SHORT-RUN TRANSPORT DEMAND
AT A PROVINCIAL AIRPORT

By G. F. Thompson*

INTRODUCTION

Much effort has been directed to developing global forecasts of air transport demand, particularly by airline companies and professional bodies in the air transport industry, but detailed analysis of the characteristics of demand for air transport over specific routes has been less well researched, especially on routes operated from smaller airports. This paper sets forth some short-run demand estimates for a selection of air transport routes operated from Birmingham Airport. Although the analysis was confined to scheduled services operated from Birmingham, the results obtained have some interesting general implications for policy towards air transport price setting in other environments, and these are pursued in the final section of the paper. The analysis was further confined to scheduled services operated by British European Airways, on which information was more readily available, and a theoretical framework easier to develop, than for non-scheduled operations. In addition, it is clear that, at the time of the analysis, revenue from year-round scheduled services was still much more important to airports like Birmingham than revenue from the predominantly seasonal non-scheduled operations.1

The model developed in this paper is a variation of the traditional gravity model.2

The functional form is:

$$T_{il} = f(P_{il}, P_{il}^*, P_{il}^C, P_{il}^{CH}, Y_i)$$

and in linear form:

$$T_{il} = K_i + aP_{il} + bP_{il}^* + cP_{il}^C + dP_{il}^{CH} + eY_i + u_{il}$$

where

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1Of the 14,500 air transport movements at Birmingham in the calendar year 1968 only 1,500 were charter movements.

2See Doganis [7] for the historical background to the gravity model development in the context of air transport forecasting.
SHORT-RUN TRANSPORT DEMAND AT A PROVINCIAL AIRPORT

G. F. Thompson

\( T_{ij}^t \) is the total number of air passengers between nodes \( i \) and \( j \) in time period \( t \).

\( K = \text{constant} \).

\( P_{ij}^t \) is the fare by air between nodes \( i \) and \( j \) in time period \( t \).

\( P_{ij}^b \) is the fare by rail between nodes \( i \) and \( j \) in time period \( t \).

\( P_{ij}^c \) is the cost by car between nodes \( i \) and \( j \) in time period \( t \).

\( P_{ij}^{CH} \) is the fare by coach between nodes \( i \) and \( j \) in time period \( t \).

\( Y_i \) = income (personal disposable income), in time period \( t \).

\( u_{ij} \) = error term.

The coefficient \( a \) in equation (2) can be used to derive the price elasticity of demand for air travel. This is defined in economic theory as the percentage variation in quantity demanded in relation to the percentage variation in price [3], [4], [6], and can thus be written:

\[
\varepsilon^A = \frac{\% \text{ change in quantity}}{\% \text{ change in price}}, \text{ or } \frac{dQ^A}{dP^A} \cdot \frac{P^A}{Q^A}.
\]

\( \frac{dQ^A}{dP^A} \) is given by the coefficient \( a \) in equation (2).

If this equation were specified in log-linear form, the coefficient \( a \) could be read directly as the price elasticity of demand.\(^3\)

\[
\varepsilon^A = \frac{d \log Q^A}{d \log P^A} = \frac{\Delta \log Q^A}{\Delta \log P^A} = a
\]

As we shall see, the logarithmic formulation (which assumes constant elasticity) sometimes gives better results than other formulations.

DATA COLLECTION

The Routes

Monthly time series data of passengers and fares were collected for scheduled services operated by B.E.A. from Birmingham over the period September 1960 to October 1968, and, with the help of B.E.A., routes thought to be atypical were eliminated.

From a possible nine routes considered for analysis three were chosen. These were the three most mature routes, and all had been operated continuously throughout the period. The Birmingham to Glasgow route was chosen as the preliminary service to be investigated in a detailed manner with the hope of pinpointing the difficulties and ironing them out before analysing the other routes. The Birmingham–Belfast route was the second chosen for analysis and the only international route, Birmingham–Dublin, was the third.

\(^3\)By an analogous argument income elasticities can be derived from coefficient \( \varepsilon \) in equation 2, and coefficients \( b, c \) and \( d \) can be interpreted as cross price elasticities.
Two preliminary points need to be made concerning the passenger data.

In the first place, the data were not broken down any further into sub-groups. Since all three services provided only tourist class accommodation, the question of proportions of passengers taking different types of accommodation did not arise. Some indication of the purpose of the journeys would have been valuable. Many studies of air travel demand [1], [3], [6], [12] have stressed the importance of differentiating between travellers journeying on business, on personal visits, and on vacation and holidays. They have found that reaction to changes in price varies according to the purpose of the journey. The Aeroport de Paris Report [1] finds a price elasticity of —1.56 for private journeys, but a much lower price elasticity for business journeys of —0.82. A similar pattern has been noted by Elle [9]. The results of some kind of “in flight” study would have enabled us to analyse the services in much greater detail; but this was impossible, as the information was not available. However, B.E.A. seemed to think that a high proportion of the passengers flying, particularly on the Glasgow route, were travelling for business purposes. In fact, the time- tabling of all-year-round scheduled services from Birmingham seemed to be closely geared to business men’s requirements.

A second point for consideration is the changing level and quality of service offered over time on any route. If, for instance, the number of flights per day from a particular airport to another increases and/or the flight time is significantly reduced, there may be an autonomous generation of traffic in response to this increase in quality, and this may be independent of any price change. On the routes chosen for analysis, however, the time taken for flights and the number of flights per day had not altered appreciably. It was not thought, therefore, that changes in the quality of service could have had any independent effect upon the data.

Detailed Analysis of the Birmingham–Glasgow Route

As stated above, a continuous monthly series of statistics of air passengers was available on the Birmingham–Glasgow route, so the dependent variable could be easily specified. Specification of the air fare variable was a little more problematical, because the number of fares available on the route varied. In particular, B.E.A. has at times during the period 1960–69 offered cheaper return fares for off-peak periods (predominantly at weekends). It was not possible to weight this variable according to the numbers of passengers travelling at these different fares, because of lack of data. It was decided to utilise the ordinary single fare in operation during the week-day period, when traffic on the route is heaviest.

For the rail price variable the second class single fare was taken. Since only a

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4A criticism of this choice may be that rail travel by first class is more competitive with air travel than is second class; but in our analysis we are concerned essentially with the effect of change in the independent variable upon the dependent variable, and as long as the change in second class fare is of the same relative magnitude as in first class the absolute difference between these fares need not concern us. In fact this relationship was found to hold between 1960–69. But there is a further problem. If there had been any shift in the proportions of 1st and 2nd class passengers over the period, then, even if the relative levels of the two classes of fares remained the same, the weighted effective fare would not have followed closely the changes in either class. The data needed to weight the passengers by 1st or 2nd class travel was not available, and no test could be made to see if there had been any substantial shift between classes.
small part of the line between Birmingham and Glasgow was electrified during the period, the time taken for the journey was much the same throughout, and so it was assumed that change in quality of service for this mode was also insignificant.

The price of using a car proved to be the most difficult to specify and the least accurate of all the variables considered. The difficulty stemmed from the basic lack of information concerning car usage on the Birmingham–Glasgow route. There was no direct information on the cost of using a car between the two cities, so some indirect measure had to be utilised. Many studies of car travel behaviour have stressed the importance of considering only the direct costs in defining the “price” of car use. A similar approach was adopted here, and “direct running costs per mile” for cars with engine capacity of between 1500 and 2000 c.c. were constructed, based upon petrol and oil costs.\(^5\)

After some initial investigation the coach price variable was dropped from the model. The journey time in 1960 of approximately eleven hours had been reduced to approximately eight hours in 1969. This was mainly due to more extensive use of the M6 Motorway, which was then being opened. Because of the very long journey time and the lack of sleeping accommodation on the only (overnight) trip, it was not thought that this service offered any appreciable competition to the other modes, particularly the air services. As has been fully reported in Thompson [15] there was also a multiplicity of rates and a lack of the further data needed for correct specification of the price variable.

Ideally, we would wish for an income variable specified through time for each of the two metropolitan areas served (Glasgow and Birmingham), weighted according to the number of originating passengers from each area travelling over the route. Such detailed data were not available. No city income statistics are kept in this country\(^6\); nor were there any statistics on the proportion of originating passengers from each conurbation. Instead it was decided to employ national income statistics, and a quarterly series of Personal Disposable Income was collected.\(^7\)

Finally, before we go on to discuss the results of the regression analysis, a general point must be made about specification of the price and income variables. The analysis involves isolating the effect on traffic of changes in price and income over a number of years. As we know, this period has been characterised by inflation, the result of which is that money changes in the price and income variables do not

\(^5\)Clearly, in specifying this variable in these simple terms a number of important considerations have been ignored. In particular, the number of people travelling in a car is important for the notional price per passenger. In addition there is the complex question whether all the track costs that are legitimately attributable to cars are actually being met by them (see [13]). Since rail is directly responsible for its track costs, some distortion can be built into “price” if no adjustment is made for the fact that perhaps the road (and even the air) mode does not cover its full track costs. A further, and wider, problem that is again not explicitly considered is the value of time, which can effect the modes in different ways. All these important considerations had to be ignored because of the lack of time series data.

\(^6\)Recently, however, Ellison [11] has compiled a proxy measure of city income statistics from Family Expenditure Survey data.

\(^7\)For the analysis these quarterly data had to be converted into a monthly series. For a description of how this was achieved see Thompson [15].
represent the real changes that have occurred in these variables. Under these circumstances analysis of time series data usually involves the deflation of the income variable by some index of the rise in prices, in order to eliminate the autonomous effect of inflation. The data used in this analysis were not deflated in this manner, for a number of reasons. In the first place there was the belief that “raw” data are always better than deflated data. When data are deflated there is always some loss of detail that may significantly mask the identification of underlying trends. The second and main reason was that the analysis was an attempt to identify the short-run influences on demand. If we analyse the data on a monthly basis and do not lag any of the variables, the effects of changes in price and in income are assumed to work themselves out, via adjustments in demand, within a month. In the short run it is doubtful whether customers take into account the effects of inflation on their spending habits: that is, they tend to react more strongly in terms of money income than of real income.

Treating the data in this way does, however, raise difficult statistical problems, in particular multicollinearity and heteroskedasticity. Adjustment of the dependent variable for population increases, and the deflation of the independent variables, could have partly eliminated both, but indices to do this on a monthly basis were not available. In our discussion of the results, tests are made for multicollinearity and heteroskedasticity, both of which appear to be less serious than might have been expected, but clearly the results obtained from deflated data might have been different from those reported in this paper. However we would expect a similar pattern of results to emerge.

RESULTS OF INITIAL RUN OF THE MODEL: BIRMINGHAM–GLASGOW

The regression model was first run with the data specified above, with the addition of a dummy variable taking the form of 1 for the summer months July to October, and 0 for the winter months November to June. With both the ordinary linear and log-linear formulations, tests revealed serious serial-correlations in the model, and a transformation was performed on the data. Auto-correlation is the lagged correlation of a particular time series with itself, lagged by a number of units of time. A variable $X$ observed in a time series is auto-correlated if the value of $X$ in period $t$, $X_t$, is correlated with $X$ in period $t-1$, $X_{t-1}$, (or $X_{t-2}$, $X_{t-3}$, etc.), i.e. the observations are not mutually independent and therefore successive disturbances are not drawn independently of previous values. To eliminate this the method of finite

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8This might seem rather an heroic assumption. Most time series studies aggregate data over a year and therefore assume that a year is necessary for demand to fully react to price changes. But as Ellison [11] argues, there is no evidence to suggest that this is correct. It will be argued later in this paper that the nature of the results obtained with our formulation suggests that a period of considerably less than 12 months is warranted.

9See Thompson [15], Chapter 16, Tables VIII and IX.
SHORT-RUN TRANSPORT DEMAND AT A PROVINCIAL AIRPORT

G. F. Thompson

differences can be employed. We can estimate the auto-regressive scheme of the form:

\[ u_t = \rho U_{t-1} + e_t \]

where \( \rho \) can be of any finite value. The estimate of \( \rho, \hat{\rho} \) can then be used to transform the variable in the form

\[ (X_t - \hat{\rho}X_{t-1}) \]

The variables we employed were transformed in the following forms and the regressions repeated.\(^{10}\)

(i) \( \hat{\rho} = 0.5 \) \( X_t - 0.5 X_{t-1} \)
(ii) \( \hat{\rho} = 0.7 \) \( X_t - 0.7 X_{t-1} \)
(iii) \( \hat{\rho} = 1.0 \) \( X_t - X_{t-1} \)

Transformation of the model on the basis of estimates of \( \hat{\rho} = 0.5 \) and \( \hat{\rho} = 1.0 \) considerably reduced the auto-correlation, and most model formulations proved satisfactory with regard to the Durbin–Watson ratio test.\(^{11}\) However, the signs of variables and their significance were very erratic.\(^{12}\) The income and dummy variables consistently showed up as the most statistically significant. The air price variable, although with the expected sign, was statistically significant in only a few of the equations tested. The addition of the rail price and car price variables added little to the explanatory power of the equations, and their signs and level of significance were also very erratic. Because the results were so unsatisfactory, it was decided to split the data into separate summer and winter series. It was thought that the marked seasonal nature of the traffic flows, which were mostly independent of any price or income changes, were distorting the results.

The Winter/Summer Differential

The data were split between the “winter” season of the seven months November to May, and the “summer” period of June to October. (This corresponds fairly closely with the airline seasonal price differential that was operative on the route for a number of years). The observations for the months over the period 1960–1969 were separated out and treated as a continuous series. This gave 56 observations for the winter series and 40 for the summer series. Since the rail fare and car cost variables were shown not to add significantly to the regressions, these variables were eliminated. For the winter series only, there were still some very sharp falls in traffic levels, usually in January; as a result a dummy form 1 for January and 0 for all the other months was constructed. Close inspection of the passenger data did not reveal any other significant holiday variation in traffic levels; the “long-period” seasonal variation on a winter/summer differential was the fundamental adjustment necessary.

The results of the preliminary regressions using these data are shown in Table 1. In the winter formulation all the variables were significant at the 5% level or better.

\(^{10}\) These were not estimated directly, but “guessed” and used to find best fits.
\(^{11}\) The \( \hat{\rho} = 0.7 \) transformation gave worse results than non-transformed data and did not produce any further insights. This formulation was therefore abandoned.
\(^{12}\) See Thompson [15], chapter 16, Tables X and XI.
Regression Equations for Birmingham–Glasgow route: Winter and Summer

<table>
<thead>
<tr>
<th>Equation No.</th>
<th>$K$</th>
<th>$P^A$</th>
<th>$Y$</th>
<th>$D$</th>
<th>$U$</th>
<th>$R^2$</th>
<th>[R2]†</th>
<th>$D/W$</th>
</tr>
</thead>
<tbody>
<tr>
<td>WINTER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Ordinary</td>
<td>-608.32</td>
<td>-5.74*</td>
<td>2.07*</td>
<td>-692.03*</td>
<td>13434</td>
<td>0.71</td>
<td>1.64</td>
<td></td>
</tr>
<tr>
<td>Linear</td>
<td>(363.50)</td>
<td>(2.32)</td>
<td>(0.25)</td>
<td>(108.98)</td>
<td>(367)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Log</td>
<td>-1.52*</td>
<td>-0.22*</td>
<td>1.64*</td>
<td>0.14*</td>
<td>0.005</td>
<td>0.70</td>
<td>1.47</td>
<td></td>
</tr>
<tr>
<td>Formulation</td>
<td>(0.56)</td>
<td>(0.11)</td>
<td>(0.22)</td>
<td>(0.02)</td>
<td>(0.072)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUMMER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Ordinary</td>
<td>-266.89</td>
<td>-6.06</td>
<td>1.99*</td>
<td>46878</td>
<td>0.78</td>
<td>1.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear</td>
<td>(258.07)</td>
<td>(6.21)</td>
<td>(0.49)</td>
<td>(216)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Log</td>
<td>0.55</td>
<td>0.25</td>
<td>1.38*</td>
<td>0.0010</td>
<td>0.81</td>
<td>1.30</td>
<td></td>
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</tr>
<tr>
<td>Formulation</td>
<td>(0.46)</td>
<td>(0.29)</td>
<td>(0.31)</td>
<td>(0.31)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. 0.5 First</td>
<td>-325.03</td>
<td>-18.19*</td>
<td>3.04*</td>
<td>58180</td>
<td>0.51</td>
<td>0.80</td>
<td>2.21</td>
<td></td>
</tr>
<tr>
<td>Diff. Ordinary</td>
<td>284.34</td>
<td>(0.03)</td>
<td>(0.66)</td>
<td>(241)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. First Diff.</td>
<td>-19.18</td>
<td>-13.79*</td>
<td>3.14*</td>
<td>51750</td>
<td>0.26</td>
<td>0.77</td>
<td>2.54</td>
<td></td>
</tr>
<tr>
<td>Ordinary</td>
<td>(19.07)</td>
<td>(6.63)</td>
<td>(0.83)</td>
<td>(227)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Linear</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

*Significant variable at the 5% level or better.
†All the transformed equations give lower $R^2$ than their non-transformed equivalents. The following formula was utilised to recompute hypothetical values of $R^2$ (for equivalent non-transformed data):

$$[R^2] = 1 - \frac{\text{variance of residuals of transformed equations}}{\text{total variance of non-transformed data}} \cdot \frac{(n-k)}{(n-1)}$$

where $n =$ number of observations and $k =$ number of independent variables.

My thanks are due to John Tzoannos for this point, which is the result of some unpublished theoretical work on his part.

Again, the income and dummy variables showed the greatest significance, but in both equations the air price variable is significant and the coefficient has the expected sign. These equations give $\varepsilon P^A$ of -0.26 for the ordinary data formulation and -0.22 for the log formulation. Significant also is that in equation E1 the Durbin–Watson ($D/W$) ratio is satisfactory up to the 2.5% level, although for the log formulation we cannot reject or support the hypothesis of auto-correlation.

In the summer series income is very significant but the air price variable, although with the expected sign, is not statistically significant. There is also evidence of autocorrelation in both equations E3 and E4. When transformations were performed on these data in the form of equations E5 and E6, the air price variable became significant in both equations (at the 5% level) and the $D/W$ ratio was sufficient to reject the hypothesis of positive auto-correlation. The coefficients for $P^A$ in E5 and E6 give $\varepsilon P^A = -0.97$ and $\varepsilon P^A = -0.90$ respectively.

One of the major difficulties with time series analysis is multicollinearity between the explanatory variables. If there is a strong relationship between, for example, price changes and income, and they tend to move in a similar manner through time, it becomes very difficult to disentangle their separate influences and obtain a
reasonably precise estimate of their relative effects. But if forecasting is the objective, and if we assume that the intercorrelation of the variables is likely to continue into the future, it may not be too serious. As a test for the presence of multi-collinearity, we inspected the Variance/Co-variance matrix of the residuals of the equations and made a rough calculation of the relationship between the variables. This relationship was fairly high between variables \( P^d \) and \( T \) in equations E1 and E2 and E5 (\( r_{X_1 X_2} = -0.78, -0.66, -0.90 \) respectively). In E6 it was fairly low, at \(-0.25\); the relationship between the other explanatory variables was very low.

The other statistical problem raised at the end of the previous section is heteroskedasticity, a non-spherical disturbance pattern resulting from the growth of residual variance as time progresses. To test for this the inspection method was used and a plot was made of the residuals against time. Inspection of this graph for the winter equations showed no evidence of heteroskedasticity, but for the summer equations there was some positive evidence, particularly in equation formulation 5 of Table 1.

**BIRMINGHAM–DUBLIN AND BIRMINGHAM–BELFAST**

Since we have covered in some detail the precise technique employed in calculating the price elasticity of demand on the Birmingham–Glasgow route, it will not be necessary to go over the mechanics in such detail when we now consider the other two routes specified for analysis, Birmingham–Dublin and Birmingham–Belfast.

Fortunately the extent of the analysis, and particularly the extent of the transformation of the data necessary to eliminate autocorrelation, was much less for these routes. Only the more interesting results are tabulated.

Both routes involve a sea-crossing. This added considerably to the difficulties of gathering accurate measurements for the car price and rail price variables, as these must include an element for the sea-leg of the journey. Since in the Birmingham–Glasgow analysis, where we could expect competition from rail and car to be greatest, neither was found to have made an important contribution to the model, attention was concentrated on the air price variable income and, again, a seasonal dummy.

**Results: Birmingham–Dublin Route**

A continuous series was available of 97 monthly observations of passenger movements and also of the price paid for the air journey. The precise specification of the income variable caused some difficulty. Ideally, we should have liked to have a breakdown of the countries of origin of passengers travelling over the route each month (or even each year), and to weight the variable according to the change in national income of their countries of origin. Clearly, it is likely that Irish and British passengers dominate this route, so even a breakdown between them would have been welcome. This was not available, however, and it was decided to utilise the income figures for Great Britain used in the Birmingham–Glasgow analysis. This is partially justified by the probably dominant position of Great Britain both
economically and in numbers of passengers originating for this route. A similar dummy variable to that used before was again constructed. For the ordinary data the following regression was obtained:

\[
\begin{align*}
(E1) \quad T^4 &= -2564.06 - 1.46 P^4 + 1.97 Y + 984.85 D + u \\
& \quad (369.84) \quad (6.84) \quad (0.40) \quad (55.66) \\
R^2 &= 0.84 \quad D/W = 1.41
\end{align*}
\]

All the coefficients have the expected sign. The price variable is not significant at the 5% level, though all the other variables are significant at the 1% level. The value of the \(D/W\) ratio is not sufficient to reject the hypothesis of significant auto-correlation. A check for multicollinearity in the independent variables proved not significant in the case of \(X_1X_3\) and \(X_2X_3\), but \(rX_1X_2\) was \(= 0.7\), indicating fairly strong collinearity between them. The log formulation gave the following result:

\[
\begin{align*}
(E2) \quad \log T^4 &= -9.60 \log K - 1.58 \log P^4 + 4.33 \log Y + 0.06 D + u \\
& \quad (0.52) \quad (0.78) \quad (0.58) \quad (0.02) \\
\bar{R}^2 &= 0.84 \quad D/W = 1.66
\end{align*}
\]

Again, all the coefficients have the expected sign. The constant is significant at the 1% level; so are the income variable and the dummy. The price variable has the expected sign and is significant at the 5% level. \(\bar{R}^2\) is fairly high at 0.84, and the \(D/W\) ratio is satisfactory at the 1% level. Further transformation of the data did not produce any further significant results, and has not been tabulated. We are left then with equation (E2) as the best explanation of the variance in the number of passengers travelling (84%) over the Birmingham–Dublin route. A scatter diagram of residuals surprisingly revealed little evidence of heteroskedasticity.

**Results: Birmingham–Belfast Route**

There were 89 monthly observations for Birmingham–Belfast on the number of air passengers, fare paid, and income variables. A seasonal dummy was formulated of the form 1 for the summer months and 0 for the other months of the year.

For ordinary data the following regressions were obtained:

\[
\begin{align*}
(E1) \quad T^4 &= -2137.29K - 21.83 P^4 + 3.16 Y + 1771.28 D + u \\
& \quad (746.51) \quad (13.34) \quad (0.60) \quad (159.11).
\end{align*}
\]

\(R^2 = 0.67 \quad D/W = 1.34\)

The constant \(K\), income and dummy variable are all significant at the 1% level and of the expected signs. The \(P^4\) variable is significant only at the 10% level. The \(R^2\) is fairly low and the \(D/W\) statistic not high enough to reject the hypothesis of the presence of autocorrelation among the variables.

With log formulation the following regression was obtained:

\[\text{---}\]

13See Doganis [8] for an analysis of Birmingham Airport passengers. Many of the passengers on the Dublin route are Irishmen who work in the Midlands area and who use the route extensively to fly home for holidays, etc.
SHORT-RUN TRANSPORT DEMAND AT A PROVINCIAL AIRPORT

G. F. Thompson

(E2) \[ T^4 = -8.24 \log K - 1.59 \log P^4 + 4.01 \log Y + 0.275 D + u \]

\[ (1.23) \quad (0.87) \quad (0.63) \quad (0.023) \]

\[ R^2 = 0.73 \quad D/W = 2.99 \]

The significance of the variables is of the same level as before, but now 73% of the variance is explained and the price elasticity of demand is -1.59. The D/W ratio is still too low, however, for us to reject the hypothesis of positive serial correlation.

Again, collinearity between \( P^4 \) and \( Y \) variables proved to be fairly strong when tested (\( \approx 0.75 \)), but in the case of \( rX_1X_3 \) and \( rX_2X_3 \) the relationship was insignificant (\( \approx 0.2 \)). Transformation of the data was necessary; it was carried out in the form \( X_t - X_{t-1} \) and \( X_t - 0.5X_{t-1} \) and the regressions were re-run. The \( X_t - X_{t-1} \) transformations did not improve upon the existing regressions, but the \( X_t - 0.5X_{t-1} \) transformation gave the following result:

(E3) \[ T^4 = -1041.18 K - 27.03 P^4 + 3.43 Y + 118.81 D + u \]

\[ (548.16) \quad (13.36) \quad (0.82) \quad (106.53) \]

\[ R^2 = 0.60; [R^2] = 0.80 \quad D/W = 2.42 \]

The D/W ratio is sufficient for us to reject the hypothesis of autocorrelation (positive) at any level. The constant \( K \) is not quite significant at the 5% level. The price variable is of the expected sign and is significant at the 5% level. The income and dummy variables are both significant at the 1% level. The regression explains 80% of the variance in \( T^4 \), and price elasticity of demand, from this equation, is equal to -1.53. Again a plot of the residuals revealed little evidence of heteroskedasticity.

SUMMARY AND CONCLUSIONS

Table 2 gives a summary of the estimated price and income elasticities of demand for the routes analysed in this paper. Perhaps the most significant feature of the analysis as a whole was the dominant position of variations in income in explaining the demand pattern over the routes. Certainly income is much more important than price for this purpose. It was only after a series of transformations that price became statistically significant, and then it was still much less significant than income. However, the fact that price elasticities were significant at all warrants some comment.14 The only recent published work carried out in the United Kingdom on air transport demand estimates is that by Ellison and Stafford [10], further extended by Ellison [11]. Ellison set up similar models to those described above for all the major domestic and international routes, but his results were very erratic in terms of explanatory powers, variable significance and sign expectation. The highly unstable

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14 We should remember here that the positive significance of these variables may be due to the presence of heteroskedasticity, which could have the effect of making the results appear significant when they really are not. The graphical method employed in testing for heteroskedasticity showed this effect to be most pronounced in the Glasgow summer series, which is therefore perhaps most suspect.
Table 2

Summary of Price and Income Elasticities

<table>
<thead>
<tr>
<th>Route</th>
<th>Estimated Elasticity of Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Price</td>
</tr>
<tr>
<td>Birmingham–Glasgow</td>
<td>-0.26</td>
</tr>
<tr>
<td>Winter (E1)</td>
<td></td>
</tr>
<tr>
<td>Winter (E2)</td>
<td>-0.22</td>
</tr>
<tr>
<td>Summer (E5)</td>
<td>-0.97</td>
</tr>
<tr>
<td>Summer (E6)</td>
<td>-0.90</td>
</tr>
<tr>
<td>Birmingham–Belfast (E3)</td>
<td>-1.53</td>
</tr>
<tr>
<td>Birmingham–Dublin (E2)</td>
<td>-1.58</td>
</tr>
</tbody>
</table>

The nature of the results led to a cutback in the number of routes analysed and to the development of a two-stage least-square model, in which the short-run influences were isolated first and the generated time series then regressed against income. Generally, Ellison concludes that price is an insignificant variable in generating forecasts of air demand changes, but that income is a much more significant variable. In fact, in most of his models, price was not statistically significant, though income was. He therefore suggests that, because price changes in the future would be difficult to estimate and would have comparatively little significance, attention should be directed to income forecasting. However, we must be very careful in arguing that price is not an important variable in determining consumer demand.

The results from our formulation suggest that a possible reason for the poor performance of the air price variable in these other studies arises from the nature of the specification of the time taken for a change in price to react on demand. A full twelve months is perhaps too long, and attention should be directed to a more short-run formulation. This is particularly so on scheduled services operated from airports like Birmingham, where a high proportion of passengers are business men and regular users of the routes (for example, Irish people working in the Birmingham area). Knowledge of impending change in price is then easily obtained and reactions to it can be fast.

Returning to our results, the elasticities themselves vary between the routes in quite an interesting fashion. There are low income and price elasticities during the winter months for the Glasgow route. This is to be expected on a route where the basic demand is made up of business travellers. In the summer months the demand is increased by holiday travellers, and their demand tends to be more price and income elastic (as other studies have shown). The Belfast and Dublin routes show very similar price elasticities, but at a much higher level than on the Glasgow route.

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13 Similar results were observed by Straszheim [14] on the North Atlantic route.
14 See the recent paper by Cooper and Maynard [5] for an argument for much greater price flexibility in air transport as a stimulant to demand.
SHORT-RUN TRANSPORT DEMAND AT A PROVINCIAL AIRPORT

G. F. Thompson

probably because the routes to Ireland are less dependent on business traffic. On competition, however, our results are perhaps less expected. There would seem to be more competition between air and other modes on the Glasgow route, as the other two routes involve a sea crossing, and with more competition we would expect a higher price elasticity. Obviously, the effect of the composition of demand is more important than competition over these routes.

Finally, the fact that we have observed different price elasticities on the routes suggests that the airline company, when considering price changes, might well benefit by differentiating between routes rather than by pressing for "across the board" changes in price on all routes, as is the present practice. For instance, fare reductions on the Belfast and Dublin routes could raise load factors enough to increase total revenue, but on the Glasgow route they would result in a decline in revenue. Greater flexibility in pricing policy is called for.

REFERENCES