Understanding customer preferences for airport access: Implications for forecasting

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DAVID JEVONS

leads Oxera's work in modelling, advising clients on issues surrounding business planning, consumer behaviour and market analysis using advanced economic and analytical tools in commercial, regulatory and litigation contexts.

THOMAS HOE

has been a member of Oxera's modelling team for two years and has experience of applying quantitative techniques in a variety of sectors; he specialises in econometric analysis.

MATTHEW SHEPHERD

has been a member of Oxera's transport and modelling teams for two years and specialises in providing quantitative analysis for clients in the transport sector.

Abstract

This paper describes the creation of a model to forecast the demand for, and revenue from, travel on the Heathrow Express services between London Heathrow and central London. The construction of the model, based on a survey of passengers at Heathrow and statistical analysis of these survey data, is described, including the data collection and analytical methodology. The paper concludes with insights from the survey data and the analysis.

Keywords

market research, statistical analysis, surface access, pricing strategy, demand forecasting

INTRODUCTION

How passengers travel to airports is important for airports across the globe, with many arriving by car, with the associated congestion and environmental impacts. However, to provide surface access by other modes (particularly those that require substantial investment, such as rail), it is necessary to produce forecasts of passenger demand and revenue to the airport. This paper discusses the creation of a model which produces demand and revenue forecasts for Heathrow Express, using a survey of passengers at London Heathrow and stated-preference techniques to analyse passenger preferences and the implications for demand and revenue.

The Heathrow Express and Heathrow Connect services provide fast and frequent rail services between Heathrow Airport and central London's Paddington Station. Paddington is one of London's major rail terminals, with connections to both the London Underground network and mainline rail services arriving from the west of England. Heathrow Express and Heathrow Connect have different service propositions and appeal to different markets. Heathrow Express is the name of the operating company and the brand name of one of the services. To avoid confusion, in this paper, 'Heathrow Express' is the operating company and the services are referred to as Connect and Express, or the Connect and Express services.

David Jevons,
Oxera,
Park Central
40/41 Park End Street,
Oxford OX1 1JD,
UK

Tel: +44 (0)1865 253097
E-mail: david.jevons@oxera.com

The Express service uses dedicated, high-quality rolling stock to provide a service of four trains per hour between all Heathrow terminals and Paddington. It is a premium service, with a train always at the platform at Paddington, a non-stop ride between the airport and the station, and prices that reflect the features of the service and the high level of customer service. Carrying more than 16,000 passengers per day, the service is targeted at business travellers.

The Connect service uses rolling stock similar to that on many suburban commuter lines, with fewer seats and more standing space. There are two trains per hour between the airport and the station, but the service takes longer than the Express as it makes a number of stops en route; however, the prices are geared to reflect this different service pattern, and the service is targeted at leisure travellers and airport staff travelling to and from the airport.

To assist with its business planning, Heathrow Express uses a model to forecast demand and revenue under different scenarios. The forecasts from the previous model had begun to decrease in accuracy for several reasons, including:

- the addition of a new terminal (Terminal 5) at Heathrow;
- airlines moving terminals due to the extensive work being undertaken at Heathrow, including the closure of Terminal 2 and the creation of Heathrow East;
- the existing model not producing forecasts for the Connect service; and
- the fares structure offered on the Express service having changed since the model was created.

In addition, the previous forecasting model was based on information from a period of strong economic growth. The severe recession following the financial crisis and the changing economic environment meant that customer tastes and preferences were likely to have changed since the original model was developed, which is another possible explanation for the decline in accuracy of the model.

Consequently, Heathrow Express needed to develop a new demand and revenue forecasting model to assist with its business planning. The new model was required to provide the standard features expected of models of this type (eg scenario planning, understanding the likely impact of different pricing strategies, the introduction of new tickets and changes in the characteristics of different access modes), but also to forecast the impact of non-standard events such as airlines moving terminals. Any new model would also need to be able to forecast the impact of abstraction (passengers switching) from Express to Connect, given the different characteristics of the two services. A new model was constructed that provided the ability to forecast these impacts; however, the model does not forecast the effect of high-impact, low-probability events, such as the Icelandic volcano eruption in early 2010 and its consequences for air services, or the disruption caused at Heathrow by the severe snowfall in December 2010. The construction of the model is described in the remainder of this paper.

To predict future demand and revenue accurately, the model has to take into account the fact that customers wanting to travel between London and Heathrow have a choice of multiple modes of transport — ie London Underground, rail (Express and Connect), coach, car and taxi — all of which have different prices, journey times and inherent features. Different types of consumer are likely to have different preferences for these characteristics and modes

of transport. A model was designed to produce monthly forecasts of revenue and passengers for 15 monthly periods ahead, plus a five-year, long-term outlook with a low margin of error. The results of statistical analysis of the survey of passengers at Heathrow were combined with other inputs (including prices and GDP forecasts) to produce the final demand and revenue forecasting model. These steps are discussed below, starting with the definition of the relevant market for passengers travelling to Heathrow using Express and Connect services.

MARKET DEFINITION

To make the model tractable yet accurate, it was important to define the market dimensions within which Express and Connect operate. Geographic scope, the potential transport options and passenger demographics are the three primary dimensions.

Geographic scope

Heathrow receives departing passengers from all over Great Britain and from other countries for connecting passengers. Non-flying visitors to the airport (eg staff) were not considered. The relevant sub-set of these passengers for this exercise was considered to be those passengers who had a realistic option to use Express or Connect. This exercise divided passengers into three categories, those of:

- London origin;
- non-London, UK origin having travelled via a London mainline rail station;
- non-London, UK origin having travelled directly to Heathrow.

All passengers in the first two categories were assumed to have the option of using Express or Connect; the second category picks up passengers who have an intermediate stop in London (eg from Cambridge). Passengers in the third category were assumed never to have considered travelling via London. Certain passengers not travelling via London may be relevant (ie they could feasibly have considered travelling via London and Heathrow Express as an alternative route) but were excluded by this assumption. The assumption to exclude such passengers was predicated on the grounds that they were a relatively small proportion of potential Heathrow Express users and that minor changes to the Heathrow Express services were unlikely to affect the majority of these passengers' travel decisions. In addition, providing travel time and costs for all modes of transport across the UK would have significantly increased the costs of the stated-preference exercise.

Within the first two categories, the market was further segmented by specific area or connecting station. London was split into eight areas: the segmentation was more granular in east and central London to reflect the more diverse journey times in these areas. West London was split into two broad areas: 'near' (travel zones 1–3) and 'far' (travel zones 4+). In total, seven mainline connecting stations were included. Together, 16 separate journey origins were considered (nine regions of London plus seven mainline stations). Figure 1 shows the geographic scope of the market for transportation to Heathrow.

Field and desk research were used to obtain travel information from each of these journey origins. For regional zones (1–8), journeys were assumed to begin five minutes' walk from a centrally located London Underground station. This assumption on 'access time' was relevant as it adds to the total journey time. For large zones, travel times were collected from multiple starting points and then averaged.

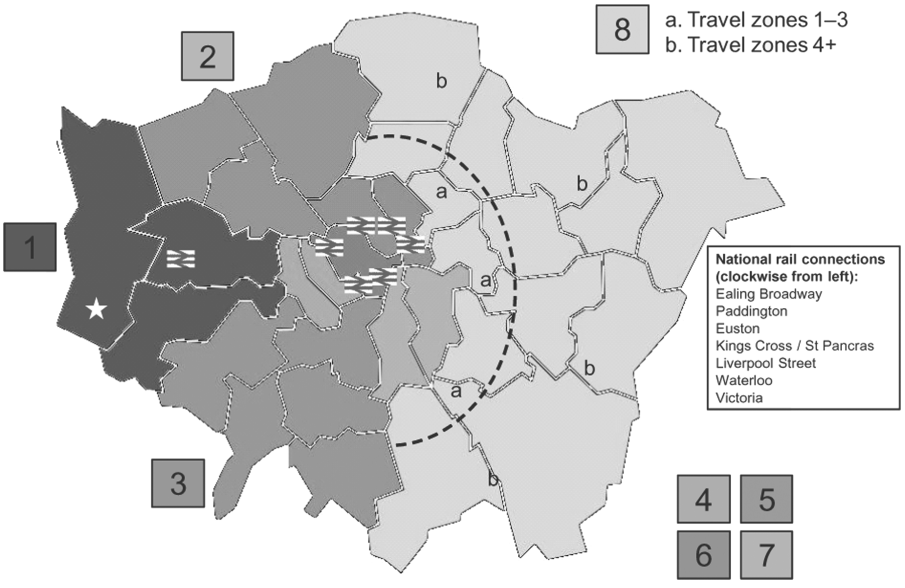

Figure 1 Geographic market definition

Notes: The segments that make up the numbered regions reflect the boundaries of each borough. For example, region 5 is made up of the Westminster Borough only. Region 8 is split into two separate journey origins, 8a and 8b, depending on in which London travel zone the journey began.

Source: Oxera

Potential transport options

Six alternative options for transport to Heathrow were identified as credible alternatives to the Express and Connect services in terms of price, journey time and frequency. Slower alternatives, such as local buses, walking or cycling were considered, but identified as being insufficiently close in terms of substitutability. The complete list of options considered was Express, Connect, park and fly, kiss and fly, black cab, minicab, coach and London Underground. Park and fly is defined as driving to and parking at the airport; it was assumed that a mid-range priced car park was chosen. Kiss and fly is defined as being driven to the airport by a friend or relative and dropped directly at the terminal. Black cab refers to a taxi hailed on the street, while minicab refers to a pre-booked taxi.

For each mode, six characteristics were considered: fare, access cost, access time, journey time, egress time and waiting time. Access time is defined as the time from the journey origin to reaching the main mode of transport (including any initial walking distance, assumed to be five minutes to the nearest Tube station in many cases). Egress time is defined as the time from the main mode of transport's destination to the terminal building. Waiting time is defined as the average waiting time between services of the main mode of transport. It was assumed that the London Underground was always chosen as the mode of transport to reach the starting point of the main mode of transport (ie Paddington Station for Express and Connect, or Victoria Station for coach). Table 1 gives an overview of the main modes of transport and their broad characteristics.

As Table 1 shows, the offerings across modes of transport are highly differentiated. Choices vary from high-cost offerings (taxi or park and fly) to low-cost offerings (coach or Tube); and from low journey-time offerings (Express or

Table 1 Modes of transport and their characteristics

Mode	*Relative fare*	*Access cost*	*Access time*	*Journey time*	*Egress time*	*Waiting time*
Express	Medium	Tube price	Tube plus five-minute walk	Low	Dependent on terminal	Medium
Connect	Medium	Tube price	Tube plus five-minute walk	Low–medium	Dependent on terminal	Medium
Park and fly	Very high	None	None	Medium	Dependent on terminal	None
Kiss and fly	Low	None	None	Medium	Low	None
Black cab	High	None	None	Medium	Low	None
Minicab	High	None	None	Medium	Low	None
Coach	Low	Tube price	Tube plus five-minute walk	High	Dependent on terminal	High
London Underground	Very low	None	Five-minute walk	High	Dependent on terminal	Low

Note: The park-and-fly fare includes the average cost of parking for a two-week holiday.
Source: Oxera

Connect) to high journey-time offerings (coach or Tube). Other factors beyond these six attributes also differentiate the offerings, eg brand value, comfort and ease of use.

Passenger demographics

Different types of passenger are expected to have different preferences for modes of transport. To reflect this in the forecasts, consideration was given to the demographics and characteristics that individual passengers may have. Passengers were categorised across the following demographics:

- travel purpose (business versus leisure);
- group size (1, 2, 3+ passengers);
- UK resident status (resident versus non-resident);
- income (high versus low).

This gave rise to 24 sub-groups, each of which was analysed separately using the methodology outlined below.

METHODOLOGY

Creating the forecasting framework required three key building blocks:

- a survey;
- statistical analysis of the survey results; and
- construction of an interactive modelling tool.

Surveying passengers at Heathrow Airport

A survey of 1,000 passengers travelling to or from Heathrow was undertaken during the summer of 2009. The period included two weeks before and two weeks during the school summer break. Passengers were drawn from the various departure lounges across the five terminals with the help of BAA's market research team. Fixed quotas for the proportion of respondents per terminal were enforced to ensure that the sample was representative of the airport as a whole. Respondents were initially filtered via a

series of questions so that only those who satisfied the market definition criteria (as discussed above) were asked the main body of questions.

The main body of the survey was split into two sections: one series of revealed-preference questions and another of stated-preference questions. The former asked about actual, historical behaviour of respondents, eg 'How did you travel to the airport today?' The latter asked questions about future or hypothetical intentions, eg 'How might you travel to the airport tomorrow?'

The factual information ascertained from the revealed-preference questions had two purposes. First and foremost, it was used to inform the stated-preference questions. Using factual information on each respondent (eg their journey origin) allowed the hypothetical questions to be personalised so that these questions were as realistic as possible. For example, the simple example given above ('How might you travel to the airport tomorrow?') is likely to elicit a more realistic answer if the available choices are realistic (eg with a travel time by car that accurately reflects the respondent's distance from the airport). Field and desk research were used to create a database of realistic journey times.

A second use for the revealed-preference questions was to gain information for Heathrow Express's wider market research purposes.

Stated-preference survey techniques

Stated-preference techniques enable researchers to understand what passengers (or equivalently, customers) would do in hypothetical situations, ie they enable researchers to ask, in a sophisticated way (avoiding response bias as far as possible), what people would do in a given situation. This can provide powerful insights into customer willingness to pay for changes in service quality, what they would do if a new piece of infrastructure were available, and so on. In this case, it was important to know how passengers would react to changes in price and other operational characteristics, such as frequency, in both the Express and Connect services, and the competing modes, such as taxi.

The process of obtaining the information from a stated-preference survey consists of two parts: conducting the survey and obtaining the data, and econometric/statistical analysis (see the following section).

A stated-preference survey is often conducted face to face with the respondent, with the aid of a computer, or over the internet (such surveys are known as computer-aided personal interviewing surveys). Respondents were asked to choose repeatedly between several options (see Figure 2 for an example), with the characteristics of the options changing slightly each time. The options that the respondent was given were calibrated to be as realistic as possible through the use of the revealed-preference data, as discussed above. This calibration should result in the respondent engaging with the survey and providing

Option A	*Option B*
• Price: £10	• Price: £12
• Brand: Y	• Brand: X
• Quality: Three	• Quality: Two
• Four trains per hour	• Two trains per hour

Figure 2 Choice screen
Note: This is an example of a simplified choice screen, it is not the screen used in the survey reported in this paper.
Source: Oxera

robust results. Of course, the design of the survey was one of the key aspects of the analysis, which should be carefully considered in any analysis of this type to ensure that the survey data are as robust as possible.

The use of this technique enables large volumes of data to be compiled from relatively few respondents, which provides a cost-effective way of generating the data required for the analysis. In this case, the survey data were used to help understand how passengers might change their access decisions should different factors vary. For example, how many passengers would change their mode of travel to the Connect service if the frequency were to be increased. Economists use the concept of elasticities to describe these changes, where the elasticity of demand with respect to A (price, frequency etc) is defined as the percentage change in demand divided by the percentage change in A. Stated-preference surveys enable researchers to estimate these elasticities by fitting a statistical model to the data.

Analysing survey data

A number of different statistical models can be used to analyse the results of stated-preference surveys. In this case, the multinomial logit model was used.[1] This model works by assigning a probability to a respondent picking a particular mode of transport to access Heathrow, eg Express or taxi. The probability of a customer using a particular mode can be influenced by the characteristics of the respondent, eg age and journey purpose. Using this model, an equation was estimated to model the probability that a consumer travels by a given mode as a function of access time, access cost, egress time, journey time, access journey fare, main journey fare and income. Equation 1 is as follows:

$$\begin{aligned} &Prob(Y_i = j) \\ &= \text{f (access time, egress time,} \\ &\text{journey time, access journey} \\ &\text{fare, main journey fare, income, ...")} \end{aligned} \quad (1)$$

Equation 2 presents how the probability of mode choice is calculated using the multinomial logit approach:

$$Prob(Y_i = j) = \frac{exp^{\beta'_j x_i}}{\sum_{j=1}^{N} exp^{\beta'_j x_i}} \quad (2)$$

where Y_i is the mode chosen by passenger i to access the airport of all the options which were available to them; j, β_j are the model parameters for option j; and x_i is characteristic x for passenger i, eg journey time. Note that the stated-preference survey changes the values of x slightly for each consecutive question (where appropriate). Elasticities can be derived using the estimates of the model parameters (βs), which were used in the forecasting model as described below. The analysis was conducted for 24 separate demographic groups, ie a separate equation was estimated for each demographic group. This enabled the identification of groups that were particularly sensitive to changes in different variables, eg high-income leisure travellers are less sensitive to changes in travel cost than low-income leisure travellers. When the statistical analysis was completed, the elasticity estimates were used as one input into the interactive spreadsheet model, which produced demand and revenue forecasts.

Interactive modelling

Outputs of the statistical analysis and additional third-party data, eg from Heathrow, were the essential inputs to the forecasting model. The model itself was

designed as an interactive spreadsheet. Figure 3 illustrates the model structure.

As Figure 3 shows, the two main inputs are the survey and the Heathrow passenger forecasts. Analysis of the former leads to data on current market shares and estimates of consumers' sensitivity to modal attributes. The latter provides the model with a baseline for the total number of potential passengers that could ever take Heathrow Express services in a given month. As this input is itself a forecast, it is subject to its own uncertainty and margin of error. Necessarily, this uncertainty also applies to the eventual forecasts for Heathrow Express services that are based on the Heathrow passenger numbers. By analysing the historical passenger number data, the trends and seasonal patterns of air demand have been incorporated into the forecasts.

Estimates of how sensitive customers are to changes in modal attributes and the current market shares of each transport mode allow the model to be calibrated, which is the final process that combines all the input data. Calibration ensures that the results from the statistical analysis are aligned with the factual market shares. In practice, an optimisation algorithm is iteratively applied until the model minimises its forecast error in the current period.

Baseline forecasts — ie estimates of how many passengers will travel on each transport mode, assuming that no factors other than airport traveller numbers change each month — are calculated by applying the market shares to the relevant proportion of the Heathrow passenger forecasts. This gives a benchmark of future passengers and revenues for each mode.

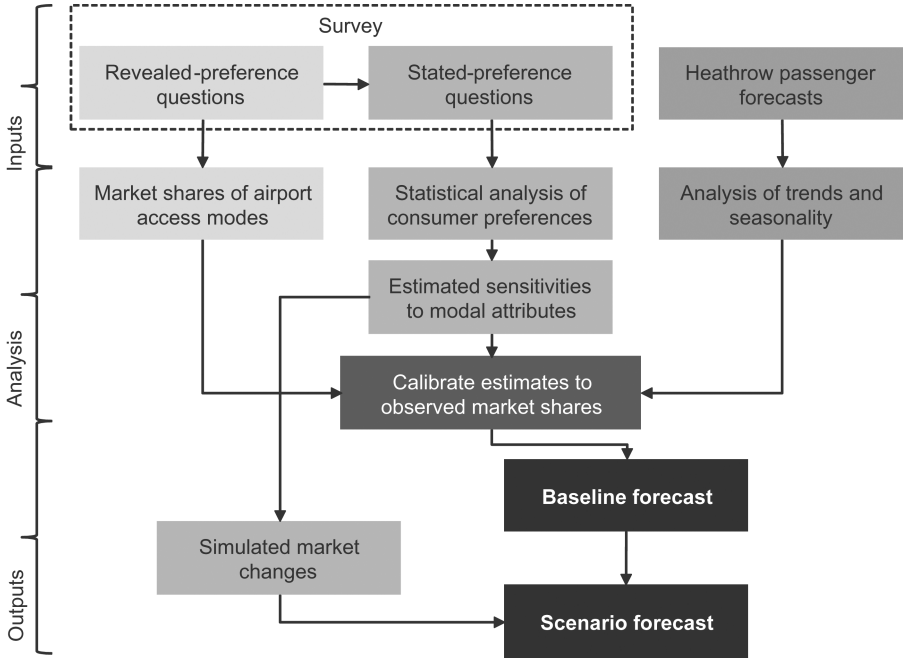

Figure 3 Stylised forecasting model — Inputs, analysis and outputs
Source: Oxera

The scenario forecast is calculated by simulating changes in the market and evaluating the implications for the market shares, and thus for passenger numbers and revenues. For business planning, various scenario forecasts can be compared with the baseline ('no change') forecast. This allows an assessment of the future revenue streams. Examples of parameters in the model that can be adjusted to simulate future market changes include:

- changes in ticket prices for each mode of transport;
- changes in travel time and frequency of service for each mode of transport;
- introduction of additional ticket types for Express and Connect;
- airline migration between terminals;
- changes in income levels between countries.

Some of these are parameters over which Heathrow Express has control (eg pricing), while others are parameters that may have changed since the time of the survey (eg coach frequency). Each simulation can include one or more of these aspects in the forecast passenger numbers and revenues.

FINDINGS

This section is split into findings from the survey and findings from the forecasting model.

Survey evidence

Evidence from each section of the survey is considered separately below.

Revealed-preference findings

The revealed-preference questions provide information on the factual behaviour of customers in the market at the point in time of the survey. This was a useful market research exercise in itself, and was also used to personalise the stated-preference questions to each respondent. The most common mode of transport was found to be the London Underground network, with 42 per cent of survey respondents having used that mode on the day of the survey. This was followed by minicab (20 per cent) and Express standard class (17 per cent). The majority of passengers originated their Heathrow journeys in central London (88 per cent); the remainder of passengers originated their journey outside London, but came via a mainline London rail station. Within London, the Westminster region was stated as the most prevalent journey origin (22 per cent), compared with the west central (15 per cent) and the north-east central and City (14 per cent) areas. Figure 4 illustrates the full modal and origin splits at the time of the survey.

Another important dimension revealed by the survey was the split between business and leisure passengers. Differences in the time and money trade-offs that individuals make were expected between the two groups. These innate preferences are likely to affect modal choices and the level of response to changes in the market (eg price rises). The survey revealed that 77 per cent of customers were travelling for leisure purposes. Variation in this proportion by current travel mode provides indicative evidence of the differences in the time and money trade-off between the two groups (see Figure 5).

The variation in business and leisure mix by current choice of transport was high, ranging from almost 50 per cent business on Express standard class to 0 per cent for coach. Figure 5 shows a rough pattern between the business passenger proportion and average journey time,

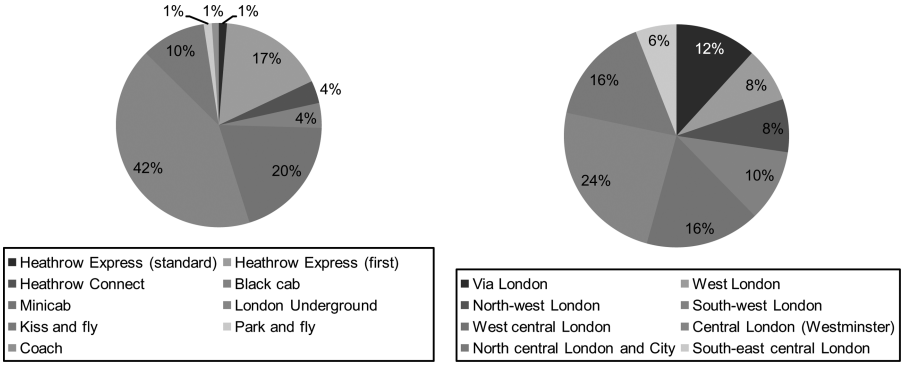

Figure 4 Modal split and origin split estimated at the time of the survey (August 2009)
Source: Oxera analysis

with the faster modes of transport generally attracting more business passengers. For instance, the average business proportion for modes taking under or around one hour on average was 29 per cent, compared with 17 per cent for the other modes; however, there were exceptions to this such as the car options, being fast but having low proportions of business passengers. The revealed-preference data alone were not sufficient to untangle the factors that determine individuals' modal choices.

Stated-preference findings

The stated-preference exercise allowed customer preferences and their sensitivity to different modal characteristics to be quantified. This approach goes beyond observing statistics such as those presented in Figure 4. Instead, it attempts to isolate

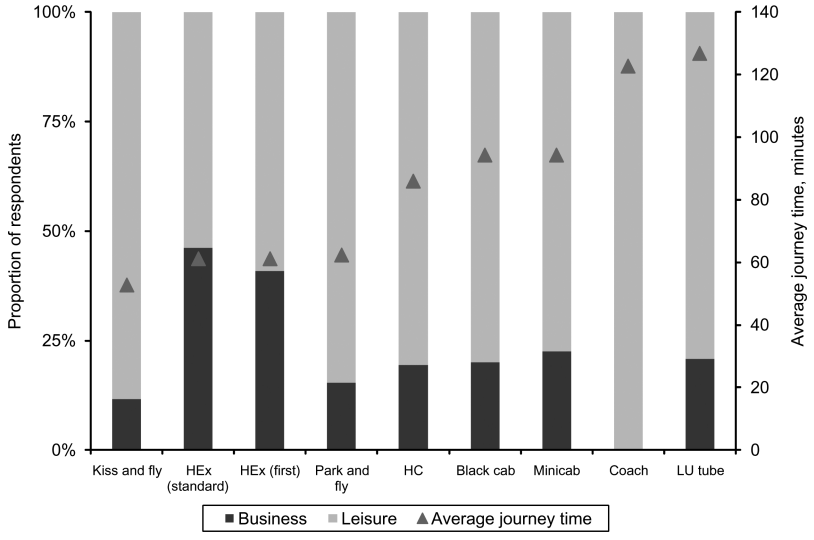

Figure 5 Business and leisure splits by transport mode
Note: HEx is the Express service; HC is the Connect service; LU tube is London Underground tube. Park and fly includes the average cost of parking for a two-week period.
Source: Oxera analysis

the individual impact of specific modal attributes (eg price) on decisions. At a high level, this part of the survey highlighted customers' strong preferences for their current mode of transport. This was reflected in the finding that the majority of passengers were not swayed away from repeatedly selecting their current choice.

Brand value and loyalty schemes are one potential explanation for this modal allegiance. The Express service has invested significant sums in marketing over the past five years, and is now listed as one of the top 500 superbrands in the UK.[2] Such branding is expected to enhance the loyalty of customers. London Underground, on the other hand, offers its users a discount for purchasing tickets that cover periods of time (travelcards). Passengers who already have such a ticket (eg for inter-London commuting) can travel to Heathrow without incurring any additional cost and thus effectively travel without incurring further cash expense. The fact that many Londoners will typically have this effective discount will increase their allegiance to the London Underground. (Oyster cards were also accounted for in the analysis by reflecting this lower (but not zero) cost in the offerings.)

A second explanation for the strong preferences may be the fact that many groups of customers prize certain modal attributes. Given the strong differences in modal attributes — see Table 1 — this leads to many customers always choosing based on one factor. For example, a journey from the most common origin, Westminster, is expected to take around 60 minutes on average via London Underground and 45 minutes via Express (including an initial trip to Paddington). If a passenger's priority is time, a large increase in journey time would be necessary before the modal choice would be affected. Alternatively, if a passenger's priority is ease of use (eg a non-resident business user) then a minicab, at around 45 minutes, may offer strong advantages that price and time changes will not affect. Furthermore, even though the taxi journey is comparable with the Express service in terms of time, the journey time via taxi is considerably less certain. The fact that taxis can command up to double the Express fare reflects these other factors (ease of use, comfort, no access time or cost).

The statistical analysis of the stated-preference exercise leads to elasticity estimates. Estimates are calculated for different demographic sub-groups of the respondents. The sensitivity of customers to time and fare, sometimes referred to as 'elasticities', are shown in Figure 6. The numbers in Figure 6 show the likely reduction in demand for a mode of transport given a particular change in journey time or fare. For example, in the case of high-income business travellers, a £10 increase in travel cost is estimated to have an impact of –7 per cent on demand. Using the full range of estimates, it is possible to estimate to which mode the reduced demand for one mode of transport would switch. There are several characteristics to note from the estimates:

- All passengers are more sensitive to changes in price than changes in time.
- Leisure passengers are more sensitive to cost than business passengers.
- Business passengers are more sensitive to time than leisure passengers.
- Low-income passengers are more sensitive to cost than high-income passengers.
- The relative sensitivity to cost and time is greater for leisure passengers than business passengers. For example, for high-income leisure passengers, it

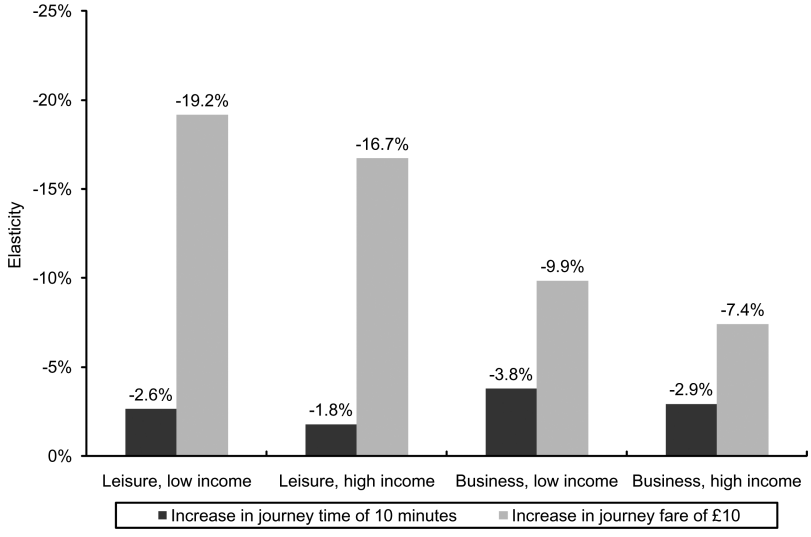

Figure 6 Responsiveness of different customer groups to changes in journey time and travel cost
Notes: Elasticities are approximate averages across all modes of transport. Income groups were specified relative to the median in the sample.
Source: Oxera analysis

would require a change in travel time of around ten times larger than a change in travel cost to elicit a similar demand response; for high-income business passengers, it would only require a change in travel time of around double that of travel cost to elicit a similar demand response.

Elasticities were calculated for a wider range of demographic groups than presented in Figure 6. Group size (1, 2, 3+ passengers) and UK resident status were also used to distinguish between responsiveness levels. These elasticities drive the forecasting model's ability to predict how changes in the time and fare values will affect future demand for each mode. The relative size of the demographic groups has been determined by the revealed-preference part of the survey. Implicitly, the forecasting model assumes that these proportions remain constant from the time of the survey and do not vary over the course of the forecast period. Repeating the survey exercise at different points during the year and at regular intervals (to detect any shifts in the demographics over time) would allow this assumption to be relaxed.

Insights from forecasting

The complete forecasting model allows a scenario analysis of any future or potential changes that may affect the Heathrow access market. This model is being used by Heathrow Express in its business planning. Insights from its usage to date suggest three key messages that may hold for other airports:

- *The competitive landscape is one of the most important drivers of passenger access decisions.* Heathrow's highly differentiated airport access options mean that customers display strong allegiance to particular modes. This has been enhanced by brand value and loyalty schemes. Changes to fare or journey time within a reasonable range (up to 30 per cent)

may not have a major impact on the modal choices. This assumes that customers respond in a rational fashion only and perceptions of unfair and/or repeated fare rises may damage the brand value; however, new modal options may cause major shifts in modal choices.

- *Airline migration between terminals may have a noticeable effect on customer choices.* The geographic features of Heathrow Airport mean that travel times from central London vary substantially with the destination terminal. For example, the egress time from the coach station is around five minutes for Terminals 1–3 compared with more than 15 minutes for Terminals 4 and 5. Other modes also have egress times that vary by terminal and, for the faster modes of transport (eg Express service), this can materially affect the total journey time. Terminal closures or airline migration can result in large groups of customers being subjected to changes in journey times, which has implications for both airport planning and the design of airport access transport.
- *Changes in the wider economy may only have a limited impact on modal choices.* Customers' modal choices are less responsive to changes in aggregate income measures (eg GDP) relative to other factors (eg fares). For most transport modes, income was estimated as having no role in the decision-making process. This suggests that, although the demand for air travel as a whole may well be closely linked to the economic climate, choices between airport access travel modes may not be. For example, if air travel falls during a recession, the demand for airport access as a whole is likely to reduce, but for those passengers who do travel, their modal choice may be unaffected.

CLOSING REMARKS

This paper has illustrated how consumer surveys can be used to understand consumer decision making. The techniques themselves are more widely applicable and can be used across a range of different contexts. Combining survey techniques with statistical analysis can lead to sophisticated business planning tools. Such tools can help airport access operators (and, indeed, airport operators and users more generally) to plan for the future.

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