ARUP

Oxera

What are the findings from the econometric analysis?

Findings report

Prepared for
the Department for Transport,
Transport Scotland, and
the Passenger Demand Forecasting Council

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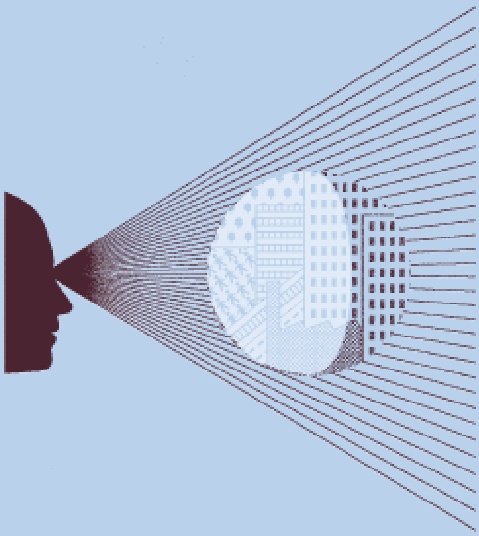

Executive summary

Oxera and Arup have undertaken a study, ‘Revisiting the Elasticity-Based Framework’, for the Department for Transport, Transport Scotland and the Passenger Demand Forecasting Council (PDFC). The primary aim of the study is to update and estimate the fares and background growth elasticities contained within the Passenger Demand Forecasting Handbook (PDFH).

The study has a number of secondary objectives, which include:

– exploring the use of innovative or alternative econometric techniques;
– re-specifying and extending the core elasticity-based framework;
– improving the underlying data.

This report sets out the findings from the analysis, and builds on a large body of work. The study has provided a substantially improved dataset, with a longer time period, improved coverage of other transport modes, and a new measure of service quality. This improved dataset has been supplemented with the use of updated econometric techniques to estimate the elasticities. It is important to note that these techniques were selected on the basis of their being the most appropriate for the task, rather than a preference being given to new techniques solely because they are new.

The study has also involved considerable analysis of market segmentation, which has resulted in a new way of segmenting the market:

– London, the South East and East of England (LSEE);
– non-London core cities;
– flows to airports;
– other.

For the first time, this market segmentation is based on both economic theory and robust empirical research. This process resulted in 29 ticket-type segments (as the dataset allows the separate modelling of full fare, reduced fare and season tickets). However, for the London, South East and East of England market segment, the full and reduced fare tickets have been combined into one ‘non-season’ ticket model because of the impact of fares regulation in the London area. Therefore, results are presented for 28 ticket-type segments.

The elasticity estimates produced by this study may be expected to differ from those presented in the PDFH for a number of reasons, including the use of:

– different datasets;
– different econometric approaches;
– different market segmentation.

Therefore, direct comparison of elasticities between sources may not be particularly enlightening. However, to facilitate comparison, the table below summarises the elasticities for four important market segments: LSEE to LSEE season and non-season tickets; and LSEE to non-London core cities, full and reduced fare tickets, and compares them to those presented in the PDFH v5.

Comparison of elasticities

	PDFH v5	Revisiting the Elasticity-Based Framework
Fare		
LSEE–LSEE (season)	–0.50[1]	–0.73
LSEE–LSEE (non-season)	–0.80	–0.95
LSEE–non-London core cities (full)	–1.05	–1.24
LSEE–non-London core cities (reduced)	–0.75	–0.25
Income[2]		
LSEE–LSEE (season)	n/a	n/a
LSEE–LSEE (non-season)	1.2	1.58
LSEE–non-London core cities (full)	0.9	1.26
LSEE–non-London core cities (reduced)	0.9	1.73
Employment		
LSEE–LSEE (season)	1.3	1.41
LSEE–LSEE (non-season)	n/a	0.49
LSEE–non-London core cities (full)	n/a	n/a
LSEE–non-London core cities (reduced)	n/a	n/a
Car cost		
LSEE–LSEE (season)	0.0	n/a
LSEE–LSEE (non-season)	0.19	1.43
LSEE–non-London core cities (full)	0.22	1.56
LSEE–non-London core cities (reduced)	0.22	0.77

Note: [1] LSEE–LSEE fare elasticities are given for the London Travelcard Area. [2] The income measure for the PDFH is GDP per capita.
Source: Association of Train Operating Companies (ATOC) (2009), 'Passenger Demand Forecasting Handbook', version 5, August, and Oxera analysis.

As can be seen from the table, the elasticity estimates from this study are typically larger in absolute magnitude than those contained within the PDFH v5. However, the relativities between ticket types are generally the same between the two sets of elasticities; for example, in the LSEE–non-London core cities segment, in both cases the fare elasticity is greater for the full fare tickets than the reduced fare tickets.

The analysis conducted for this study provides some evidence for the hypothesis that, in some cases, elasticities vary with the level of the variable, with the preferred model containing variable elasticities in:

- LSEE to other, reduced fare tickets;
- LSEE to other, full fare tickets;
- LSEE to other, season tickets;
- non-London core cities to other, reduced fare tickets;
- other to non-London core cities, full fare tickets;
- to airports, full fare;
- to airports, reduced fare.

This study provides very limited evidence of a distance effect on the elasticities. However, there is strong support for the hypothesis of 'overshooting'—in some cases, the initial demand response to a change in a demand driver is greater than the long-run response.

The measure of income used in the study is in most cases disposable income per capita at the origin of the flow, even in some cases where this would not be expected, such as for some season ticket flows.

The models produced in this study have been selected using a robust process and provide a good fit to national-level data.

The findings set out in this report, which will be subject to further testing and synthesis with the existing literature on the demand for passenger rail travel in Great Britain, provide some interesting policy implications, including the following.

– There is no evidence of market saturation. Assuming that the economy will grow according to trend in the long term, rail demand will continue to increase, and plans will have to be drawn up to cater for this growth.

– Having controlled for car ownership (availability) and car journey times in the general econometric model, this study has found that the typical elasticity to car cost is higher than is reported in the PDFH v5 (although the PDFH also includes a car journey time parameter). To the extent that the costs of running a car increase relative to rail in future, there would seem to be scope for more market growth.

– Elasticities to passenger performance measure (PPM) are also consistently greater than previously seen, suggesting that work supporting today’s typically high PPM levels should continue.

– Furthermore, there seem to be indications that (generalised, including frequency, interchange and in-vehicle time) journey time improvements are likely to increase demand by more than is suggested by previous evidence. To the extent that these would be affordable, the case for speeding up journey times seems to be stronger on the basis of this analysis. In addition, choices between slower trains and increased punctuality will need to be made carefully.

– The study often finds higher fare elasticities of demand than the PDFH v5. Taken at face value, this might call into question the existing fares policy of rebalancing cost recovery away from the taxpayer and towards the passenger.

While this study has extended rail passenger demand forecasting in a number of ways, there are many aspects where further work may be beneficial. Of particular importance are:

– updating the dataset regularly;
– enhancing the dataset to cover those areas where it is still weak;
– a short repeat of the analysis each year to establish whether the elasticities change with increased length of time series;
– more disaggregate-level analysis (including LSEE–Other), where variable elasticity functional forms seem to predominate;
– further investigation of the relationships between the fare/income/generalised journey time (GJT) parameters;
– investigation of the dynamic relationship between GDP, employment and the demand for rail travel;
– investigation of market saturation using more disaggregate data—ie, examine the dataset to see whether there are (local) areas or flows where there is evidence of market saturation.

Different industry participants are likely to have differing priorities as to the most important areas for future research, but the above suggestions identify areas that are likely to be feasible and provide useful results.

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1 Introduction

Oxera and Arup have undertaken a study, 'Revisiting the Elasticity-Based Framework', by the Department for Transport (DfT), Transport Scotland and the Passenger Demand Forecasting Council (PDFC). The primary aim of the study is to update and estimate the fares and background growth elasticities contained within the Passenger Demand Forecasting Handbook (PDFH).

The study has a number of secondary objectives, which include:[1]

- exploring the use of innovative or alternative econometric techniques;
- re-specifying and extending the core elasticity-based framework;
- improving the underlying data.

As part of this study, a number of reports have been produced, detailed below, which form key elements in the formulation of the overall final forecasting framework, and are referenced a number of times here.

Reports prepared by Oxera and Arup for the 'Revisiting the Elasticity-Based Framework' study:

- 'What are the findings from the econometric analysis?' (the *Findings* report)
  - 'Is the data capable of meeting the study objectives?' (the *Data capability* report)
  - 'How has the preferred econometric model been derived?' (the *Econometric approach* report)
  - 'What are the key issue for model specification?' (the *Model specification* report)
  - 'How has the market for rail passenger demand been segmented?' (the *Market segmentation* report)
  - 'Does quality of service affect demand?' (the *Service quality* report)
- 'How should the revised elasticity-based forecasting framework be implemented?' (the *Guidance* report)

The economic models have been derived from economic theory and industry knowledge in the *Model specification report*, and are as follows:

$$\text{Journeys} = \text{Journeys}_{t-1} + \text{fare} + \text{population} + \text{income} + \text{employment} + \text{prop. no car} + \text{car cost} + \text{car journey time} + \text{GJT} + \text{performance} + \text{service quality index}$$

where Prop. no car denotes the proportion of households without access to a car, and GJT denotes generalised journey time.

To undertake a comprehensive investigation of the main relationships of interest in this study, Oxera has examined five separate functional forms for each of the market segments:

- a basic specification, in which all elasticities (except for car ownership) are assumed to be constant along the demand curve, and hence variables enter the model in logs;
- to allow for elasticities which alter with the level of the variable, a specification is run where income, population and employment enter the specification as levels, not logs;

[1] Department for Transport (2008), 'Rail Passenger Demand Forecasting: Revisiting the Elasticity-Based Framework Request for Proposal and Statement of Requirement', July, pp. 12–13.

– to allow for elasticities which vary over time, time dummy variables are interacted with fares, income, GJT, and car journey time,[2] along with the level of the variable and the importance of these interactions tested statistically;[3]
– market saturation is tested by including squared terms of the income, fare and employment variables in the model;
– the impact of distance is tested by interacting the distance of the flow with certain variables (income, population, employment) and testing whether the interaction term is different from zero.

The M*arket segmentation report* identified 29 ticket-type segments, each of which have been investigated. In order to do this, Oxera has developed a robust approach to modelling each market segment, which involves, for each segment:

– graphing key variables (using histograms for the variable in 2007), to assess cross-sectional variation, and time-series plots to examine trends/patterns and outliers in the data. This is important because outliers can exert an unduly large influence on the results of the analysis, and an awareness of the patterns in the data is important in order to arrive at robust models;
– generating a matrix of correlation coefficients between the variables in the model, to assess the degree of correlation between the variables. This is important because including two or more highly correlated variables in an econometric model can result in a number of problems, such as increased standard errors of the elasticities;
– following a general-to-specific modelling procedure, where every variable (apart from journeys) is lagged twice in the general model (eg, the initial model contains the variable at time t, t–1 and t–2). The journeys variable is only lagged once.

General-to-specific modelling is a process whereby the analysis begins with a ‘general’ model, in which all variables and lags of those variables are included in the model. This model is then estimated, and variables or lags are sequentially dropped, on the basis of certain criteria. The model is then re-estimated, without the variable or lag, and the process continues until all remaining variables are statistically significant and economically meaningful. Following the identification of the specific model, diagnostic tests are completed to assess carefully the statistical robustness of the model. This technique is generally accepted in the econometric literature as a robust model selection procedure.

A number of criteria could be used to select which variables or lags to remove from the model. In this study, the adopted procedure is to remove the variable or lag which is the least statistically significant. (Other possibilities, which were not available in this case, include the use of an information criterion,[4] or measures of model fit such as R^2.[5]) Although this procedure sounds mechanistic, it involves considerable attention to the results of each estimation and iteration, in order to check that the coefficients are economically meaningful. In this way, a model which is consistent with both economic theory and industry knowledge is constructed in a statistically robust way. Figure 1.1 illustrates the procedure.

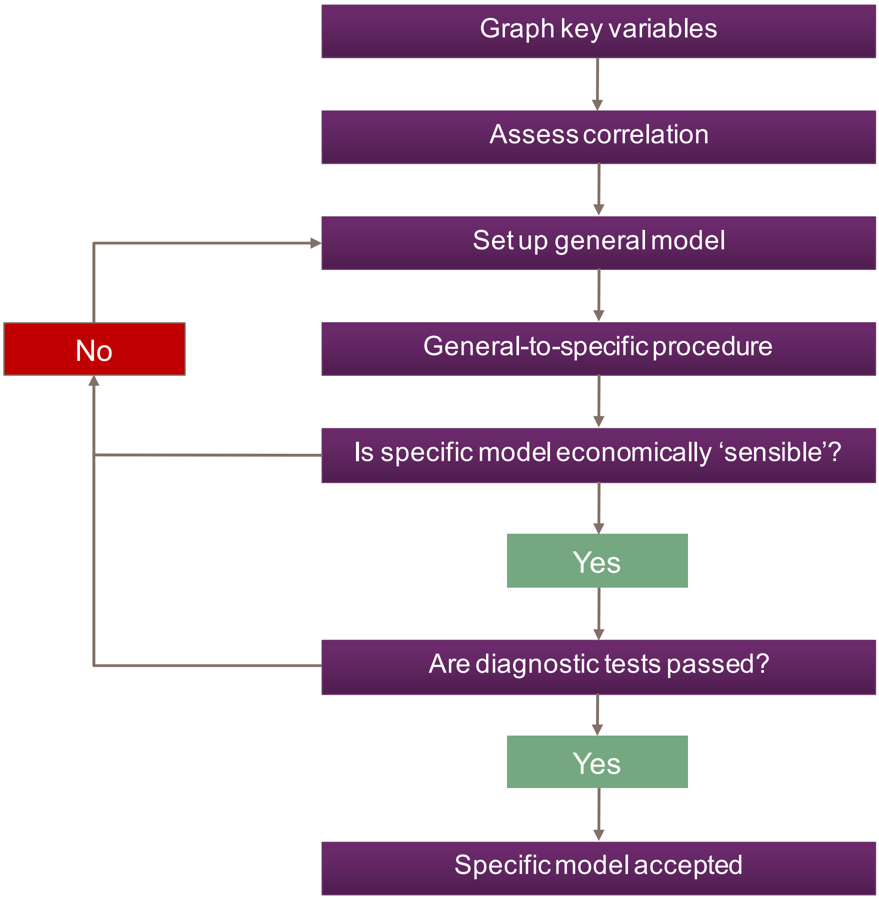
[2] Dummy variables are variables which take a value of one in the period of interest and zero otherwise.

[3] An F-test is conducted on the interactions to test whether they are jointly different from zero.

[4] There are a number of different information criteria, including the Akaike Information Criterion and the Schwartz Information Criterion. The principle is that these criteria trade off model fit against the number of variables, with a ‘better’ model achieving a good fit to the data with as simple a model as possible.

[5] These approaches are not available in this study because neither the R^2 nor the likelihood function (on which the information criteria are based) is calculated for the estimators used.

Figure 1.1 Modelling process



Source: Oxera.

To obtain standard errors (an estimate of the uncertainty around the central estimate) for the three-year elasticities, the Delta method has been used. This is required because the three-year elasticities are non-linear combinations of estimated model parameters. (For details on how to use the estimated model parameters to calculate the three-year elasticities, see the *Econometric approach* report). This is important because, otherwise, the range of uncertainty around these parameters is unquantified.

The segments that have received the most attention are those with the largest share of the rail market. Market share has been defined in a number of ways, including passenger journeys, passenger kilometres and revenue. Here, market share refers to the proportion of journeys in the dataset, not the proportion of rail as a mode of transport.

This section has considered the process followed for each of the 29 ticket-type segments. Section 2 looks at some of the intermediate decisions made to arrive at the final forecasting framework.

Section 3 outlines the key results from the modelling process, while section 4 provides some commentary on the results. Section five concludes the report and offers recommendations on further work.

The appendix presents a complete set of 'dashboards' presenting the models, together with their diagnostics.

2 Intermediate outputs

A number of decisions were taken during the course of the analysis, the process of which has been outlined in the section above. These decisions have had an impact on the final forecasting framework and are therefore detailed in this section. The key decisions taken were:

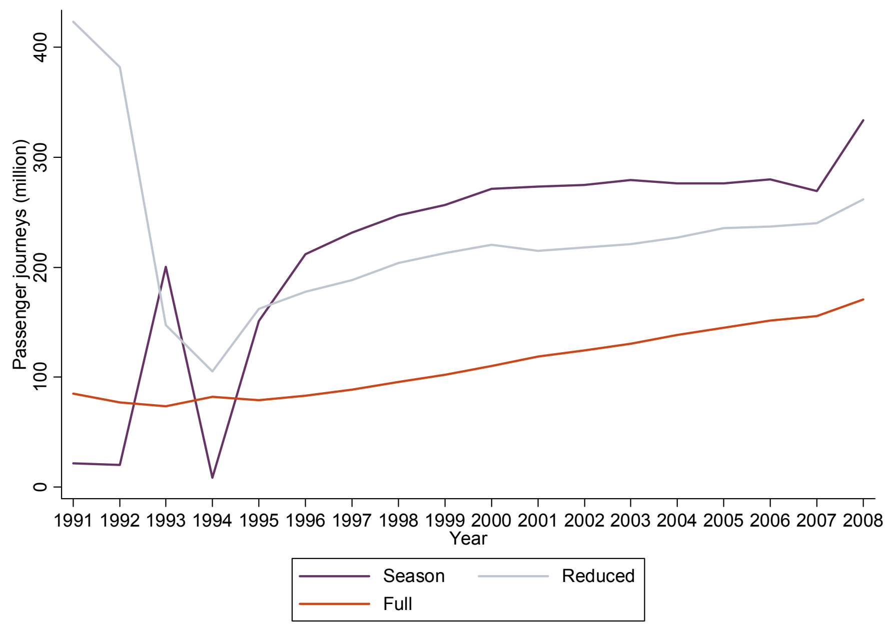
- in some cases to use shorter time series than the full 18 years available;
- to confirm that Central London should be included in the London, South East and East of England (LSEE) market segment, rather than treating it as a separate market segment;
- to combine full and reduced fare tickets to create a single, non-season ticket segment for LSEE to LSEE (thus providing 28 ticket-type segments in the final framework);
- the choice of the core cities for inclusion in the Core cities segment;
- to focus on three-year elasticities when assessing how economically meaningful the results of the general-to-specific modelling were.

These decisions, and the rationale for them, are discussed in more detail below. In some cases, the decision is based mainly on theoretical grounds, and in others on a combination of economic considerations/industry knowledge and the data. In all cases, the supporting evidence is presented.

2.1 Shorten time series

The base data provided for this study covered 18 years, but as Figure 2.1 demonstrates, the data for the years before 1995 is volatile, displaying large increases and decreases in the number of passenger journeys for no apparent reason. The estimation period has therefore often been shortened to using data from after 1994/95 only.

Figure 2.1 Passenger journeys



Source: Oxera analysis.

In other cases, the estimation period has been shortened still further due to the availability of data on the explanatory variables. For example, the data on service quality is only available since 1999 (for more detail, see the *Data capability* and *Service quality* reports).

2.2 Including Central London in the wider segment

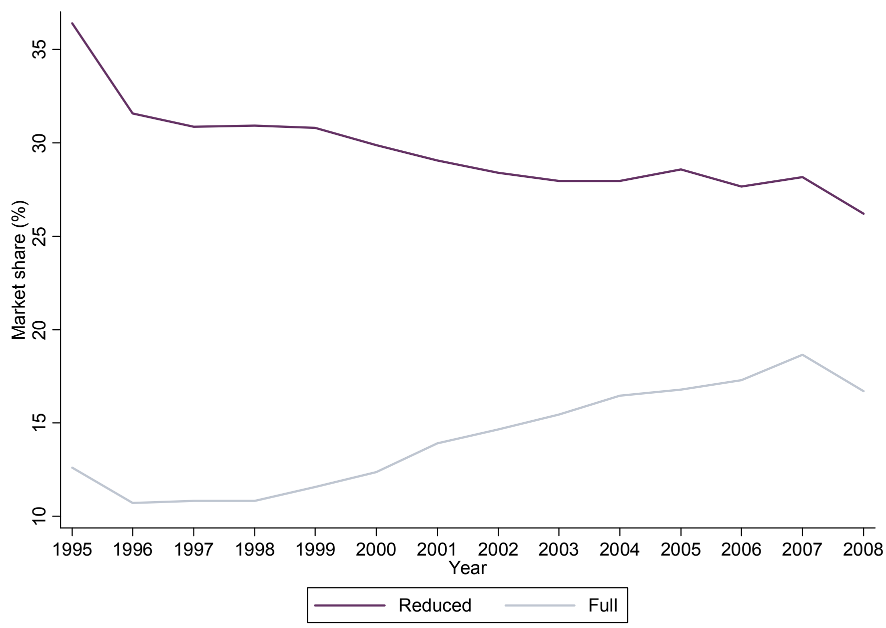
One of the concerns raised during the market segmentation process (as detailed in the *Market segmentation* report) was whether Central London should be treated as a separate market from the rest of the South East and East of England, as is currently the case in the PDFH v5.[6] Although not supported by the results of the market segmentation analysis, the study team investigated this question by estimating a separate model for 'to London from the rest of the South East and East of England' using the same process and functional forms as for the other market segments. However, the estimated elasticities from this modelling were implausible (eg, negative but statistically significant income and car cost elasticities); hence, Central London was included within the wider LSEE market segment.

2.3 Combining full and reduced fare tickets in the London, South East and East of England market segment

The study team began by estimating separate full and reduced fare ticket models for this market segment, especially given its importance for both number of passenger journeys and revenue.

In this sector, the regulated ticket was the full fare ticket, compared with other sectors where the regulated ticket was the reduced fare ticket. In LSEE, fares regulation, in many cases, resulted in the full fare ticket being as cheap as the reduced fare ticket. This in turn had implications for passengers' ticket choices. Figure 2.2 shows the market share of full and reduced tickets in this market segment between 1995/96 and 2007/08.

Figure 2.2 Market share in London, the South East and East of England (%)



Source: Oxera analysis.

[6] ATOC (2009), 'Passenger Demand Forecasting Handbook Version 5', August.

The rapidly rising full fare market share, compared with the falling reduced fare market share, suggests that fares regulation has had a substantial impact on ticket choice, which is beyond the scope of the study to model. Therefore the study team aggregated full and reduced fare tickets together for the final forecasting framework in order to obtain models with meaningful elasticities.

2.4 Choosing core cities

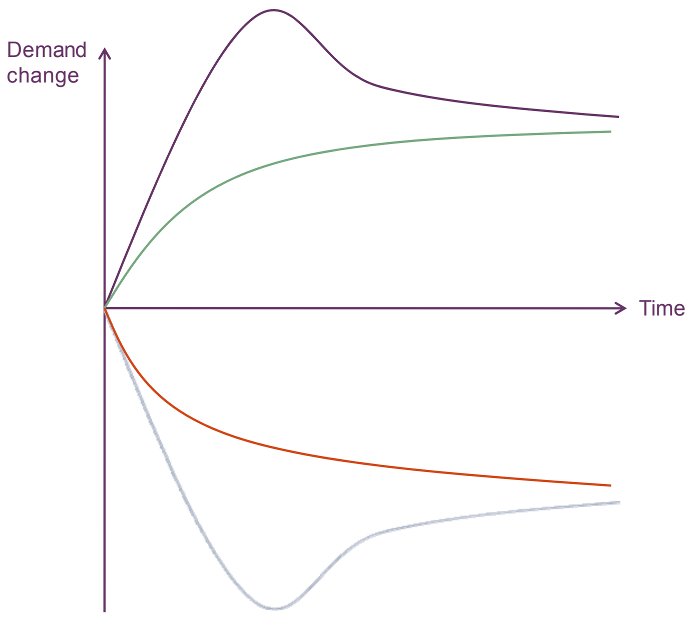
The choice of core cities as a separate market segment is a substantial departure from existing, PDFH, segmentation. This decision was based on extensive analysis, detailed in the *Market segmentation* report. The choice of which cities to use in the Core cities segment was based on an analysis of the patterns of flows from those cities compared with other large conurbations and the surrounding government office region (GOR). The core cities are listed in Appendix 1.

2.5 Focus on three-year elasticities

The study team has estimated models which enable elasticities of different durations to be presented (see the *Guidance* report for more detail). However, when considering model estimates, the focus has been on the three-year elasticities, although elasticities for any length of time could be calculated using the methodology set out in the *Econometric approach* report. This is because of the prevalence of either overshooting or a build-up effect over time. These effects mean that the one-year elasticities are often not a reliable guide to the longer-run impact of changes.

There are two scenarios presented in Figure 2.3: first, where the overshooting is for a negative change (eg, an increase in fares); and, second, for a positive change in demand (eg, an increase in income or employment). The process is similar in both cases. The overshooting is represented by the grey and purple lines respectively, while more gradual adjustments are represented by the red and green lines respectively. In the long run, the lines will converge (purple and green, and red and grey, respectively). However, the adjustment path followed by the different lines has substantial implications for rail demand.

Figure 2.3 Overshooting and build-up effects



Source: Oxera.

The concept that suggests that a period of time is taken for demand to adjust to changes in a driver has been investigated in a number of previous studies, and is addressed explicitly in the PDFH v5.[7] The economic rationale for this effect is typically that passengers respond slowly to changes in the drivers of rail demand, with the response times varying depending on whether the changes are positive or negative (an improvement typically takes longer to have its full effect than a negative change).

However, less common is overshooting, in which the first-year response is larger than the long-run response. An economic rationale for this phenomenon is that passengers may overreact to changes in certain variables (it is notable that overshooting appears to occur in the fare elasticities). For example, passengers may respond to increases in fares by either using another mode, not travelling, or reducing their frequency of travel, but subsequently discover that rail is a preferable mode and hence start using it again. Two examples of this are the LSEE to non-London core cities, full fare tickets; and non-London core cities to non-London core cities, reduced fare tickets. More details are given in section 3.3.

As stated above, the focus in this report is on the three-year elasticities, as this is judged to be the time period over which most of the adjustment to the long run takes place and presenting them in this way gives a better sense of the relativity of the different effects. Elasticities over a longer time period can be calculated using the methodology set out in the *Econometric approach* report.

This section has presented the intermediate decisions which have been taken, and the rationale for taking them. The next section summarises the models and the elasticities that can be derived from them.

[7] ATOC (2009), op. cit., Chapter B12.

3 Results

3.1 Summary tables

The previous section looked at the key decisions taken during the modelling phase of the study to arrive at the final forecasting framework. This section presents the derived one- and three-year elasticities (see Tables 3.1 and 3.2). Where the elasticities are variable, they are calculated at the average value of the variable for each segment in 2007/08. Full results are provided in Appendix 1, including confidence intervals, the results of diagnostic tests, and the definitions of the variables for each of the market segments.

Table 3.1 One-year elasticities

	Segment	Price	Income	Employment	Population	Car ownership	Car cost	Performance	GJT	Service quality index	Functional form: constant/ variable elasticity	Income variable	Market share: journeys (%)	Market share: revenue (%)
LSEE to LSEE	Reduced/full	–0.79	0.74	0.48			0.82	0.43	–0.38		Constant	DIO	33.0	29.1
	Season	–2.08		1.04					–1.42		Constant	Emp	34.1	25.1
LSEE to non-London core cities	Reduced	0.39	1.28				*0.05*	0.22	–0.97		Constant	DIO	0.7	2.9
	Full	–1.51	0.88				1.33		–1.13	1.30	Constant	DIO	0.2	2.6
	Season	*–0.57*									Constant	n/a	0.1	0.2
LSEE to other	Reduced	–0.26^{+}	0.83^{+}				0.17		*–0.03*		Variable	DIO	1.0	3.5
	Full	–1.38^{+}	0.32				0.76	0.62	–0.33		Variable	DIO		
	Season	*–0.46*$^{+}$		*0.98*$^{+}$				1.61	–1.86		Variable	Emp	0.1	0.2
Non-London core cities to LSEE	Reduced	–0.56	*–0.55*				0.43	*0.31*	–0.94		Constant	DIO	0.7	2.9
	Full	–1.78	0.58				1.36		–0.73		Constant	DIO	0.3	0.2
	Season	–0.94							–0.27		Constant	n/a	0.1	0.2
Non-London core cities to non-London core cities	Reduced	–2.05	1.41						–0.79		Constant	DIO	0.8	1.4
	Full	–2.01^{+}	*0.65*$^{+}$				1.41	0.46	–0.93		Variable	DIO	0.3	0.8
	Season	–1.70							–2.57		Constant	n/a	0.2	0.2
Non-London core cities to other	Reduced	–1.23^{+}	0.53				0.41	0.25	*–0.03*		Squared terms	DIO	1.6	1.7
	Full	–1.85	1.33			–1.61	1.16	0.39	–0.25		Constant	DIO	1.4	1.1
	Season	–1.48					1.09		–1.39		Constant	n/a	0.5	0.2
Other to LSEE	Reduced	*–0.12*	1.25				0.91	0.80	–0.33		Constant	DIO	1.4	4.3
	Full	–1.81	0.69		1.88		0.68		–0.16	1.15	Constant	DIO	0.6	5.9
	Season	–1.40		1.41					*–0.34*		Constant	Emp	0.5	1.0
Other to non-London core cities	Reduced	–1.07	1.77			–1.82	0.57	0.53			Constant	DIO	5.2	3.1
	Full	–0.68^{+}	0.61^{+}			–1.41	0.36	0.34	–0.49		Variable	DIO	3.0	2.0
	Season	–1.36					0.66	0.33	–1.27		Constant	n/a	1.6	0.7
Other to other	Reduced	–0.24	0.93					–0.09			Constant	DIO	3.8	2.0
	Full	–1.36	0.77				1.06	0.24	–0.25		Constant	DIO	2.9	1.5
	Season	–0.98	1.30				–0.34	*–0.06*	*–0.02*		Constant	GDPD	1.0	0.4
To airports	Reduced	*–0.31*$^{+}$	0.56			0.91	0.38		–0.50		Squared term	PAX	0.4	0.6
	Full	–1.67^{+}	0.58^{+}				0.85	0.71	–1.64		Variable	PAX	0.6	1.3

Note: Numbers in italics show parameter estimates insignificant at the 5% level; however, many of these variables are significant at the 10% level. DIO, disposable income at origin; GDPD, GDP per employee at destination; Emp, employment at destination; PAX, passenger throughput. $^{+}$ Indicates variable/squared elasticities. Car ownership is always a variable elasticity.
Source: Oxera analysis.

Table 3.2 Three-year elasticities

	Segment	Price	Income	Employment	Population	Car ownership	Car cost	Performance	GJT	Service quality index	Functional form: constant/ variable elasticity	Income variable	Market share: journeys (%)	Market share: revenue (%)
LSEE to LSEE	Reduced/full	–0.95	1.58	0.49			1.43	1.14	–1.60		Constant	DIO	33.0	29.1
	Season	–0.73		1.41					–4.35		Constant	Emp	34.1	25.1
LSEE to non-London core cities	Reduced	*–0.25*	1.73				0.77	1.26	–1.31		Constant	DIO	0.7	2.9
	Full	–1.21	1.06				1.59		–2.92	1.55	Constant	DIO	0.2	2.6
	Season	*–0.79*									Constant	n/a	0.1	0.2
LSEE to other	Reduced	–0.04[+]	0.98[+]				0.20		–0.53		Variable	DIO	1.0	3.5
	Full	–1.74[+]	0.73[+]				1.61	0.79	–2.03		Variable	DIO	0.3	2.5
	Season	–0.91[+]		*1.22*				2.01	–2.32		Variable	Emp	0.1	0.2
Non-London core cities to LSEE	Reduced	–0.68	1.40				0.52	*0.38*	–1.15		Constant	DIO	0.7	2.9
	Full	–1.38	0.78				1.84		–3.37		Constant	DIO	0.3	0.2
	Season	–0.34						–4.51			Constant	n/a	0.1	0.2
Non-London core cities to non-London core cities	Reduced	–1.16	2.01						–1.12		Constant	DIO	0.8	1.4
	Full	–1.59[+]	*1.24*[+]				2.24	0.82	*0.04*		Variable	DIO	0.3	0.8
	Season	–1.03							–3.91		Constant	n/a	0.2	0.2
Non-London core cities to other	Reduced	–1.23[+]	3.04				0.56	1.15	*–0.04*		Squared terms	DIO	1.6	1.7
	Full	–1.71	1.63			–1.97	1.42	1.22	–1.75		Constant	DIO	1.4	1.1
	Season	–2.79					2.06		–2.63		Constant	n/a	0.5	0.2
Other to LSEE	Reduced	–0.63	1.44				1.57	1.67	–2.01		Constant	DIO	1.4	4.3
	Full	–1.50	0.93		2.53		0.91		–1.18	1.55	Constant	DIO	0.6	5.9
	Season	–2.12		2.13					–2.68		Constant	Emp	0.5	1.0
Other to non-London core cities	Reduced	–1.38	2.28			–2.35	0.73	1.53			Constant	DIO	5.2	3.1
	Full	–0.54[+]	0.82[+]			–1.89	0.49	1.32	–2.23		Variable	DIO	3.0	2.0
	Season	–1.21					1.05	1.24	–4.29		Constant	n/a	1.6	0.7
Other to other	Reduced	–0.58	2.25					0.94			Constant	DIO	3.8	2.0
	Full	–1.21	2.66				0.81	1.30	–1.19		Constant	DIO	2.9	1.5
	Season	–1.42	*3.45*				*–0.10*	2.04	*–0.62*		Constant	GDPD	1.0	0.4
To airports	Reduced	*–0.43*[+]	0.78			1.26	0.53		*–0.69*		Squared term	PAX	0.4	0.6
	Full	–1.04[+]	0.72[+]				1.04	0.87	–2.01		Variable	PAX	0.6	1.3

Note: See note to Table 3.1.
Source: Oxera analysis.

Both one- and three-year elasticities are presented to enable an understanding of the importance of the dynamics in the elasticity estimates.

The PDFH v5 suggests that, after three years, the response of demand to a change in a demand driver is complete, with the exception of major new services. The lag structure estimated for this study is considerably more complex than that provided in the PDFH, notably with a different lag structure for each variable and market segment. However, as a rule of thumb, the changes in demand (due to a change in a demand driver) are also expected to be greater than 95% complete after three years, using the methodology developed in this study.

The three-year elasticities have formed the basis for comparison of the 'preferred' models, as this provides an appropriate time length for the overshooting or build-up effects to have levelled off (see section 2 for more details).

It is important to emphasise that the results presented in this report should be viewed as a package. Although the focus of the study has been on the fare, background growth and modal competition drivers, the estimated elasticities are dependent on (and related to) the elasticities for GJT and performance.

There are a number of key features in the results, as discussed in detail below.

3.2 Key market segments

Four market segments are discussed in more detail here (market shares by journey and revenue are given in brackets), which together accounted for 68% of journeys and 60% of revenue in 2007:

– LSEE, season (33.0%, 29.1%);
– LSEE, non-season (34.1%, 25.1%);
– LSEE to non-London core cities, full fare tickets (0.2%, 2.6%);
– LSEE to non-London core cities, reduced fare tickets (0.7%, 2.9%).

Table 3.3 presents the three-year fare, income, employment and car cost elasticities for these segments with those in the PDFH. When drawing comparisons between the two sets of results, care should be exercised because the results may differ for a number of reasons, including differences in the following:

– demand datasets;
– explanatory variables and measures of those variables;
– econometric techniques;
– market segmentation;
– functional forms.

Table 3.3 Comparison of elasticities

	PDFH v5	Revisiting the Elasticity-Based Framework
Fare		
LSEE–LSEE (season)	–0.50[1]	–0.73
LSEE–LSEE (non-season)	–0.80	–0.95
LSEE–non-London core cities (full)	–1.05	–1.24
LSEE–non-London core cities (reduced)	–0.75	–0.25
Income[2]		
LSEE–LSEE (season)	n/a	n/a
LSEE–LSEE (non-season)	1.2	1.58
LSEE–non-London core cities (full)	0.9	1.26
LSEE–non-London core cities (reduced)	0.9	1.73
Employment		
LSEE–LSEE (season)	1.3	1.41
LSEE–LSEE (non-season)	n/a	0.49
LSEE–non-London core cities (full)	n/a	n/a
LSEE–non-London core cities (reduced)	n/a	n/a
Car cost		
LSEE–LSEE (season)	0.0	n/a
LSEE–LSEE (non-season)	0.19	1.43
LSEE–non-London core cities (full)	0.22	1.56
LSEE–non-London core cities (reduced)	0.22	0.77

Note: [1] Fare elasticities for the London Travelcard Area. [2] The income measure for the PDFH is GDP per capita.
Source: ATOC (2009), op. cit. and Oxera analysis.

As can be seen from the table, in many cases the elasticities from 'Revisiting the Elasticity-Based Framework' are larger in absolute magnitude than those given in the PDFH. However, as previously stated, the elasticities should be taken as a package, and hence comparing individual elasticities between sources may not be overly informative. For example, car cost has been estimated to be much larger than in the PDFH, but in many cases neither car ownership nor car journey time is statistically significant, whereas both appear in the PDFH for different segments.

3.3 Key results

3.3.1 Evidence for variable elasticities

Seven of the final model specifications contain variable elasticities which suggest that, in some cases, the magnitude of the elasticity is dependent on the level of the variable. These models were chosen because they offer either a better model fit or more plausible elasticities than the constant elasticity formulation. These ticket-type segments are:

- LSEE to other, reduced fare tickets;
- LSEE to other, full fare tickets;
- LSEE to other, season tickets;
- non-London core cities to other, reduced fare tickets;
- other to non-London core cities, full fare tickets;
- to airports, full fare tickets;
- to airports, reduced fare tickets.

The finding that elasticities in some market segments are variable rather than fixed suggests that further research may be required to understand why this is the case in some segments, but not others, since there is no apparent pattern in which segments contain variable elasticities and which contain constant elasticities.

Three of the markets for which there is evidence of variable elasticities are for London, the South East and East of England to the ‘other’ segment. One explanation for this may be a combination of strong road competition and destination competition from London. As the demand drivers change, the elasticities vary and passengers switch to car or travel to London instead.

3.3.2 Market maturity

Market maturity/saturation occurs where the demand for passenger rail travel starts to increase at a decreasing rate, particularly with respect to the overall economy. In other words, despite drivers increasing in magnitude, passengers are travelling as much as they desire, and hence the elasticity of demand with respect to those drivers decreases.

The analysis undertaken for this study presents little evidence of market maturity. The study estimated functional forms which allow for market maturity or saturation, but the data did not support these functional forms, with the exception of two cases where the saturation related to fare elasticities, not income. In other words, there is no evidence of a long-term decoupling of income and demand. This is a finding with important policy implications and consequently may warrant further investigation.

3.3.3 Impact of car ownership

The impact of car ownership on the demand for passenger rail travel has been estimated to be positive, negative, or zero, depending on the market segment. This suggests that owning a car could be both a substitute for, and complement to, rail travel—particularly when this allows access to a rail station (where this was not previously possible, or easier access if it was).

This effect may arise because car ownership allows both access to a train station (contingent upon suitable parking facilities) and the use of the car to undertake the same journey as the train. Therefore, it is difficult to explain a priori the direction of this effect; suffice to say that, by controlling thoroughly for other drivers of rail demand, car availability appears to be less important than previously thought.

3.3.4 Car variables

The general model for this study included car journey time and car cost, but since the former is not statistically significant, the specific models contain car cost only. Given the evidence available for this study, this suggests that either car journey times are not an important driver of the demand for rail travel, or the modelled car journey time data does not accurately reflect car journey time/congestion. One explanation may be that passengers are much more concerned about the variability of the journey time than the expected journey time.

Car cost is statistically significant in most non-season ticket models, and appears to be economically important, with a substantial sign in many models. This may suggest that the cost of owning a car, when measured appropriately, is an important determinant in the demand for passenger rail travel.

3.3.5 Performance and GJT

Both performance and GJT, although not the focus of the study, appear to be important determinants of the demand for rail travel.

3.3.6 Distance effect

The analysis conducted for this study included testing distance effects on a number of variables (fare, income and employment). Although the analysis presented in the M*arket segmentation* report suggested that distance was an important factor for consideration, there is little evidence to suggest that there is a distance effect on the model parameters—ie, on the rate of change in demand.

3.3.7 Overshooting

As discussed in section 2, and demonstrated in section 3, there is substantial evidence of overshooting, particularly in the fares elasticities. Two examples are the LSEE to non-London core cities, full fare tickets; and non-London core cities to non-London core cities, reduced fare tickets. In the first example, the one-year fare elasticity is –1.5, which implies that, for a 1% increase in fares, all else being equal, after one year there is likely to be a fall in passenger journeys of 1.5%. However, in subsequent years, some of this demand loss is recovered, so that, after three years, the effect is a reduction of 1.2% in passenger journeys.

In the second example—non-London core cities to non-London core cities, reduced fare tickets—the one-year fare elasticity is –2.1. This implies that, all else being equal, after one year, a 1% increase in fares will result in a 2.1% fall in passenger journeys. However, after three years, some of this loss will have been recouped, with the overall decrease being 1.6% of initial demand.

3.3.8 Measure of income

One of the important aspects of this study has been the investigation of different income variables, which has led to the preferred measure of income in many cases being disposable income per capita at the origin of the rail flow.

It is well established that changes in employment often lag changes in GDP, and macroeconomic forecasts take this into account. Personal disposable income forms only part of GDP, and therefore the relationship between disposable income and employment is likely to differ from that between GDP/GVA and employment.

Personal disposable income will tend to follow wages (as wages are the main determinant of personal disposable income) and wages, like employment, tend to lag changes in GDP/GVA due to labour market rigidities, such as ‘labour hoarding’ by firms in a downturn. This suggests that the *share* of personal disposable income in GDP/GVA is likely to be anti-cyclical, increasing in downturns and decreasing when GDP/GVA growth is positive.

In addition to this effect, personal taxes are often pro-cyclical—for example, due to capital gains tax and stamp duty. This is likely to produce an anti-cyclical effect, in terms of the share of wages (and hence personal disposable income) in GDP/GVA. The above discussion has related to *shares* of GDP/GVA, but it is the levels that are important for demand forecasting. The relationship between levels of GDP, personal disposable income and employment is likely to be positive over time. However, around the turning points in the economic cycle, the lags in the relationships are likely to be important. For example, in the early stages of a recovery, personal disposable income and employment may continue to fall after GDP/GVA begins to rise, and conversely for a downturn. Therefore, it might be expected that the elasticities on personal disposable income and GDP/GVA are different, and that the dynamic adjustment of rail demand to changes in these variables may vary.

Finally, the relationship between these variables (particularly employment and GDP/GVA) may be changing over time as there is some evidence that employers have hoarded labour to a greater degree in the recent recession than in previous recessions (see the 2009 Pre-Budget Report for more discussion).[8]

3.3.9 Relationships between parameters

In most cases, the signs of the estimated elasticities correspond to economic theory and industry expectations—eg, a negative fare and positive income elasticity. To understand the results, Oxera has calculated the implicit value of time from the fare and GJT elasticities for

[8] HM Treasury (2009), ‘Securing the recovery: growth and opportunity. Pre-Budget Report’, December. Box A4.

both the elasticities reported in the PDFH and those calculated for this study, which are shown in Figure 3.1. The methodology is set out in Box 3.1.

Box 3.1 Deriving values of time from elasticities

Assuming that the demand for rail travel can be represented by:

$$Q = a\,F^{b}GJT^{c}Y^{d}$$

where a, b, c, and d are parameters to be estimated, Q is the demand for rail travel, GJT is generalised journey time, Y is income and F is fare. The relationship between the value of time, the GJT elasticity and the fare elasticity can be shown to be:

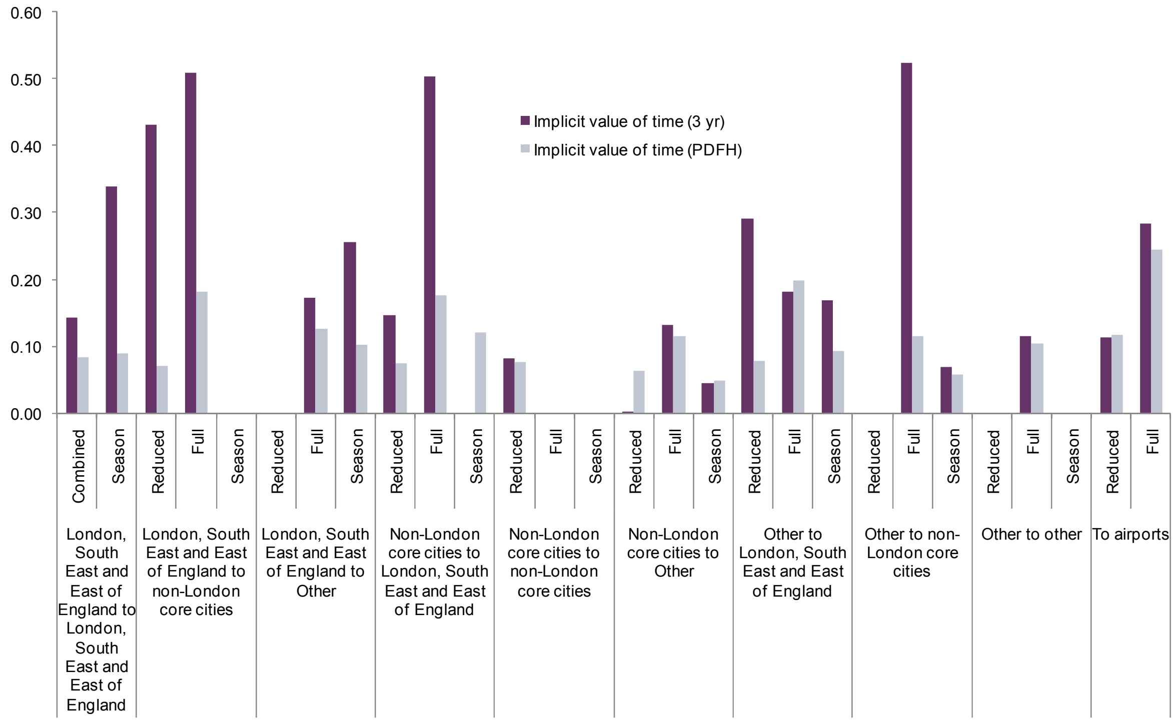
$$c \equiv b[(cQGJT^{-1})/(bQF^{-1})]GJT/F$$

where the implied value of time is given by the term in square brackets. Therefore:

$$VoT = [c/b][F/GJT]$$

ie, the GJT elasticity equals the ratio of the GJT elasticity to the fare elasticity multiplied by the ratio of fare to GJT.

Figure 3.1 Implicit values of time (pence/minute at 2007 prices)



Source: Oxera analysis.

In general, the value of time for passengers travelling on full fare tickets is higher than that for passengers travelling on reduced fare tickets. This is in line with prior expectations, given the likely journey purposes of these tickets. The pattern for season tickets is less obvious.

The values of time derived from this study are generally higher than those in the PDFH. However, comparing the two sets of values is not necessarily comparing 'like with like', as the elasticities for this study are estimated within the same model, while those from the PDFH are the combinations of several different studies, and hence may not be internally consistent.

This section has presented the key messages on the results. The next section provides some further commentary.

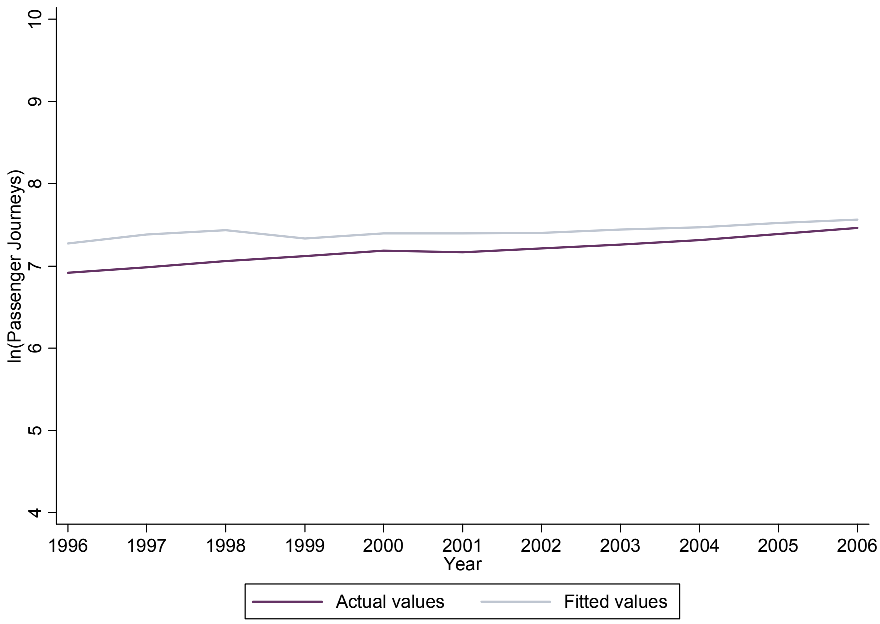
4 Commentary on results

This section provides some further commentary on the key results that have arisen from the analysis conducted for this study. It may be of interest to convert the presented elasticities into those by journey purpose and an approach to do this is set out in the *Guidance* report.

4.1 Model results

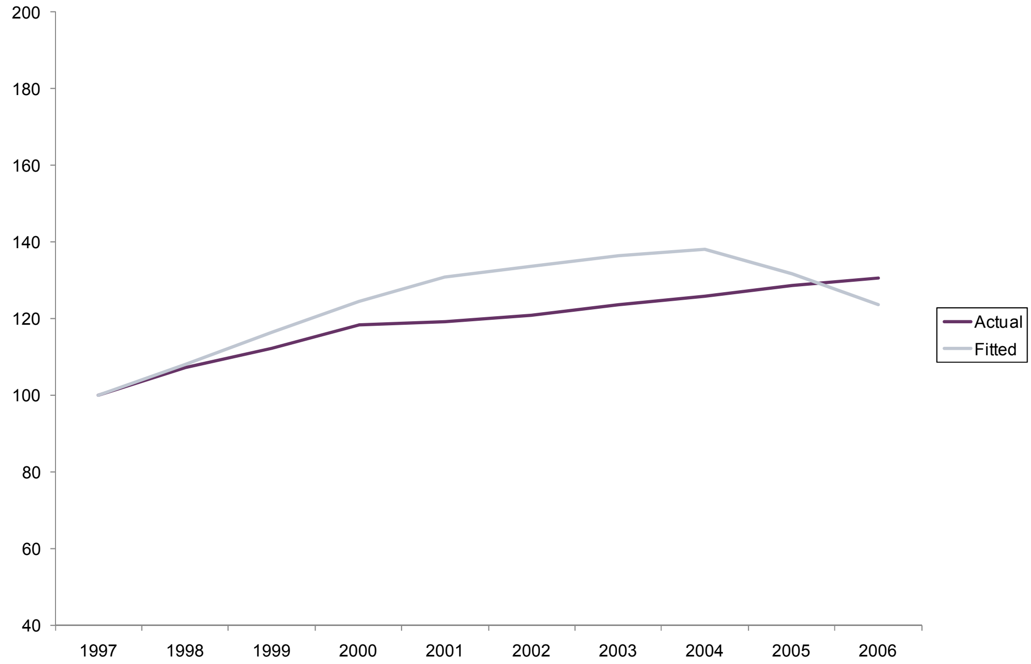
Figures 4.1 and 4.2 present the model fit at a national level by aggregating the segment-level models to provide a national picture. Figure 4.1 was created by aggregating the model fitted values for the segment-level models (ie, it illustrates how the segments perform to match total demand, rather than the product of a national model). Figure 4.2 was created by indexing the numbers of actual and fitted journeys to be 100 in 1996.

Figure 4.1 Model fit



Source: Oxera analysis.

Figure 4.2 Indexed model fit



Source: Oxera analysis.

As can be seen from Figure 4.1, the models provide a reasonably good fit to the sample data throughout the estimation period. This is important because, assuming the past can provide a prediction of the future, it offers reassurance that the models pick up the important changes in demand for passenger rail travel, and hence are likely to produce reasonable forecasts.

The diagnostic tests used in this study are discussed in the *Econometric approach* report. In this, 71% of the models (20 out of 28) pass the autocorrelation test at the 5% level.[9]

None of the models passes the test for instrument validity at the 5% level, although discussions with academic advisers suggest that this does not necessarily imply that the model is misspecified.[10]

All models pass the unit root test of residuals.[11] This suggests that the estimated models do not suffer from a problem of spurious correlation.

The study team has carefully considered the robustness of each of the presented models; naturally, as is often the case, some models are more robust than others. Elements of robustness include the passing of diagnostic tests, the size of the sample, and the stability of the model. For these reasons, the LSEE to LSEE combined full and reduced model may be considered to be one of the most robust, while some of the smaller, season ticket markets are considered to be less robust.

[9] A further three models pass at the 10% level. It is important to note that failing the autocorrelation test may have implications for the validity of the estimator used in this study.

[10] Technically, the test statistic does not have a standard distribution if there is heterogeneity in the way in which passenger demand is generated on different flows—ie, in the data-generating process.

[11] In five models, there are too many observations for Stata to calculate the unit root test.

4.2 Why would the elasticities differ from the PDFH v5?

As noted in section 3.2, a number of factors may influence why the estimated elasticities differ from those in the PDFH, and these can be divided into:

- the data;
- the econometric analysis;
- the market segmentation.

These factors are discussed in more detail below.

4.2.1 Data

The dataset complied for this study (The Oxera Arup Dataset, or TOAD) has substantially extended the available data, in terms of the both time-series availability (TOAD contains 18 years of annual data, while the PDFH elasticities were estimated on considerably less data) and the coverage of other variables of interest.

In particular, the variables representing the competitiveness of the car are more comprehensive than have previously been used, with a car cost variable that reflects changes not only in fuel pump price, but also in fleet mix and efficiency. A range of income variables have been tested in the analysis, based on economic theory, which has resulted, in many cases, in the preferred measure of income being disposable income per capita. The dataset is discussed in the *Data capability* report, and so is not detailed here.

The estimated income elasticity does not include the effect of crowding due to the use of the service quality index. However, a more detailed crowding model would be an appropriate extension to the framework produced by this study.

4.2.2 Econometric analysis

This study has used the most suitable econometric techniques, based on rigorous academic advice and the most 'state of the art' research. This may be expected to provide more confidence in the results, given that other approaches were rejected as being less suitable and/or introducing potential bias into the analysis.

In addition to using the most appropriate econometric techniques, the study team has investigated a number of functional forms for each market segment, at the same time allowing for (and testing) a range of factors. This robust approach should provide confidence that, where possible, alternative relationships have been investigated.

4.2.3 Market segmentation

A new market segmentation has been derived, based on industry knowledge and economic theory, but also grounded in empirical work. This may be expected to change the presented elasticities if it does not map onto the existing market segmentation (which it does not).

4.2.4 Summary

There are a number of reasons why the elasticities presented from this study may differ from those currently in the PDFH. This section has discussed some of the reasons. The next section provides some conclusions on the 'Revisiting the Elasticity-Based Framework' study.

4.3 Policy implications

The findings of this study—while subject to synthesis with the existing body of literature in the area of forecasting rail passenger demand in Great Britain—have some interesting policy implications. Perhaps most noteworthy in light of the cost of increasing capacity on the rail network is the finding that there is no evidence of market saturation—in other words, a decoupling of passenger growth from income growth. Assuming that the economy will grow at trend in the long term, rail demand will continue to increase, and plans will have to be drawn up to cater for this growth.

Further indications of growth in the market arise from the stronger relationship than previously seen between rail demand and this study's definition of the running cost of a car. Having controlled for car ownership (availability) and car journey times in the general econometric model, this study has found that the typical elasticity to car cost is much higher than is reported in PDFH (although PDFH also includes a car journey time parameter). To the extent that car running costs increase relative to rail in future,[12] there would seem to be scope for more market growth.

Elasticities to PPM are also consistently greater than previously seen. For example, previous simple econometric analysis by Oxera using annual National Rail Trends data suggested a PPM elasticity of 0.3–0.5.[13] However, this study has found PPM to be a stronger influence on demand, suggesting that work supporting today's typically high PPM levels should continue. The study team has investigated how the performance and GJT elasticities combine to provide an implied delay multiplier to GJT.[14] The results of this work suggest that the delay multiplier on GJT implied by this analysis may be substantially higher than those currently given in the PDFH.

Furthermore, there seem to be indications that (generalised, including frequency, interchange and in-vehicle time) journey time improvements are likely to increase demand by more than previously thought. To the extent that these would be affordable, the case for speeding up journey times seems to be stronger on the basis of this analysis. In addition, choices between slower trains and increased punctuality will need to be made carefully.

Finally, the study often finds higher fare elasticities of demand, which might be a function of the lack of detail available to the study team on cross-effects to other ticket types. Taken at face value, however, this might call into question the existing fares policy of rebalancing cost recovery away from the taxpayer and towards the passenger. For example:

– the study team finds that season ticket elasticities, which might be less prone to switching between ticket types (except perhaps for commuters travelling fewer than five days per week), are higher than in PDFH v5, for all but the smallest ticket-type segments;

– full fare elasticities are typically higher than reduced fare elasticities. Whether this can be explained by changes to ticketing over the period, or reflects fares baskets that provide incentives to keep down the cost of off-peak tickets, at the expense of increases in the costs of season and some other ticket types, is an area for further research;

– in many cases, the absolute fare elasticity is higher than in the PDFH.

The overall policy prescription is a difficult one. Capacity needs to increase[15] while enhancing journey times and punctuality, but the farebox seems less likely as a source of funds for the necessary improvements. However, if the cost of running a car increases relative to rail, more people will choose the train than previously thought, even at existing levels of fare and punctuality.

[12] Previous Oxera research suggests that, due to the lag between increased oil prices feeding into rail fares, but the almost immediate impact on the pump price, increases in oil prices tend to lead to an increase in car running costs relative to rail, at least in the short term.

[13] Oxera (2005), 'How do rail passengers respond to change?', February 11th.

[14] See ATOC (2009), op. cit.

[15] Assuming that incomes increase over time, demand (and, therefore, crowding) will also grow, further assuming an even spread of demand increases between peak and off-peak travel.

5 Conclusions

This report has presented the framework in which the analysis has been carried out, and the results of that analysis. It is designed to be read in conjunction with a number of other reports, including the *Market segmentation*, *Data capability*, *Model specification*, *Econometric approach* and *Guidance* reports.

The results set out in this report need to be considered as a package, rather than looking at the individual elasticities in isolation. The key findings from the analysis are as follows.

– The estimated elasticities are greater in absolute magnitude than are contained in the PDFH v5.

– Disposable income per capita at origin is the preferred measure of income, even for some market segments where this may not be expected (such as season tickets).

– Car cost, but not car journey time, is statistically and economically significant in most full and reduced fare ticket models.

– Typically, performance and GJT are also economically and statistically significant.

– Population, car ownership and the service quality indices are important in some cases.

– Of the models considered, 22 have constant elasticities, while six have variable elasticities.

– There is limited evidence of a distance effect.

– The effect of car ownership is both positive and negative on the demand for passenger rail travel.

– There is evidence that the dynamic adjustment of passengers to changes in the explanatory variables is important.

This study is not intended to replace the PDFH, but rather to provide a further research study to sit in Section E of the PDFH. However, it is hoped that the results from this research will be given serious consideration during the next update of the PDFH.

The framework outlined in this study will be used to produce forecasts, which will be compared with those generated by the PDFH. In due course, future uses for the framework set out in this report may include developing the case for High-Speed 2, the High Level Output Specifications (HLOSs), and commercial applications.

5.1 Recommendations

This study has highlighted a number of issues which merit further study. These include the further improvement of the dataset, specifically to include data on:

– actual fares, rather than yield;
– air fares;
– bus and coach fares and timetables;
– increased time series of detailed performance data;
– crowding;
– car park availability and cost.

The impact of the recession which began in 2008 will become clear as data over the next couple of years becomes available. It may be advisable to test the impact of the recession in a similar study in two to three years' time, to include testing on the symmetry of responses to positive and negative economic growth.

Further refinements to the demand data may result in being able to run the analysis using more than three ticket types. This would enable an improved understanding of the difference (if any) between the ticket types which are currently aggregated together (eg, first class and full fare, or reduced fare and advanced purchase tickets).

The diagnostic testing of dynamic panel data models is likely to continue to advance, and this would be an important area to include in any future study. However, the study team is confident that the diagnostic tests which have been employed, and the academic advice which has been provided, mean that the models presented in this report are as robust as it is currently possible to test.

Figure 5.1 presents a summary of recommendations for further work, arranged in a matrix of feasibility and priority. The DfT has provided comments on this matrix, although other industry stakeholders may have other priorities for further work.

Figure 5.1 Recommendations for further work

Feasibility \ Importance/interest	Low	High
Low	– production of forecasts of the service quality indices – examination of whether the dataset can be used for car cost/road pricing/modal shift analysis – analysis of the impact of policy interventions on the national networks (eg, ATM on motorways) – investigation of whether there are regions where income has decreased, and establish whether this can provide insight into the likely impact of the recession – examination of the impact of aviation security costs	– analysis of the impact of local measures that are not included in the dataset (eg, infrastructure improvements, car parking) – examination of the impact of local incidents and 'ripple' effects – matching of NTS (or NRTS) to the dataset to provide richer details on actual passengers, including whether income/fare elasticities vary with socio-economic characteristics – estimation of elasticities using more flexible functional forms
High	– comparison of results with those produced using structural time series/unobserved components models – policy analysis for the devolved governments – expansion of the service quality indices using TOC surveys of passengers – comparison of the PPM elasticities with Schedule 8 parameters – policy analysis of the question: if fares increase/quality changes, which passengers would leave rail, and why? – use of latent class models – analysis of whether elasticities are asymmetric – analysis of whether perceptions of rail travel/elasticities vary by region, or socio-economic characteristics – revisit of the segments from the 'Revisiting' study that perform less well – allow for threshold effects in the modelling (particularly variable performance elasticities)	– a short repeat of the analysis each year to establish whether the elasticities change with increased length of time series – more disaggregate-level analysis (including LSEE–Other) – further investigation of the relationships between the fare/income/GJT parameters – investigation of the dynamic relationship between GDP, employment and the demand for rail travel – examination of market saturation using more disaggregate data—ie, examine the dataset to see whether there are (local) areas or flows where there is evidence of market saturation – examination of the behaviour of elasticities using quantile regressions

Source: Oxera.

A1 Complete dashboard

Oxera

Definitions

Segments

London, South East and East of England (LSEE)	London, South East and the East of England are defined by the relevant Government Office Regions (GORs).
Core cities	Core cities are defined as non-London core cities. Specifically: Birmingham, Manchester, Liverpool, Nottingham, Bristol, Sheffield, Cardiff, Edinburgh, Glasgow, Newcastle, Leeds, Leicester, York and Hull.
Airports	The airport stations that are included within the airports segment are: Gatwick Airport, Stansted Airport, Luton Airport Parkway, Manchester Airport, Birmingham International, Inverkeithing (Edinburgh) and Prestwick International Airport.
Other	The other segment includes all the flows in the dataset that are not included in one of the other segments.

Summary statistics

Market share (journeys)	Market share is calculated as journeys within the segment as a proportion of the total journeys in the dataset.
Market share (distance)	Market share is calculated as passenger journeys multiplied by the average distance of the flows within the segment as a proportion of the total dataset.
Market share (revenue)	Market share is calculated as revenue within the segment as a proportion of the total revenue in the dataset.
Passenger journeys	Average annual number of journeys for the segment. Note that this is affected by lower journeys at the beginning of the sample period.
Average distance	Average distance is measured in km.
Average fare per km	Average fare per km is calculated as the average fare divided by the average distance within the segment. Units are pence per km (2007 prices).

Diagnostics

Model formulation	The estimator used in this project is the Blundell and Bond estimator for dynamic panel data, which is a system Generalised Method of Moments (GMM) estimator for dynamic panel data, for which there are no direct tests of model misspecification. However, there are a number of diagnostic tests which can be carried out to indirectly test for model misspecification. These are set out below.
Arellano-Bond (autocorrelation)	This tests for autocorrelation in the first differenced error terms of the regression.
Sargan (instrument validity)	This tests the validity of the underlying assumptions of the estimator. However, it can still be rejected if there is heterogeneity in the data generating process, even if the model is correctly specified.
Unit root test on residuals	If the error term from a model is non-stationary, then the identified relationships which have been identified between the variables may be spurious. To test this, the panel data unit root test developed by Maddala and Wu (1999) has been used.
Stable model	The stability of the models have been tested by rolling regressions.
Model fit	Unlike in ordinary least squares (OLS) regression, there is no R2 for system GMM estimators. As a measure of model fit, the squared correlation between actual and fitted data is presented. This measure is bounded by zero and one, with a measure of one showing perfect correlation between actual and fitted data.

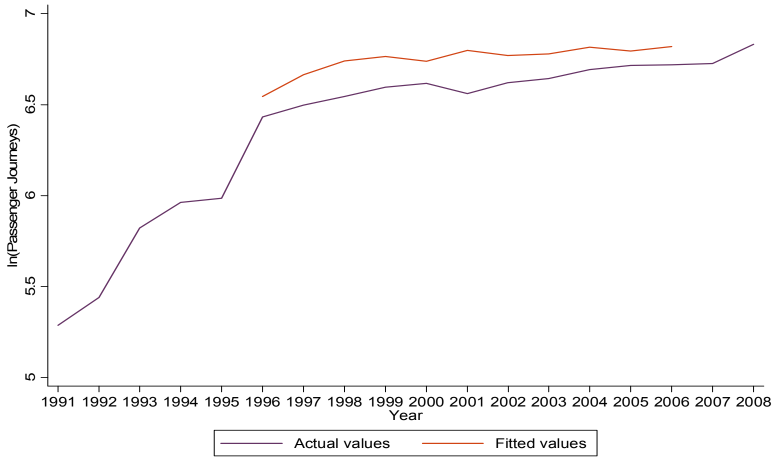
Core cities to London, South East and East of England: Reduced price

	One-year elasticity				Three-year elasticity			
Variable list	Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-0.56**	**-0.881**	**-0.232**	**0.81**	**-0.68**	**-1.084**	**-0.285**	**0.99**
Cross-price								
Income	***-0.55***	**-1.498**	**0.406**	**-0.37**	**1.40**	**0.488**	**2.311**	**0.95**
Population								
Employment								
Car ownership								
Car cost	**0.43**	**0.100**	**0.752**	**0.81**	**0.52**	**0.122**	**0.928**	**0.99**
Car Journey Time								
GJT	-0.94	-1.456	-0.416	0.81	-1.15	-1.762	-0.543	0.99
Performance	*0.31*	-0.0223	0.645	0.81	*0.38*	-0.0268	0.794	0.99
SQI								

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	0.7%
Market share (Distance)	4.5%
Market share (Revenue)	2.9%
Passenger journeys	4,356,000
Ave distance (km)	189.2
Ave fare per km (£)	0.113



Diagnostics

Model formulation	Constant elasticities
Sample size (number of observations)	6868
Number of years of sample	11
Arellano-Bond (autocorrelation)	Pass
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.64

As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	Disposable income per capita at origin
Population	
Employment	
Car ownership	
Car cost	Cost of journey
Car Journey Time	
GJT	Generalised Journey Time
Performance	Sectoral PPM
SQI	

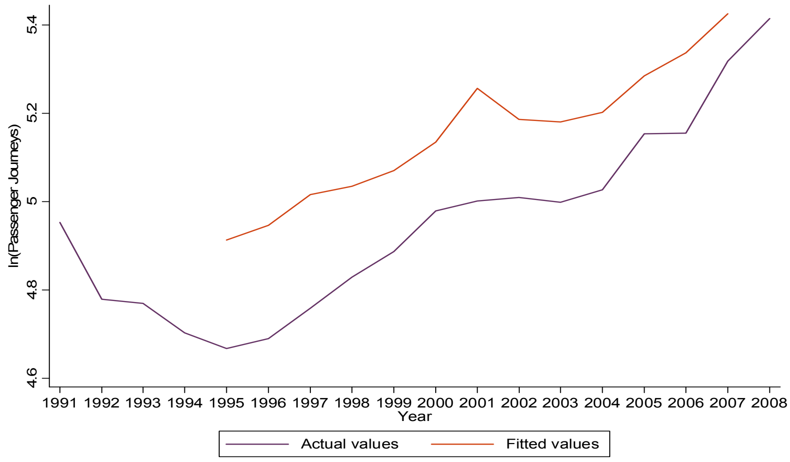
Core cities to London, South East and East of England: Full price

Variable list	One-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-1.78**	**-2.002**	**-1.567**	**1.29**	**-1.41**	**-1.676**	**-1.145**	**1.02**
Cross-price	**0.18**	**0.0180**	**0.348**	**0.29**	**0.60**	**0.316**	**0.886**	**0.95**
Income	**0.58**	**0.0485**	**1.107**	**0.74**	**0.77**	**0.0646**	**1.468**	**0.98**
Population								
Employment								
Car ownership								
Car cost	**1.36**	**0.937**	**1.790**	**0.74**	**1.81**	**1.249**	**2.368**	**0.98**
Car Journey Time								
GJT	-0.73	-1.106	-0.344	0.22	**-2.82**	-3.433	-2.200	0.84
Performance								
SQI								

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	0.3%
Market share (Distance)	1.9%
Market share (Revenue)	3.8%
Passenger journeys	1,886,000
Ave distance (km)	188.6
Ave fare per km (£)	0.273



Diagnostics

Model formulation	Constant elasticities
Sample size (number of observations)	7269
Number of years of sample	13
Arellano-Bond (autocorrelation)	Pass
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.69

As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	Reduced price tickets
Income	Disposable income per capita at origin
Population	
Employment	
Car ownership	
Car cost	Cost of journey
Car Journey Time	
GJT	Generalised Journey Time
Performance	
SQI	

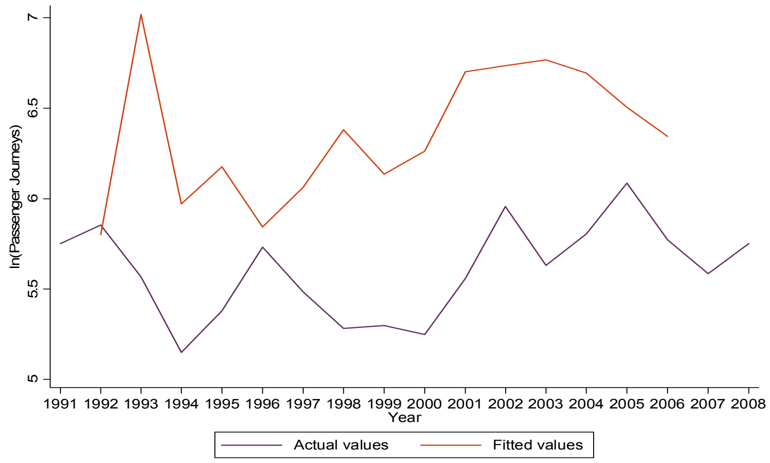
Core cities to London, South East and East of England: Season tickets

Variable list	One-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-0.94**	**-1.731**	**-0.148**	**4.34**	**-0.34**	**-1.697**	**1.016**	**1.57**
Cross-price								
Income								
Population								
Employment								
Car ownership								
Car cost								
Car Journey Time								
GJT								
Performance	-0.27	-2.224	1.686	0.05	-4.51	-6.823	-2.198	0.84
SQI								

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	0.1%
Market share (Distance)	0.4%
Market share (Revenue)	0.2%
Passenger journeys	1,079,000
Ave distance (km)	163.6
Ave fare per km (£)	0.0948



Diagnostics

Model formulation	Constant elasticities
Sample size (number of observations)	1297
Number of years of sample	15
Arellano-Bond (autocorrelation)	Pass
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.67

As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	
Population	
Employment	
Car ownership	
Car cost	
Car Journey Time	
GJT	
Performance	Sectoral PPM
SQI	

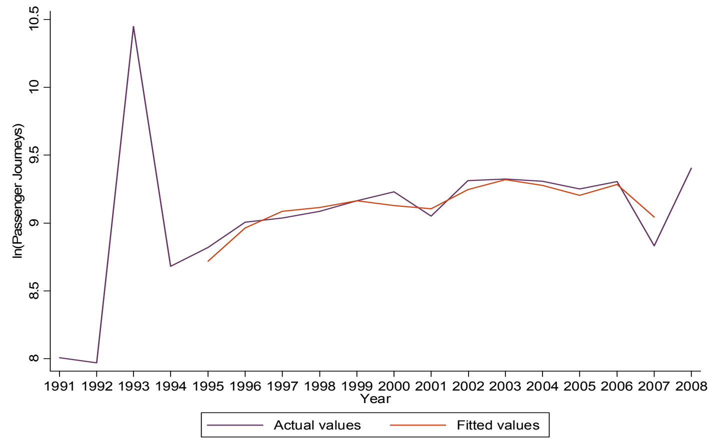
Core cities to core cities: Reduced price

Variable list	One-year elasticity Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-2.05**	**-2.948**	**-1.154**	**1.94**	**-1.16**	**-1.709**	**-0.609**	**1.10**
Cross-price								
Income	**1.41**	**0.187**	**2.623**	**0.68**	**2.01**	**0.627**	**3.383**	**0.97**
Population								
Employment								
Car ownership								
Car cost								
Car Journey Time								
GJT	-0.79	-1.374	-0.197	0.68	-1.12	-1.833	-0.408	0.97
Performance								
SQI								

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	0.8%
Market share (Distance)	2.4%
Market share (Revenue)	1.4%
Passenger journeys	4,775,000
Ave distance (km)	162.3
Ave fare per km (£)	0.102



Diagnostics

Model formulation	Constant elasticities
Sample size (number of observations)	2319
Number of years of sample	13
Arellano-Bond (autocorrelation)	Pass
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.66

As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	Disposable income per capita at origin
Population	
Employment	
Car ownership	
Car cost	
Car Journey Time	
GJT	Generalised Journey Time
Performance	
SQI	

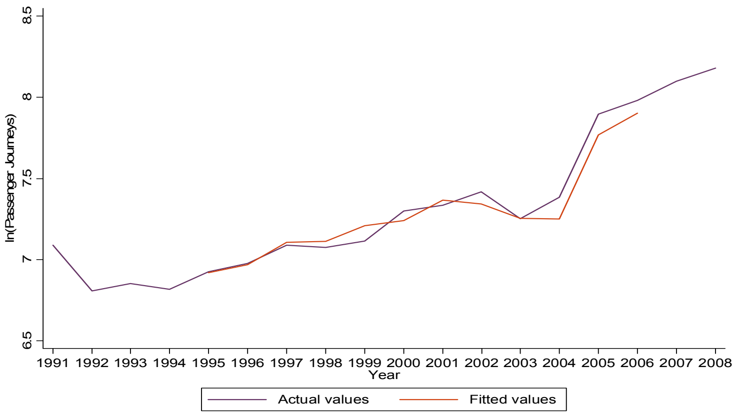
Core cities to core cities: Full price

Variable list	One-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-2.01**	**-2.430**	**-1.594**	**1.24**	**-1.65**	**-2.064**	**-1.235**	**1.02**
Cross-price								
Income	**0.65**	**0.0588**	**1.239**	**0.72**	**0.88**	**-0.0324**	**1.796**	**0.98**
Population								
Employment								
Car ownership								
Car cost	**1.41**	**0.577**	**2.243**	**0.54**	**2.35**	**1.043**	**2.789**	**0.90**
Car Journey Time								
GJT	-0.93	-1.900	0.0414	0.16	-4.82	-5.551	-2.716	0.82
Performance	0.46	0.0929	0.824	0.54	0.76	0.0596	1.186	0.90
SQI								

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	0.3%
Market share (Distance)	0.7%
Market share (Revenue)	0.8%
Passenger journeys	1,840,000
Ave distance (km)	163.4
Ave fare per km (£)	0.215



Diagnostics

Model formulation	Variable elasticities
Sample size (number of observations)	2114
Number of years of sample	12
Arellano-Bond (autocorrelation)	Pass
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.81

As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	Disposable income per capita at origin
Population	
Employment	
Car ownership	
Car cost	Cost of journey
Car Journey Time	
GJT	Generalised Journey Time
Performance	Sectoral PPM
SQI	

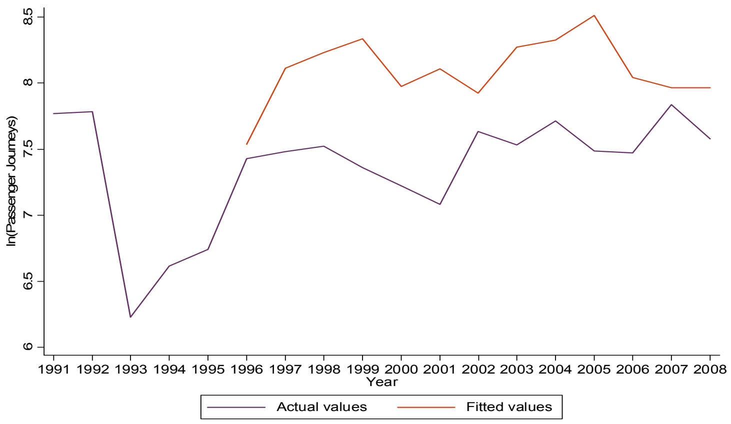
Core cities to core cities: Season tickets

Variable list	One-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-1.70**	**-2.419**	**-0.989**	**1.85**	**-1.03**	**-1.824**	**-0.239**	**1.12**
Cross-price								
Income								
Population								
Employment								
Car ownership								
Car cost								
Car Journey Time								
GJT	-2.57	-3.852	-1.284	0.62	-3.91	-5.603	-2.217	0.95
Performance								
SQI								

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	0.2%
Market share (Distance)	0.3%
Market share (Revenue)	0.2%
Passenger journeys	896,190
Ave distance (km)	106.9
Ave fare per km (£)	0.0982



Diagnostics

Model formulation	Constant elasticities
Sample size (number of observations)	659
Number of years of sample	13
Arellano-Bond (autocorrelation)	Fail
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.45

As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	
Population	
Employment	
Car ownership	
Car cost	
Car Journey Time	
GJT	Generalised Journey Time
Performance	
SQI	

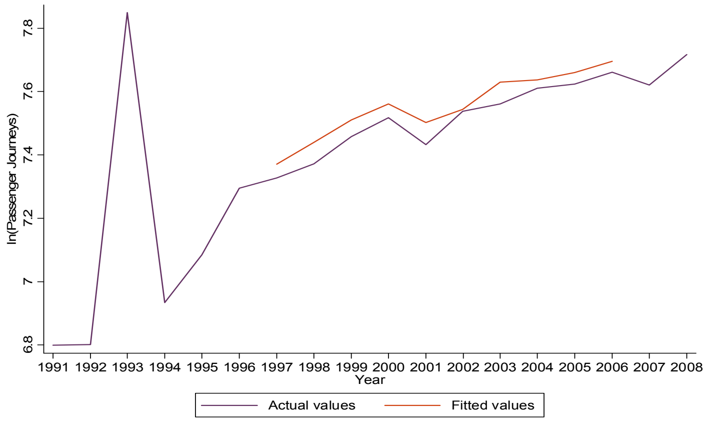
Core cities to Other: Reduced price

Variable list	One-year elasticity Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-1.23**	**-1.497**	**-0.952**	**105%**	**-1.23**	**-1.501**	**-0.898**	**105%**
Cross-price				**0%**				
Income	**0.53**	**-0.0378**	**1.089**	**14%**	**3.04**	**2.579**	**3.624**	**80%**
Population								
Employment								
Car ownership								
Car cost	**0.41**	**0.217**	**0.602**	**71%**	**0.56**	**0.296**	**0.829**	**98%**
Car Journey Time								
GJT	-0.03	-0.184	0.130	71%	-0.04	-0.249	0.175	98%
Performance	0.25	0.0742	0.422	19%	1.15	0.948	1.484	88%
SQI								

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	1.6%
Market share (Distance)	2.8%
Market share (Revenue)	1.7%
Passenger journeys	8,860,000
Ave distance (km)	116.7
Ave fare per km (£)	0.104



Diagnostics

Model formulation	Including squared terms
Sample size (number of observations)	16336
Number of years of sample	10
Arellano-Bond (autocorrelation)	Pass
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.53

As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross price	
Income	Disposable income per capita at origin
Population	
Employment	
Car ownership	
Car cost	Cost of journey
Car Journey Time	
GJT	Generalised Journey Time
Performance	Sectoral PPM
SQI	

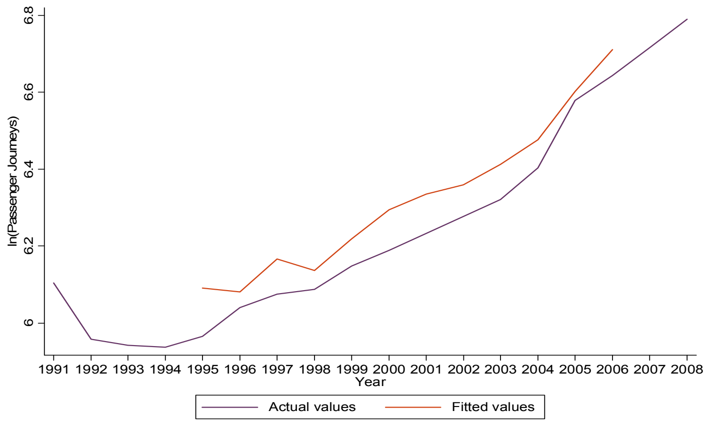
Core cities to Other: Full price

Variable list	One-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-1.85**	**-2.089**	**-1.611**	**109%**	**-1.71**	**-1.920**	**-1.499**	**100%**
Cross-price	**0.09**	**-0.00870**	**0.194**	**81%**	**0.11**	**-0.0101**	**0.236**	**99%**
Income	**1.33**	**0.429**	**2.231**	**81%**	**1.63**	**0.495**	**2.753**	**99%**
Population								
Employment								
Car ownership	**-1.61**	**-2.547**	**-0.677**	**81%**	**-1.97**	**-3.072**	**-0.867**	**99%**
Car cost	**1.16**	**0.825**	**1.496**	**81%**	**1.42**	**1.010**	**1.825**	**99%**
Car Journey Time								
GJT	-0.25	-0.453	-0.0533	13%	-1.75	-2.224	-1.287	90%
Performance	0.39	0.241	0.547	32%	1.22	0.961	1.476	98%
SQI								

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	1.4%
Market share (Distance)	1.1%
Market share (Revenue)	1.1%
Passenger journeys	7,804,000
Ave distance (km)	116.5
Ave fare per km (£)	0.186



As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Diagnostics

Model formulation	Constant elasticities
Sample size (number of observations)	19106
Number of years of sample	12
Arellano-Bond (autocorrelation)	Fail
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.79
Comments on diagnostics	The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross price	Reduced price tickets
Income	Disposable income per capita at origin
Population	
Employment	
Car ownership	Prop. of households without access to a car
Car cost	Cost of journey
Car Journey Time	
GJT	Generalised Journey Time
Performance	Sectoral PPM
SQI	

Core cities to Other: Season tickets

Variable list	One-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-1.48**	**-1.673**	**-1.280**	**43%** **0%**	**-2.79**	**-3.194**	**-2.389**	**82%**
Income								
Population								
Employment								
Car ownership								
Car cost	**1.09**	**0.614**	**1.563**	**43%**	**2.06**	**1.137**	**2.979**	**82%**
Car Journey Time								
GJT	-1.39	-2.262	-0.520	43%	-2.63	-4.058	-1.202	82%
Performance								
SQI								

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	0.5%
Market share (Distance)	0.4%
Market share (Revenue)	0.2%
Passenger journeys	2,500,000
Ave distance (km)	68.56
Ave fare per km (£)	0.105

Diagnostics

Model formulation	Constant elasticities
Sample size (number of observations)	6063
Number of years of sample	13
Arellano-Bond (autocorrelation)	Pass
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.67

As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross price	
Income	
Population	
Employment	
Car ownership	
Car cost	Cost of journey
Car Journey Time	
GJT	Generalised Journey Time
Performance	
SQI	

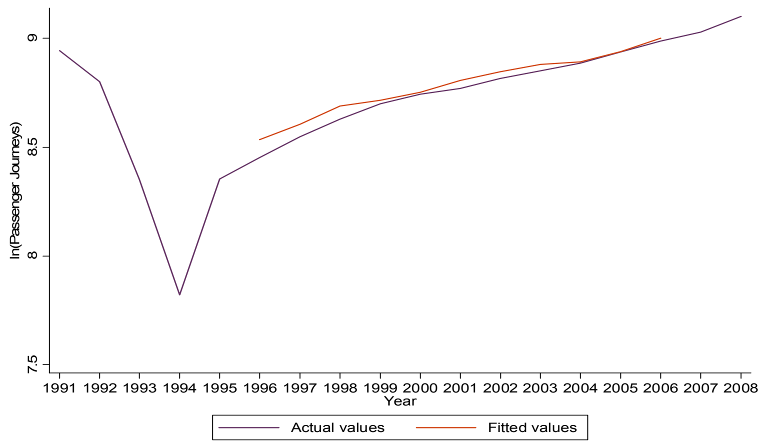
London, South East and East of England to London, South East and East of England: Combined model

Variable list	One-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-0.79**	**-0.899**	**-0.675**	**83%**	**-0.95**	**-1.070**	**-0.834**	**100%**
Cross-price								
Income	**0.74**	**0.425**	**1.059**	**47%**	**1.58**	**1.382**	**1.787**	**100%**
Population								
Employment	**0.48**	**0.369**	**0.584**	**97%**	**0.49**	**0.384**	**0.601**	**100%**
Car ownership								
Car cost	**0.82**	**0.726**	**0.909**	**57%**	**1.44**	**1.291**	**1.579**	**99%**
Car Journey Time								
GJT	-0.39	-0.501	-0.286	24%	-1.60	-1.804	-1.402	98%
Performance	0.43	0.336	0.514	37%	1.14	1.040	1.246	100%
SQI								

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	34.9%
Market share (Distance)	24.1%
Market share (Revenue)	26.5%
Passenger journeys	193,000,000
Ave distance (km)	30.1
Ave fare per km (£)	0.211



Diagnostics

Model formulation	Constant elasticities
Sample size (number of observations)	71894
Number of years of sample	11
Arellano-Bond (autocorrelation)	Pass
Sargan (instrument validity)	Fail
Unit root test on residuals	unit root test: too many values
Stable model	Pass
Model fit	0.42

As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	Disposable income per capita at origin
Population	
Employment	Total jobs at destination
Car ownership	
Car cost	Cost of journey
Car Journey Time	
GJT	Generalised Journey Time
Performance	Sectoral PPM
SQI	

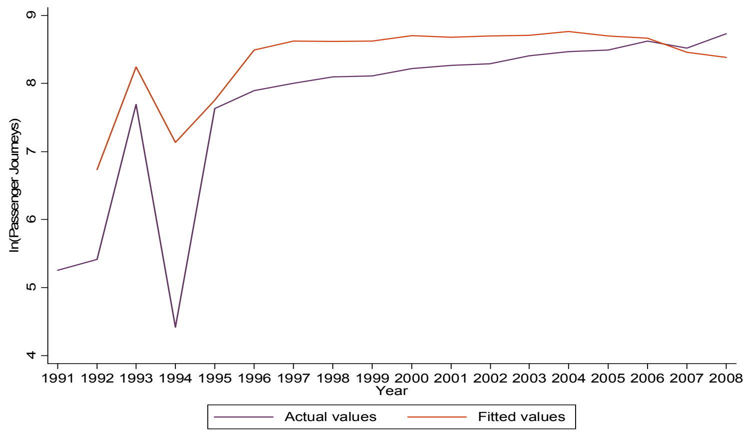
London, South East and East of England to London, South East and East of England: Season tickets

Variable list	One-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-2.08**	**-2.206**	**-1.757**	**341%**	**-0.73**	**-0.838**	**-0.306**	**119%**
Cross-price								
Income								
Population								
Employment	**1.04**	**0.885**	**1.171**	**72%**	**1.41**	**1.275**	**1.639**	**98%**
Car ownership								
Car cost								
Car Journey Time								
GJT	-1.42	-1.342	-0.749	31%	-4.35	-4.760	-3.589	94%
Performance								0%
SQI								0%

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	34.8%
Market share (Distance)	21.5%
Market share (Revenue)	25.0%
Passenger journeys	218,000,000
Ave distance (km)	26.25
Ave fare per km (£)	0.178



Diagnostics

Model formulation	Constant elasticities
Sample size (number of observations)	64996
Number of years of sample	17
Arellano-Bond (autocorrelation)	Fail
Sargan (instrument validity)	Fail
Unit root test on residuals	unit root test: too many values
Stable model	Yes
Model fit	0.53

As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	
Population	
Employment	Total jobs at destination
Car ownership	
Car cost	
Car Journey Time	
GJT	Generalised Journey Time
Performance	
SQI	

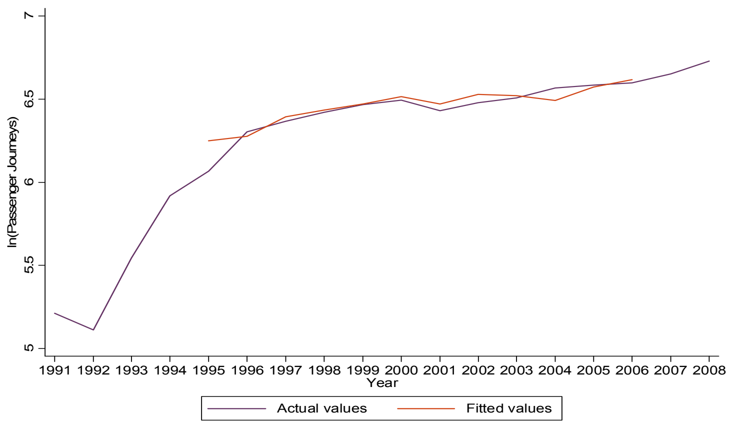
London, South East and East of England to Core cities: Reduced price

Variable list	One-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**0.39**	**0.0605**	**0.721**	**-129%**	**-0.25**	**-0.541**	**0.0368**	**83%**
Cross-price				**0%**				
Income	**1.28**	**0.728**	**1.833**	**72%**	**1.73**	**1.029**	**2.435**	**98%**
Population								
Employment								
Car ownership								
Car cost	**0.05**	**-0.0964**	**0.203**	**6%**	**0.77**	**0.431**	**1.110**	**93%**
Car Journey Time								
GJT	-0.97	-1.386	-0.553	72%	-1.31	-1.845	-0.777	98%
Performance	0.22	0.0298	0.400	16%	1.26	0.906	1.620	94%
SQI								

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	0.7%
Market share (Distance)	4.4%
Market share (Revenue)	2.9%
Passenger journeys	4,157,000
Ave distance (km)	188
Ave fare per km (£)	0.115



As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Diagnostics

Model formulation	Constant elasticities
Sample size (number of observations)	10982
Number of years of sample	12
Arellano-Bond (autocorrelation)	Pass
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.66

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	Disposable income per capita at origin
Population	
Employment	
Car ownership	
Car cost	Cost of journey
Car Journey Time	
GJT	Generalised Journey Time
Performance	Sectoral PPM
SQI	

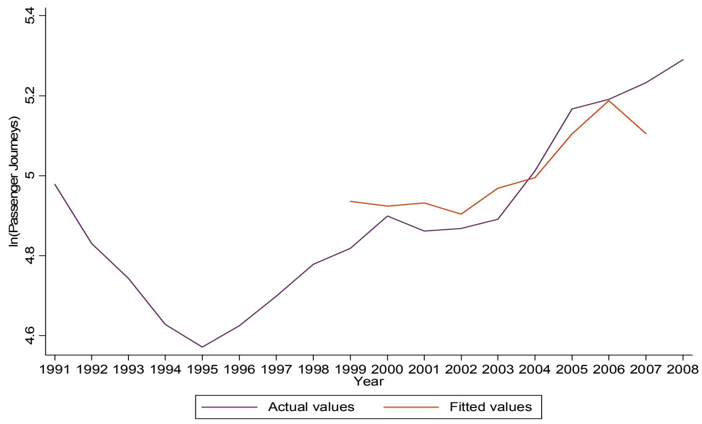
London, South East and East of England to Core cities: Full price

Variable list	One-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-1.51**	**-1.756**	**-1.260**	**119%**	**-1.27**	**-1.545**	**-0.996**	**101%**
Cross-price				**0%**				
Income	**0.88**	**0.199**	**1.568**	**83%**	**1.06**	**0.265**	**1.845**	**100%**
Population								
Employment								
Car ownership								
Car cost	**1.33**	**0.897**	**1.757**	**83%**	**1.59**	**1.071**	**2.099**	**100%**
Car Journey Time								
GJT	-1.13	-1.639	-0.613	38%	-2.92	-3.827	-2.010	98%
Performance				0%				
SQI	1.30	0.955	1.646	83%	1.55	1.162	1.945	100%

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	0.2%
Market share (Distance)	1.4%
Market share (Revenue)	2.6%
Passenger journeys	1,380,000
Ave distance (km)	187.6
Ave fare per km (£)	0.284



Diagnostics

Model formulation	Constant elasticities
Sample size (number of observations)	8064
Number of years of sample	9
Arellano-Bond (autocorrelation)	Pass
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.55

As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	Disposable income per capita at origin
Population	
Employment	
Car ownership	
Car cost	Cost of journey
Car Journey Time	
GJT	Generalised Journey Time
Performance	
SQI	Service Quality Index

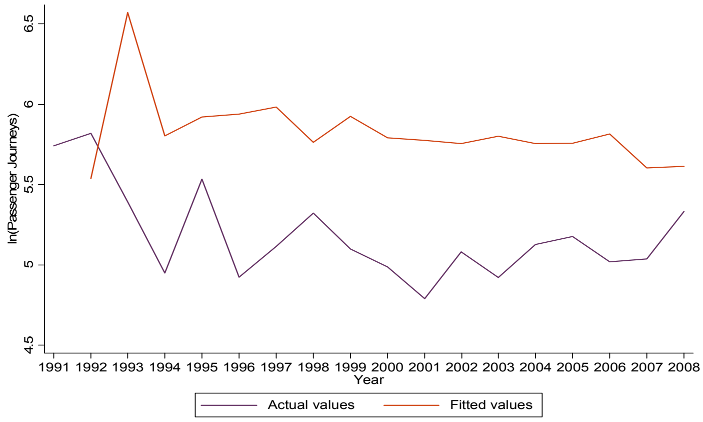
London, South East and East of England to Core cities: Season tickets

Variable list	One-year elasticity Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-0.57**	**-1.163**	**0.0262**	**70%**	**-0.79**	**-1.614**	**0.0342**	**97%**
Cross-price				**0%**				
Income								
Population								
Employment								
Car ownership								
Car cost								
Car Journey Time								
GJT								
Performance				0%				
SQI								

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	0.1%
Market share (Distance)	0.3%
Market share (Revenue)	0.2%
Passenger journeys	1,074,000
Ave distance (km)	163
Ave fare per km (£)	0.0957



Diagnostics

Model formulation	Constant elasticities
Sample size (number of observations)	8064
Number of years of sample	9
Arellano-Bond (autocorrelation)	Pass
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.55

As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	
Population	
Employment	
Car ownership	
Car cost	
Car Journey Time	
GJT	
Performance	
SQI	

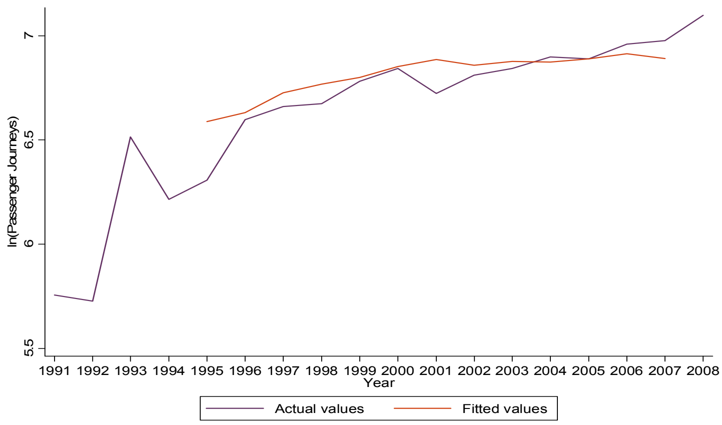
London, South East and East of England to Other: Reduced price

Variable list	One-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-0.26**	**-0.654**	**-0.0416**	**741%**	**-0.04**	**-0.601**	**0.136**	**115%**
Cross-price				**0%**				
Income	**0.83**	**0.476**	**1.342**	**85%**	**0.98**	**0.596**	**1.544**	**100%**
Population								
Employment								
Car ownership								
Car cost	**0.17**	**0.0160**	**0.331**	**85%**	**0.20**	**0.0179**	**0.391**	**100%**
Car Journey Time								
GJT	-0.03	-0.237	0.174	6%	-0.53	-1.008	-0.0651	98%
Performance								
SQI								

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	1.0%
Market share (Distance)	5.1%
Market share (Revenue)	3.5%
Passenger journeys	5,871,000
Ave distance (km)	170
Ave fare per km (£)	0.113



As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Diagnostics

Model formulation	Variable elasticities
Sample size (number of observations)	86310
Number of years of sample	11
Arellano-Bond (autocorrelation)	Pass
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.58
Comments on diagnostics	The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	Disposable income per capita at origin
Population	
Employment	
Car ownership	
Car cost	Cost of journey
Car Journey Time	
GJT	Generalised Journey Time
Performance	
SQI	

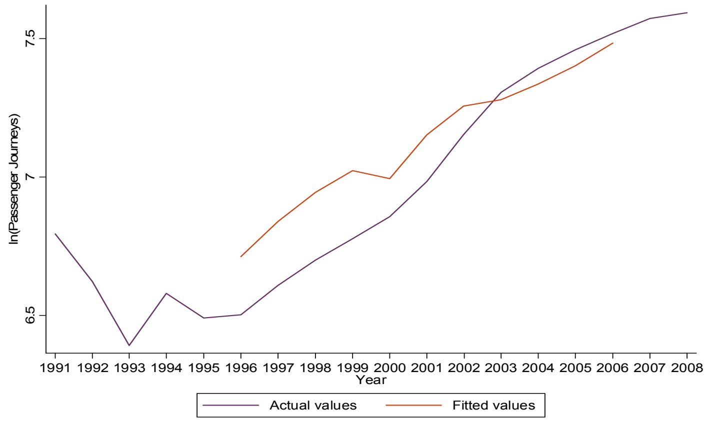
London, South East and East of England to Other: Full price

Variable list	One-year elasticity Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-1.38**	**-1.545**	**-1.212**	**79%**	**-1.74**	**-1.978**	**-1.500**	**99%**
Cross-price				**0%**				
Income	**0.32**	**-0.0677**	**0.703**	**42%**	**0.73**	**0.686**	**1.747**	**97%**
Population								
Employment								
Car ownership								
Car cost	**0.76**	**0.303**	**1.218**	**42%**	**1.61**	**1.095**	**2.125**	**88%**
Car Journey Time								
GJT	-0.33	-0.609	-0.0408	12%	-2.03	-2.612	-1.440	77%
Performance	0.62	0.473	0.775	71%	0.79	0.588	0.986	89%
SQI								

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	0.3%
Market share (Distance)	1.4%
Market share (Revenue)	2.5%
Passenger journeys	1,687,000
Ave distance (km)	169.9
Ave fare per km (£)	0.258



As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Diagnostics

Model formulation	Variable elasticities
Sample size (number of observations)	14785
Number of years of sample	11
Arellano-Bond (autocorrelation)	Pass
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.58

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	Disposable income per capita at origin
Population	
Employment	
Car ownership	
Car cost	Cost of journey
Car Journey Time	
GJT	Generalised Journey Time
Performance	Sectoral PPM
SQI	

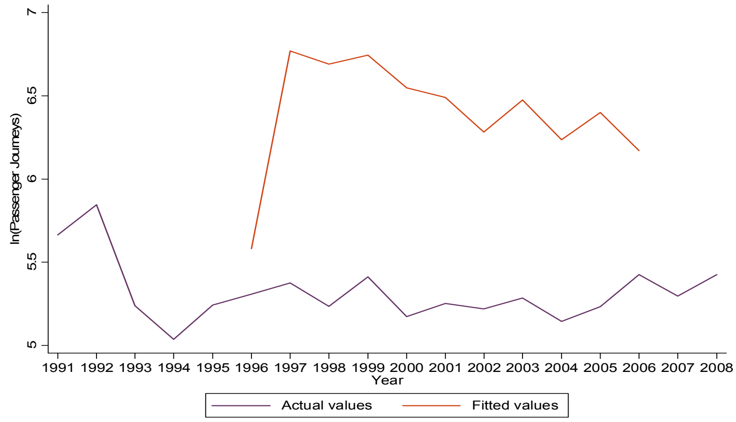
London, South East and East of England to Other: Season tickets

Variable list	One-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-0.46**	**-0.972**	**0.0537**	**46%**	**-0.91**	**-1.400**	**-0.412**	**91%**
Cross-price				**0%**				
Income								
Population								
Employment	**0.98**	**-0.799**	**2.473**	**79%**	**1.22**	**-1.016**	**3.071**	**99%**
Car ownership								
Car cost								
Car Journey Time								
GJT	-1.86	-3.446	-0.269	63%	-2.32	-4.242	-0.395	78%
Performance	1.61	0.442	2.785	63%	2.01	0.628	3.400	78%
SQI								

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	0.1%
Market share (Distance)	0.4%
Market share (Revenue)	0.2%
Passenger journeys	1,124,000
Ave distance (km)	134.1
Ave fare per km (£)	0.0991



Diagnostics

Model formulation	Variable elasticities
Sample size (number of observations)	1197
Number of years of sample	14
Arellano-Bond (autocorrelation)	Pass
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.42

As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	
Population	
Employment	Total employment at destination
Car ownership	
Car cost	
Car Journey Time	
GJT	Generalised Journey Time
Performance	Sectoral PPM
SQI	

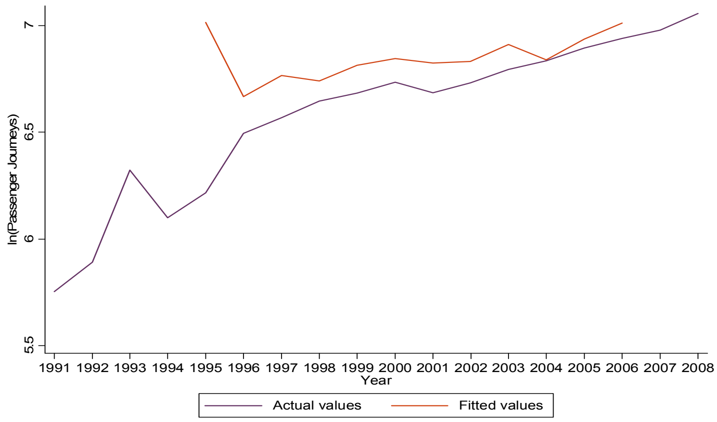
Other to London, South East and East of England: Reduced price

Variable list	One-year elasticity Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-0.12**	**-0.437**	**0.202**	**18%**	**-0.63**	**-1.011**	**-0.256**	**94%**
Cross-price				**0%**				
Income	**1.25**	**0.625**	**1.882**	**87%**	**1.44**	**0.700**	**2.183**	**100%**
Population								
Employment								
Car ownership								
Car cost	**0.91**	**0.579**	**1.248**	**54%**	**1.57**	**0.951**	**2.181**	**93%**
Car Journey Time								
GJT	-0.33	-0.560	-0.0932	15%	-2.01	-2.701	-1.313	93%
Performance	0.80	0.482	1.111	47%	1.67	1.160	2.187	99%
SQI								

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	1.4%
Market share (Distance)	6.7%
Market share (Revenue)	4.3%
Passenger journeys	7,990,000
Ave distance (km)	166.6
Ave fare per km (£)	0.11



Diagnostics

Model formulation	Constant elasticities
Sample size (number of observations)	18244
Number of years of sample	12
Arellano-Bond (autocorrelation)	Fail
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.48

As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	Disposable income per capita at origin
Population	
Employment	
Car ownership	
Car cost	Cost of journey
Car Journey Time	
GJT	Generalised Journey Time
Performance	Sectoral PPM
SQI	

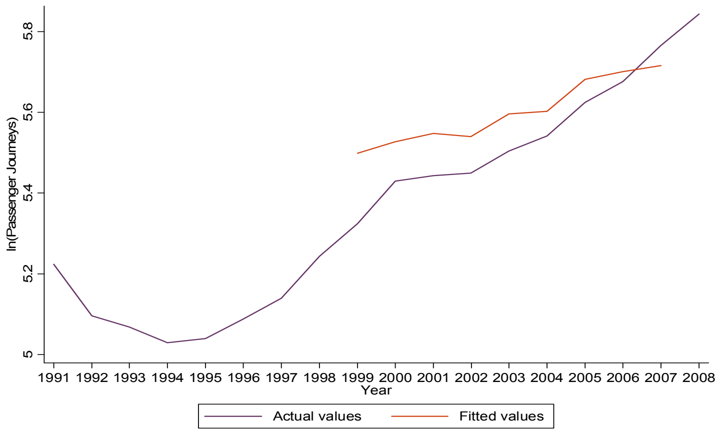
Other to London, South East and East of England: Full price

Variable list	One-year elasticity				Three-year elasticity			
	Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-1.81**	**-2.055**	**-1.572**	**123%**	**-1.50**	**-1.817**	**-1.180**	**102%**
Cross-price	**0.38**	**0.216**	**0.535**	**73%**	**0.51**	**0.298**	**0.714**	**98%**
Income	**0.69**	**0.114**	**1.269**	**73%**	**0.93**	**0.180**	**1.685**	**98%**
Population	**1.88**	**0.281**	**3.469**	**73%**	**2.53**	**0.398**	**4.657**	**98%**
Employment								
Car ownership								
Car cost	**0.68**	**0.227**	**1.131**	**73%**	**0.91**	**0.300**	**1.531**	**98%**
Car Journey Time								
GJT	**-0.16**	**-0.446**	**0.125**	**13%**	**-1.18**	**-1.712**	**-0.654**	**93%**
Performance								
SQI	**1.15**	**0.678**	**1.620**	**73%**	**1.55**	**0.895**	**2.203**	**98%**

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	0.6%
Market share (Distance)	2.9%
Market share (Revenue)	5.9%
Passenger journeys	3,518,000
Ave distance (km)	166.7
Ave fare per km (£)	0.272



As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Diagnostics

Model formulation	Constant elasticities
Sample size (number of observations)	13919
Number of years of sample	9
Arellano-Bond (autocorrelation)	Pass
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.55

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	Reduced price tickets
Income	Disposable income per capita at origin
Population	Total population at origin
Employment	
Car ownership	
Car cost	Cost of journey
Car Journey Time	
GJT	Generalised Journey Time
Performance	
SQI	Service Quality Index

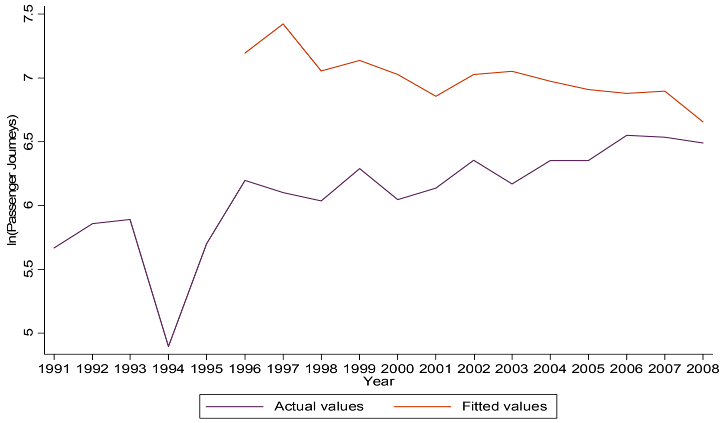
Other to London, South East and East of England: Season tickets

Variable list	One-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-1.40**	**-1.841**	**-0.962**	**63%**	**-2.12**	**-2.828**	**-1.412**	**95%**
Cross-price				**0%**				
Income								
Population								
Employment	**1.41**	**0.910**	**1.912**	**63%**	**2.13**	**1.494**	**2.774**	**95%**
Car ownership								
Car cost								
Car Journey Time								
GJT	-0.34	-1.185	0.513	11%	-2.68	-4.652	-0.709	88%
Performance				0%				
SQI								

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	0.5%
Market share (Distance)	1.6%
Market share (Revenue)	1.0%
Passenger journeys	2,815,000
Ave distance (km)	130.1
Ave fare per km (£)	0.103



Diagnostics

Model formulation	Constant elasticities
Sample size (number of observations)	4084
Number of years of sample	13
Arellano-Bond (autocorrelation)	Pass
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.64

As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	
Population	
Employment	Total employment at destination
Car ownership	
Car cost	
Car Journey Time	
GJT	Generalised Journey Time
Performance	
SQI	

Other to Core cities: Reduced price

Variable list	One-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-1.07**	**-1.427**	**-0.715**	**77%**	**-1.38**	**-1.769**	**-0.996**	**99%**
Cross-price				**0%**				
Income	**1.77**	**1.051**	**2.490**	**77%**	**2.28**	**1.324**	**3.246**	**99%**
Population								
Employment								
Car ownership	**-1.82**	**-2.633**	**-1.009**	**77%**	**-2.35**	**-3.260**	**-1.441**	**99%**
Car cost	**0.57**	**0.283**	**0.851**	**77%**	**0.73**	**0.383**	**1.081**	**99%**
Car Journey Time								
GJT								
Performance	0.53	0.274	0.792	33%	1.53	1.181	1.890	96%
SQI								

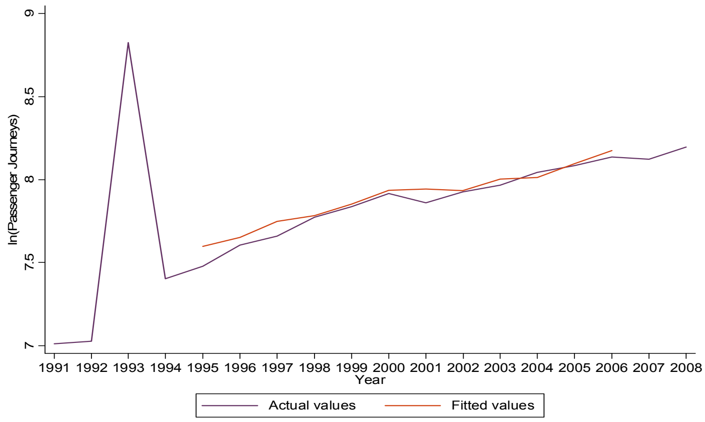
*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	5.2%
Market share (Distance)	5.2%
Market share (Revenue)	3.1%
Passenger journeys	29,000,000
Ave distance (km)	109.7
Ave fare per km (£)	0.103

Diagnostics

Model formulation	Constant elasticities
Sample size (number of observations)	22387
Number of years of sample	11
Arellano-Bond (autocorrelation)	Fail
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.44



As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	Disposable income per capita at origin
Population	
Employment	
Car ownership	Prop. of households without access to a car
Car cost	Cost of journey
Car Journey Time	
GJT	
Performance	Sectoral PPM
SQI	

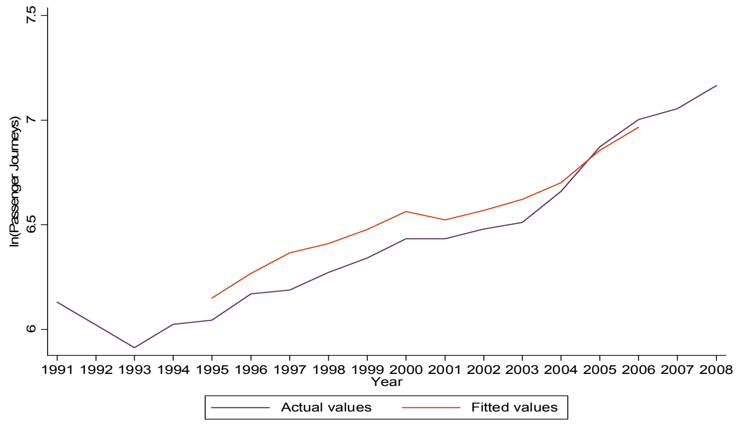
Other to Core cities: Full price

Variable list	One-year elasticity				Three-year elasticity			
	Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-0.68**	**-0.763**	**-0.587**	**127%**	**-0.54**	**-0.637**	**-0.420**	**102%**
Cross-price				**0%**				
Income	**0.61**	**0.138**	**1.086**	**73%**	**0.82**	**0.178**	**1.462**	**98%**
Population								
Employment								
Car ownership	**-1.41**	**-1.958**	**-0.869**	**73%**	**-1.89**	**-2.583**	**-1.204**	**98%**
Car cost	**0.36**	**0.0797**	**0.639**	**71%**	**0.49**	**0.107**	**0.857**	**98%**
Car Journey Time								
GJT	-0.49	-0.801	-0.185	19%	-2.23	-2.644	-1.763	86%
Performance	0.34	0.216	0.454	24%	1.32	1.110	1.477	94%
SQI								

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	3.0%
Market share (Distance)	2.0%
Market share (Revenue)	1.9%
Passenger journeys	16,500,000
Ave distance (km)	110.8
Ave fare per km (£)	0.182



Diagnostics

Model formulation	Variable elasticities
Sample size (number of observations)	22833
Number of years of sample	12
Arellano-Bond (autocorrelation)	Fail
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.80

As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	Disposable income per capita at origin
Population	
Employment	
Car ownership	Prop. of households without access to a car
Car cost	Cost of journey
Car Journey Time	
GJT	Generalised Journey Time
Performance	Sectoral PPM
SQI	

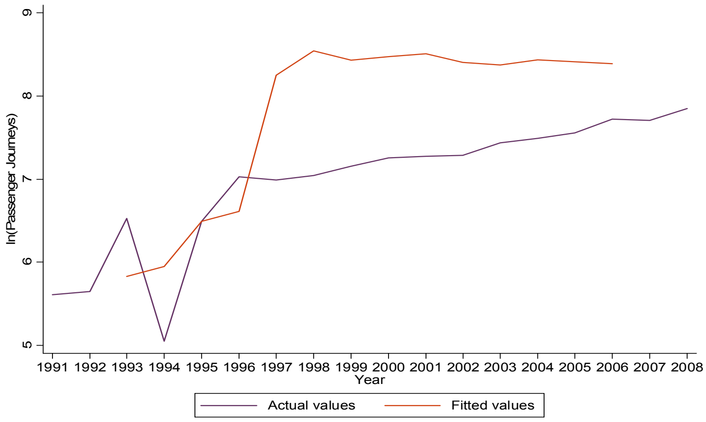
Other to Core cities: Season tickets

Variable list	One-year elasticity Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-1.36**	**-1.727**	**-0.995**	**115%**	**-1.21**	**-1.797**	**-0.629**	**103%**
Cross-price				**0%**				
Income								
Population								
Employment								
Car ownership								
Car cost	**0.66**	**0.149**	**1.163**	**58%**	**1.05**	**0.258**	**1.838**	**93%**
Car Journey Time								
GJT	-1.27	-1.820	-0.712	23%	-4.29	-5.545	-3.026	79%
Performance	0.33	-0.0888	0.754	23%	1.24	0.540	1.947	86%
SQI								

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	1.6%
Market share (Distance)	1.2%
Market share (Revenue)	0.7%
Passenger journeys	8,401,000
Ave distance (km)	65.83
Ave fare per km (£)	0.114



Diagnostics

Model formulation	Constant elasticities
Sample size (number of observations)	6002
Number of years of sample	14
Arellano-Bond (autocorrelation)	Pass
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.70

As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	
Population	
Employment	
Car ownership	
Car cost	Cost of journey
Car Journey Time	
GJT	Generalised Journey Time
Performance	Sectoral PPM
SQI	

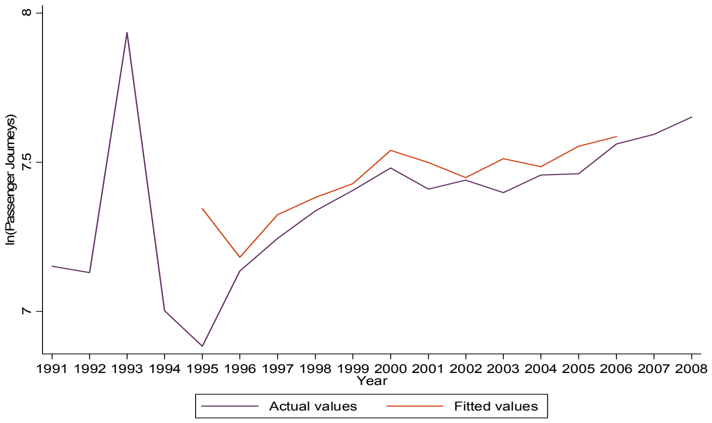
Other to Other: Reduced price

	One-year elasticity				Three-year elasticity			
Variable list	Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-0.24**	**-0.391**	**-0.0881**	**21%**	**-0.58**	**-0.941**	**-0.219**	**50%**
Cross-price				**0%**				
Income	**0.93**	**0.617**	**1.241**	**21%**	**2.25**	**1.504**	**2.992**	**50%**
Population								
Employment								
Car ownership								
Car cost								
Car Journey Time								
GJT								
Performance	-0.09	-0.172	-0.00946	-3%	0.94	0.702	1.186	35%
SQI								

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	3.8%
Market share (Distance)	3.2%
Market share (Revenue)	2.0%
Passenger journeys	21,300,000
Ave distance (km)	79.51
Ave fare per km (£)	0.111



As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Diagnostics

Model formulation	Constant elasticities
Sample size (number of observations)	40938
Number of years of sample	12
Arellano-Bond (autocorrelation)	Pass
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.86

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

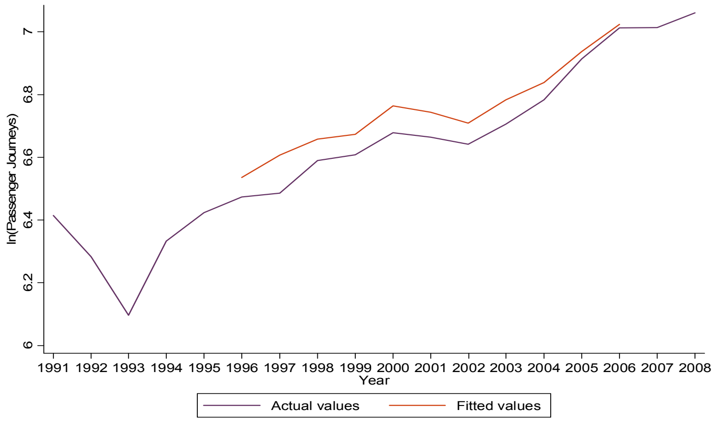
Variable definition

Fare	Revenue/journeys
Cross-price	
Income	Disposable income per capita at origin
Population	
Employment	
Car ownership	
Car cost	
Car Journey Time	
GJT	
Performance	Sectoral PPM
SQI	

Other to Other: Full price

Variable list	One-year elasticity				Three-year elasticity			
	Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-1.36**	**-1.593**	**-1.133**	**115%**	**-1.21**	**-1.484**	**-0.930**	**102%**
Cross-price				**0%**				
Income	**0.77**	**0.395**	**1.147**	**26%**	**2.66**	**2.121**	**3.197**	**90%**
Population								
Employment								
Car ownership								
Car cost	**1.06**	**0.800**	**1.321**	**139%**	**0.81**	**0.433**	**1.177**	**105%**
Car Journey Time								
GJT	-0.25	-0.357	-0.145	17%	-1.19	-1.441	-0.936	81%
Performance	0.24	0.137	0.332	16%	1.30	1.132	1.470	88%
SQI								

*The variables in bold are the elasticities which are of direct interest for the project



Summary statistics for segment

Market share (Journeys)	2.9%
Market share (Distance)	1.5%
Market share (Revenue)	1.5%
Passenger journeys	16,300,000
Ave distance (km)	79.12
Ave fare per km (£)	0.181

Diagnostics

Model formulation	Constant elasticities
Sample size (number of observations)	37735
Number of years of sample	11
Arellano-Bond (autocorrelation)	Fail
Sargan (instrument validity)	Fail
Unit root test on residuals	Cannot conduct unit root test
Stable model	Pass
Model fit	0.88

As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	Disposable income per capita at origin
Population	
Employment	
Car ownership	
Car cost	Cost of journey
Car Journey Time	
GJT	Generalised Journey Time
Performance	Sectoral PPM
SQI	

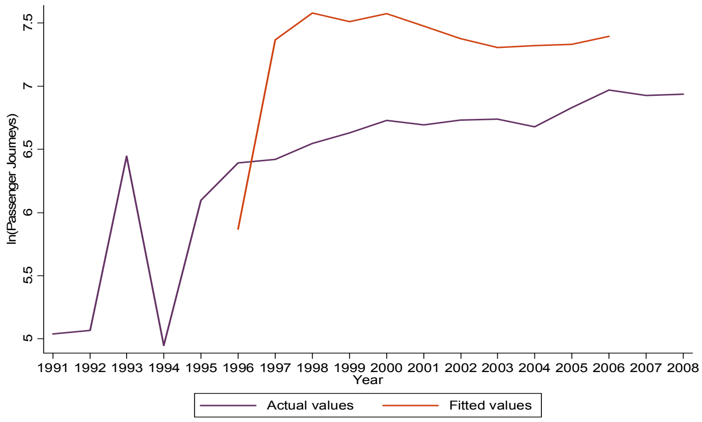
Other to Other: Season tickets

Variable list	One-year elasticity				Three-year elasticity			
	Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-0.98**	**-1.186**	**-0.780**	**33%**	**-1.42**	**-2.011**	**-0.822**	**48%**
Cross-price								
Income	**1.30**	**-1.308**	**0.152**	**12%**	**3.45**	**-3.382**	**0.390**	**31%**
Population								
Employment								
Car ownership								
Car cost	**-0.34**	**-0.864**	**0.175**	**-44%**	**-0.10**	**-1.158**	**0.962**	**-12%**
Car Journey Time								
GJT	-0.02	-0.202	0.165	1%	-0.62	-1.332	0.0855	23%
Performance	-0.06	-0.473	0.361	0%	2.04	0.845	3.231	16%
SQI								

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	1.0%
Market share (Distance)	0.6%
Market share (Revenue)	0.3%
Passenger journeys	5,321,000
Ave distance (km)	45.27
Ave fare per km (£)	0.114



Diagnostics

Model formulation	Constant elasticities
Sample size (number of observations)	10590
Number of years of sample	12
Arellano-Bond (autocorrelation)	Pass
Sargan (instrument validity)	Fail
Unit root test on residuals	Could not conduct unit root test
Stable model	Pass
Model fit	0.76

As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	GVA per employee at destination
Population	
Employment	
Car ownership	
Car cost	Cost of journey
Car Journey Time	
GJT	Generalised Journey Time
Performance	Sectoral PPM
SQI	

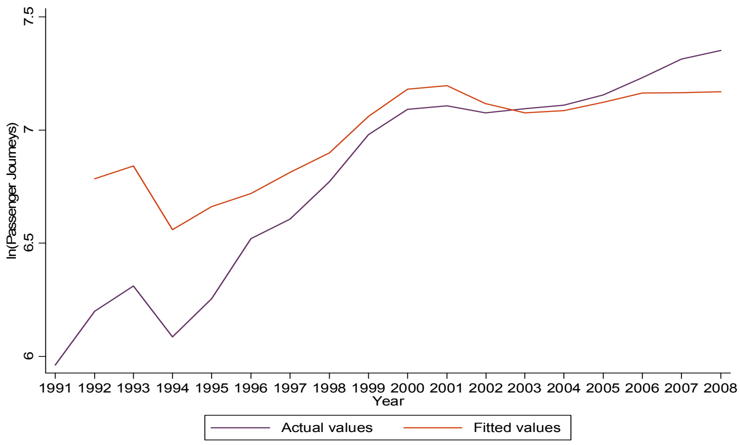
To airports: Reduced price

Variable list	One-year elasticity Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-0.31**	**-0.924**	**0.302**	**70%**	**-0.43**	**-1.196**	**0.335**	**97%**
Cross-price				**0%**				
Income				**0%**				
Population								
Employment								
Car ownership	**0.91**	**0.248**	**1.527**	**20%**	**1.26**	**0.418**	**2.039**	**27%**
Car cost	**0.38**	**0.0449**	**0.719**	**70%**	**0.53**	**0.140**	**0.916**	**97%**
Car Journey Time								
GJT	**-0.50**	**-0.952**	**-0.0423**	**70%**	**-0.69**	**-1.380**	**0.00435**	**97%**
Performance				**0%**				
SQI								
Throughput	**0.56**	**0.154**	**0.970**	**70%**	**0.78**	**0.374**	**1.182**	**97%**

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	0.4%
Market share (Distance)	0.7%
Market share (Revenue)	0.6%
Passenger journeys	2,386,000
Ave distance (km)	94.51
Ave fare per km (£)	0.134



Diagnostics

Model formulation	Including squared terms
Sample size (number of observations)	8300
Number of years of sample	11
Arellano-Bond (autocorrelation)	Pass
Sargan (instrument validity)	Fail
Unit root test on residuals	Cannot conduct unit root test
Stable model	Pass
Model fit	0.46

As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	
Population	
Employment	
Car ownership	Prop. of households without access to a car
Car cost	Cost of journey
Car Journey Time	
GJT	Generalised Journey Time
Performance	
SQI	
Throughput	Airport throughput

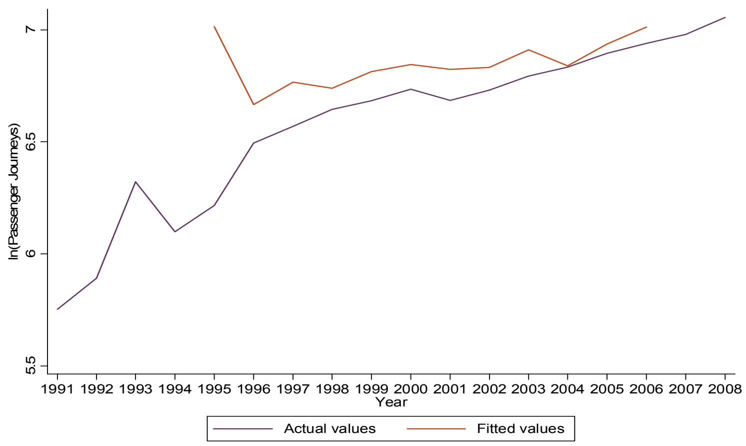
To airports: Full price

Variable list	One-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after one year	Three-year elasticity: Point estimate	95% CI lower bound	95% CI upper bound	Percentage adjustment to long run after three years
Fare	**-1.67**	**-2.059**	**-1.278**	**164%**	**-1.04**	**-1.367**	**-0.713**	**102%**
Cross-price								
Income								
Population								
Employment								
Car ownership								
Car cost	**0.85**	**0.351**	**1.339**	**88%**	**1.04**	**0.445**	**1.630**	**108%**
Car Journey Time								
GJT	**-1.64**	**-2.239**	**-1.034**	**88%**	**-2.01**	**-2.699**	**-1.034**	**108%**
Performance	**0.71**	**0.401**	**1.022**	**88%**	**0.87**	**0.504**	**1.243**	**108%**
SQI								
Throughput	**0.58**	**0.404**	**0.761**	**88%**	**0.72**	**0.491**	**0.939**	**108%**

*The variables in bold are the elasticities which are of direct interest for the project

Summary statistics for segment

Market share (Journeys)	0.6%
Market share (Distance)	0.7%
Market share (Revenue)	1.3%
Passenger journeys	3,489,000
Ave distance (km)	94.26
Ave fare per km (£)	0.247



Diagnostics

Model formulation	Variable elasticities
Sample size (number of observations)	86310
Number of years of sample	11
Arellano-Bond (autocorrelation)	Fail
Sargan (instrument validity)	Fail
Unit root test on residuals	Pass
Stable model	Pass
Model fit	0.62

As a measure of goodness of fit, the graph illustrates how well the predicted values from the model match the actual values of log(journeys) over time

Comments on diagnostics: The Sargan test may still be failed if there is heterogeneity in the DGP, even if the model specification is correct

Comments on model

Variable definition

Fare	Revenue/journeys
Cross-price	
Income	
Population	
Employment	
Car ownership	
Car cost	Cost of journey
Car Journey Time	
GJT	Generalised Journey Time
Performance	Sectoral PPM
SQI	
Througput	#N/A

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