend (t), rail service quality, represented by generalised time (GT), and rail fare (F). The parameters α, β and γ are the elasticities to GDP, fare and GT whilst n denotes the number of years between the base and forecast period.

The GDP variable captures the positive effect on rail demand from increased wealth and economic activity whilst the time trend essentially proxies for car ownership growth and the negative impact this has on rail demand. These two external factors have their origins in the work of Owen and Phillips (1987). GT represents the service quality aspects of station to station journey time (T), service headway (H) and interchange (I) and is formulated as:

$$GT = T + \delta H + \lambda I$$

where δ and λ are respectively headway and interchange penalties which convert headway and interchange into equivalent time units.

A number of criticisms can be levelled at this framework, such as the use of constant GT and fare elasticities, the use of a time trend to proxy for car ownership rather than explicit allowance for the latter, the absence of cross-elasticity terms, and the use of the composite service quality term GT which forces the elasticities to the component attributes of GT to vary directly with the proportion they form of GT. However, the shortcoming that we are primarily interested in here is that the parameters used within this forecasting framework do not distinguish between rail users to and from airports and other rail users yet we can expect, even for a given journey purpose, that the demand parameters will be different between the two market segment for the following reasons.

- The growth in air travel far exceeds the growth in GDP and the growth in rail travel in general. The recommended GDP elasticity can be expected to be highly inappropriate for the market of rail travellers to and from airports. Indeed, it would seem to be more sensible to relate future rail travel to and from airports to future forecast levels of passenger activity at airports. This would have the advantage of allowing for differential rates of growth at different airports according to capacity constraints and market potential.

- The time trend proxies for the effects of increasing car ownership levels yet it would not be unreasonable to assume that the vast majority of those accessing airports have a car at their disposal. The car ownership cross elasticity should be low, if not zero, and the time trend used in general rail demand forecasting is highly inappropriate. Although those arriving in Britain do not have their own car available, they might hire a car or be picked up. However, there is no reason why the time trend currently used is appropriate in this context.

- We might reasonably expect that, for a given journey purpose, those making air trips would be less sensitive to rail fare than domestic travellers. In part this is because those making international trips are likely to have higher incomes, and thus be less concerned about fare variations. Moreover, cost considerations are likely to be less on infrequently made international trips whilst the rail fare forms a relatively low proportion of the overall costs of the journey in this context.

- As far as GT is concerned, it is the sensitivity to interchange that we would expect to differ most between airport travellers and other rail travellers. The GT elasticity is expected to be higher for the former because the interchange penalty will be greater for those with luggage whilst interchange increases the chances of late arrivals and the consuequences of the late arrivals will be more serious in this context. Service headway might also be relatively highly valued for airport travellers given that it provides cover in the event of cancellations and missed connections and because of the convenience factor in the light of variable flight arrival times.

Furthermore, we might expect the rail demand elasticities to differ within the segment of airport users according to whether the flows are essentially British residents travelling to the airport and subsequently from it, which we term outward travel, or are overseas residents travelling from the airport and then back to it, which we term inward travel. For example, there is less competition from other modes for inward travel, since overseas residents will generally have less information about alternatives to the rail service and, although car hire is an option, the intense competition from car for outward travel will not be present. This reduced competition will tend to lower the rail elasticities. On the other hand, it is reasonable to state that rail faces more intense competition on journeys to airports than on other flows, with generally good motorway connections, relatively strong coach and bus competition and many taxi companies offering direct minibus services, whereupon this will tend to inflate rail elasticities compared with comparable rail travel not involving airpoirts.

We therefore hypothesise that the parameters associated with each four of the forecasting variables in the adopted framework will be different for those travelling to and from airports than from those used for entirely domestic journeys of the same purpose and distance. In particular, we expect that for airport users:

- The GDP elasticity will be higher
- The time trend will be lower
- The fare elasticity will be lower for inward travellers than for outward travellers and the latter may be lower than for general rail travel
- The GT elasticity will be higher for outward travellers than for inward travellers and the latter may be higher than for general rail travel.

3. DATA COLLECTION AND METHODOLOGY

WHAT DATA – FLOWS – YEARS – WHY THESE? WHAT INDEPENDENT VARIABLES COLLECTED. TESTS ON DATA – what thrown out.

STATE ANNUAL DATA

4. EMPIRICAL FINDINGS

The results reported below here are derived from models estimated to XXXX observations using the formulation outlined in equation X. We first present a number of models of the conventional type where the elasticities are constant before proceeding to models which permit elasticity variation. Only the parameter estimates of key interest are reported; the XX origin, destination and airport specific parameters, which would be needed to forecast the absolute volume of trips, are not given here.

The notation adopted throughout is that the suffixes M and S denote Manchester and Stansted Airports respectively whilst O denotes what we have assumed to be journeys by British residents which have termed outward travel and I denotes what we have assumed to be journeys by overseas residents which we have termed inward travel. We have assumed that tickets sold at the airport are for inward travellers and that tickets sold at the non-airport rail station relate to outward travellers. This is not unreasonable given that the vast majority of tickets sold are return tickets covering both legs of the journey.

4.1 Constant Elasticity Models

Table 1 presents the results of three variants of the conventional constant elasticity model. Model I is, with the exception of the omitted time trend, the standard model which is widely used in the railway industry in Great Britain and which was outlined in section 2. Model II replaces the GDP variable with the number of annual air passengers at the appropriate airport and Model III generalises Model II by disaggregating GT into separate components for station-to station journey time (Time), service headway (Head) and the number of interchanges (Int).

Prior to discussing the results for each model, we can mention some common features of all the estimated models.

Firstly, none of the models contain a time trend because it is very highly correlated with GDP (ρ^2>0.9), which we regard to be the prime external influence on rail demand, we have only a short time series and, according to F tests, the inclusion of the time trend did not improve the model. (BILL DO – was it significant).

Secondly, given that we have data for the first full year of operation of each airport station, we allowed for a build-up of traffic as awareness of the new rail links grew. A dummy variable for the first year of operation was found to be significant, which in Model I denotes that demand is 25% lower in the first year. Further year effects were not statistically significant.

Thirdly, we can also give a broad indication of the generation and attracting potential of Manchester and Stansted airports in relation to each other. It was found that GENERAL TERMS

The final common feature we discuss is the combination of parameter estimates for different airports and directions of travel. We could estimate four separate models, for the combinations of outward and inward travel and Manchester and Stansted Airports. Not only could this lead to greater difficulties in applying the results of the model, particularly in the transferability of airport specific results, but it is not a parsimonious approach. Estimating models to combined data sets and only allowing parameters to vary where it is both theoretically warranted and empirically justified, will increase the precision with which key parameters are estimated.

Previous analysis (Lythgoe, 1999) estimated four separate models. In this re-working, a single model was estimated which pooled all the data and allowed parameters to vary by airport and direction. It was found that even though the individual coefficients estimates had a high degree of significance, there was no significant difference between the GDP and AP elasticities for inward and outward travel. This is despite the fact that the measure of AP (CHECK DEFINED AP) did not distinguish between inward and outward travellers and that British GDP figures are not appropriate for inward travellers unless GDP elsewhere is on average growing at the same rate as in Britain. Nonetheless, there were significant differences in these elasticities between airports. With regard to the fare and service quality attributes, there was a remarkable degree of similarity between the coefficient estimates for the different airports but noticeable and statistically significant different according to direction of travel. The reported models there distinguish between airports for the external influences and according to direction of travel for the effects of service quality and fare.

Model I shows that the GDP elasticity for rail travellers to and from airports is far higher than is appropriate for other rail travellers. If the negative time trend was ignored, to be consistent with our models, then the recommended GDP elasticities for inter-urban rail travel in Great

Britain would be of the order of 1 to 1.5. The GDP elasticity for Stansted is far higher because ……

Model II replaces GDP with the more appropriate measure of air passengers. We might expect rail travellers to and from airports to increase broadly in line with the number of passengers using the airport. This was indeed found to be the case for Stansted, where the AP elasticity is estimated very precisely with a 95% confidence interval of ±x% of the central estimate. However, the AP elasticity for Manchester is somewhat higher and (CHECK) significantly different from 1. EXPLAIN. STATE TRIED TESTS TO SEE IF ELAS GROWS.

The GT elasticities in Models I and II are similar and are precisely estimated. GIVE 95% CI's –COMMENT ON THESE. COMMENT ON OUT AND IN RESULTS

Wardman (1994) tested whether the elasticity variation forced by adopting the composite GT variable, whereby the elasticities to time, headway and interchange vary directly with the proportion that they form of GT, was justified. It was concluded that the use of GT in the form specified here could not be empirically supported.

Model III reports the more general model where separate, albeit constant, elasticities are estimated to time, headway and interchange. Given that the latter can be zero, it is specified in absolute form, instead of the logarithmic form of the others – GIVE ELAS.

COMMENT ON OUT AND IN RESULTS

The fare elasticity is common to each of the three models reported in Table 1. NOW DISCUSS IT – BUT BEAR IN MIND WILL RETURN TO THIS IN FARE ELAS VARIATION

In conclusion to this section, we report on the diagnostic tets conducted on the models HETERO, AUTO

MOVE TABLE

Table 1: Constant Elasticity Models

	Model I	Model II	Model III
GDP-M	2.753 (6.8)	n.a	n.a
GDP-S	5.938 (18.2)	n.a	n.a
AP-M	n.a.	1.944 (8.9)	1.665 (7.7)
AP-S	n.a	1.004 (18.8)	1.079 (20.3)
Fare-O	-0.710 (7.0)	-0.621 (6.2)	-0.813 (8.8)
Fare-I	-0.391 (3.6)	-0.319 (3.0)	-0.596 (6.1)
GT-O	-1.465 (12.3)	-1.549 (13.2)	n.a

GT-I	-0.957 (7.6)	-1.022 (8.2)	n.a
Time-O	n.a	n.a	-0.756 (6.5)
Time-I	n.a	n.a	-0.183 (1.5)
Head-O	n.a	n.a	-0.188 (2.4)
Head-I	n.a	n.a	-0.059 (0.8)
Int-O	n.a	n.a	-0.503 (8.1)
Int-I	n.a	n.a	-0.467 (7.9)
First	-0.290 (6.5)	-0.133 (2.9)	-0.175 (3.8)
Adj R^2	0.951	0.952	0.954

Want: to Manchester effect, From Manchester effect, From Stansted. – Report outside table

4.2 Variable Elasticity Models

	Model IV	Model V
AP-M	1.559 (7.4)	1.621 (7.9)
AP-S	1.111 (21.6)	1.137 (22.7)
Fare-O	-0.924 (10.3)	n.s
Fare-I	-0.607 (8.1)	n.s
α-O		-0.433 (2.3)
α-I		-0.332 (2.2)
λ		0.519 (3.6)
Time-O	-0.486 (4.5)	-0.656 (6.2)
Time-I	n.s	n.s
Head-O	-0.186 (2.7)	-0.202 (3.0)
Head-I	-0.078 (1.2)	-0.071 (1.2)
Int1	-0.961 (14.6)	-0.911 (14.2)
Int2	-1.301 (15.5)	-1.206 (14.7)
Int3	-1.495 (10.1)	-1.263 (8.3)
First	-0.153 (3.5)	-0.140 (3.2)
Adj R^2	0.958	0.959

STATE MODEL III – SPLITS OUT GT INTO SEPARATE BITS. NO LONGER FORCED ELASTICITIE TO VARY WITH PROPORTION OF GT – BUT DOES FORCE TO BE CONSTANT. STATE ATEMPTED NON-LINEAR ON VARIABLES.

WORK OUT SOME FARE ELASTICITIES:

FOR BOTH TO AND FROM, FOR 10%, 25% 50%, 75% AND 90% iles FARES IN DATA SET FOR THE LAST YEAR, CALCULATE ELASTICITIES TO AND FROM.
USE SEPARATE FARES FOR TO AND FROM

Work out some interchange effects – because will add wait time as well as interchange

Int	Transfer	Effect-To	Effect-From
1	15 mins		
1	45 mins		
2	15 mins		
2	45 mins		
3	15 mins		
3	45 mins		

REMEMBER – FOR 2 INTERCHANGES WILL HAVE TWO LOTS OF WAIT TIME.

To and from different effects cos from has no time

5. APPLICATIONS

Compare elasticities

Being used to evaluate bids

6. CONCLUSIONS

In further research – extend to include competition between airports – both gc to get to airports and quality at airport. What did we think up to represent this. Do we say anything in above. Also competition between modes.

CONCS – VERY GENERAL FORM OF FARE AND TIME ELASTICITIY VARIATION ALLOWED – PER MILE AND ABSOLUTE. STATE WHAT FOUND. MAYBE MORE DATA NEEDED FOR NLLS.

CONCS – MODEL USED IN FRANCHISE EVALUATIONS.

Harrison, K. (2000) A Revealed Preference of Airport Access Mode Choice. MSc Dissertation, Institute for Transport Studies, University of Leeds.

Operational Research Unit (OR) British Railways Board (1986) 'Calibrating Airport Access Models' Memo 13403/M6.

Operational Research Unit (OR) British Railways Board (1989) 'Demand Changes due to Service Improvements and Sprinter Introduction on the North TransPennine' Memo 10323/M7.

Owen, A.D. and Phillips, G.D.A. (1987) The Characteristics of Railway Passenger Demand. Journal of Transport Economics and Policy 21, pp.231-253.

TAS (1999) Rail Industry Monitor. Preston.

Transportation Consultants International (1997) Forecasting Rail Demand: The Effect of External Factors. Report SSF004/02.

Wardman, M. (1994) Forecasting the Impact of Service Quality Changes on the Demand for Inter-Urban Rail Travel. Journal of Transport Economics and Policy 28, pp.287-306.

Wardman, M. (1997) Inter-Urban Rail Demand Elasticities and Competition in Great Britain: Evidence from Direct Demand Models. Transportation Research E, 33 pp.15-28.

Wardman, M. (19XX) Great Western

Wardman, M. CROSS-SECTIONAL.