Estimating Air Travel Demand Elasticities

InterVISTAS

strategic
transportation
& tourism
solutions

Final Report

Executive Summary

This report summarises analysis which examines fare elasticities in the passenger aviation market – the demand response by air passengers to fare increases or decreases. The aim of the study is to provide robust elasticity estimates to address policy issues related to liberalisation, airport charges, taxation, emissions schemes, etc. The key study components were:

Extensive Literature Review

A literature review was conducted to examine previous research on air fare elasticities over the last 25 years. Over 23 papers were reviewed, from the following conclusions were developed:

- **Sensitivity to Air Fare Changes**
  All of the studies reviewed, spanning a period of over 25 years, found that there was a significant demand response to changes in air fares, such that increases in air fare lead to lower passenger traffic demand. The consistency of this result strongly indicates that any policy action that results in higher fares (e.g., taxes, increased landing fees) will result in a decline in demand. The actual decline in demand will depend on a number of factors, as discussed below.

- **Business Versus Leisure Passengers**
  In general, the results show that, all else being equal, business travellers are less sensitive to fare changes (less elastic) than leisure travellers. Intuitively, this result is plausible – business travellers generally have less flexibility to postpone or cancel their travel than leisure travellers. Nevertheless, the studies do show that even business travel will decline in the face of fare increases, albeit not to the say expect as leisure travel.

- **Short-Haul Versus Long-Haul Travel**
  Another fairly consistent finding was that fare elasticities on short-haul routes were generally higher than on long-haul routes. In par, this reflects the opportunity for inter-modal substitution on short haul routes (e.g., travellers can switch to rail or car in response to air fare increases).

- **Carrier Versus Market Versus National Elasticities**
  Some of the studies supported the idea that the demand elasticity faced by individual air carriers is higher than that faced by the whole market. For example, Oum, Zhang, and Zhang (1993) estimated firm-specific elasticities in the U.S. and estimated values ranging from -1.24 to -2.34, while studies estimating market or route elasticities ranged from -0.6 to -1.8. In contrast, Alperovich and Machnes (1994) and Njegovan (2006) used national-level measures of air travel in Israel and the UK respectively and produced even lower elasticity values (-0.27 and -0.7, respectively).

- **Income Elasticities**
  Many of the studies also including an income variable, in part, to isolate the effects of a shift *along* the demand curve (such as would be caused by a price change) from the effect of a shift *in* the demand curve (as might be caused by a change in income levels). The studies including the income term all produced positive income elasticities, as would be expected (air travel increases as incomes increase). Virtually all of these studies estimated income elasticities above one, generally between +1 and +2. This indicates air travel increases at a higher rate than incomes.

Econometric Analysis of a Various Datasets to Estimate Additional Elasticities

Econometric analysis was conducted on three different datasets:

- **U.S. DB1A data (U.S. domestic).** A U.S. government database with a 10% random sampling of all tickets purchased in the U.S. for travel on U.S. airlines going back to 1993. Quarterly traffic and fare data was taken for the period from 1994 Q1 to 2005 Q4 for the top 1000 city pair routes (by traffic).
- **PaxIS (worldwide traffic).** This database captures market data through IATA's Billing and Settlement Plan (BSP) and uses statistical estimates to address missing direct sales, low cost carriers, charter flight operators, under-represented BSP markets, and non-BSP markets. The advantage of data series is that traffic and fare estimates are available for routes around the world. However, this dataset is limited by the short time series (data is available from 2005).
- **International Passenger Survey (UK outbound traffic).** The International Passenger Survey (IPS) is a survey of a random sample of passengers entering or leaving the UK by air, sea or the Channel Tunnel. This report exclusively used *outbound* leisure air passenger traffic data from the IPS. Quarterly traffic and fare data was taken for the period from 2003 Q2 to 2006 Q2.

Over 500 regression models were estimated. The key results are provided in the full report.

General Guidelines on Air Fare Elasticity Values

The literature review and econometric analysis demonstrated that air fares elasticities vary depending on a number of factors such as geography, distance and level of aggregation. Ultimately, the determining the right elasticity value to use depends on the type of question being asked. Examining the traffic impact of a fare increase on a given route requires a different elasticity than when examining the impact of an across-the-board fare increase on all routes in a country or region.

In this study, the results of the literature review and econometric analysis were synthesised to develop some general guidelines on the use and application of air fare elasticities. While the literature review and econometrics did not provide a full set of elasticities covering all possibilities, they did provide sufficient information to infer a full set of elasticities.

The following elasticities have been developed as a synthesis of the literature review and the econometric analysis. The approach taken was to develop three base elasticities reflecting the levels of aggregation (route, national and pan-national level). Multiplicative adjustors were then developed to adjust the elasticities to reflect specific markets.

Base Elasticities

The base elasticities were developed from the analysis of the various datasets and the generalised findings from the literature review.

- **Route/Market Level: -1.4**
  The literature review found that elasticities at the route or market level in the range of -1.2 to -1.5. This was verified by our own econometric analysis of the U.S. DB1A where it was possible to capture the effects of route substitution through the use of route dummy variables and experiments using variables capturing the price of route substitutes. These regressions

produced fare elasticities in the region of -1.4, which has been used as the base elasticity at the route level.

- **National Level: - 0.8**
  The econometric analysis of all three datasets found that without the route substitution term, the analysis produced elasticities in the region of -0.8. This elasticity is essentially a combination of the route own price elasticity with cross price elasticities when all national routes have prices which vary identically. Thus, the less elastic result is consistent with observations that part of the so called price elasticity observed from LCCs at secondary airports involves diversion from primary airports in the catchment area, or from diversion from trips on other routes. When this is controlled for, LCCs have a lower level of market stimulation, consistent with less elastic national elasticities.

- **Pan-National Level: -0.6**
  This result is conceptually derived from the same mathematics which show the relationship between route and national elasticities. In this case, a much broader set of routes (e.g., across a continent) experience an identical price change.

Thus the route elasticity is applicable to a situation where the price of an individual route changes. For example, the fare on Warsaw-Coventry increases but the price of routes from Warsaw to other UK and other European points remain unchanged. The national elasticity applies to situations such as all Warsaw-UK prices changing identically, but the price from Warsaw to other European points being unchanged. Pan-national changes apply where prices from Warsaw to all points in Europe change identically.

Geographic Aviation Market

The econometric analysis of the IATA PaxIS data found considerable differences between aviation markets. Based on this analysis, the following elasticity multipliers have been developed:

Geographic Market	Elasticity Multiplier	Comment
Intra North America	1.00	Most research uses US data. This is our reference point.
Intra Europe	1.40	Shorter average distances, observed use of very low fares resulting great market stimulation. The significantly low fares in Europe (relative to North America) are consistent with higher elasticities in Europe. Traditionally the European market had high charter carrier share, which today is merely being converted to very low fare LCCs.
Intra Asia	0.95	The LCC phenomena is emerging in Asia, but modest sized middle class in many markets suggests somewhat less elastic than in North America
Intra Sub-Sahara Africa	0.60	These economies have limited middle class, resulting in high weight on higher income individuals who are less elastic
Intra South America	1.25	There is an emerging middle class which makes the market more elastic than sub-Saraha Africa,

Geographic Market	Elasticity Multiplier	Comment
		and LCCs are emerging in Brazil, Chile, and Mexico.
Trans Atlantic (North America – Europe)	1.20	This market is often observed to have fares only slightly higher than domestic U.S. fares, consistent with high price elasticity. Market has been well developed by charter carriers, consistent with high price elasticity. Price is likely more important than frequency in this market than in domestic U.S.
Trans Pacific (North America – Asia)	0.60	TransPacific has had no charter services, and continues to have major markets (Japan, China) with less liberal pricing provisions. Some emergence of long haul LCCs (e.g., Oasis) but at present this market seems to be less elastic than domestic US and than the well developed trans Atlantic which serves a substantial middle class
Europe – Asia	0.90	This market has marginally lower elasticities than the U.S. domestic market.

Short-Haul/Long-Haul Adjustment

The literature review consistently found that the fare elasticities on short-haul routes were generally higher than on long-haul routes. In part, this reflects the opportunity for inter-modal substitution on short haul routes (e.g., travellers can switch to rail or car in response to air fare increases). While the geographic breakdowns capture some variation by length of haul, there is still considerable variation within each market. In particular, very short-haul flights (approximately less than 1 hour flight time) are subject to greater competition from other modes.

On this basis, the following short-haul multiplicative adjustors can be applied to analysis of short-haul routes:

- Short haul: 1.1 (+10%).

Note that this adjustor does not apply to analysis of the trans-Atlantic and trans-Pacific market, which are considered entirely long haul, with virtually no opportunity for modal substitution.

Application of Adjustors

Elasticities for different situations can be developed by selecting the relevant base elasticity and applying the relevant multipliers, for example:

1.   To examine the impact of an EU-wide aviation tax on short-haul markets, the elasticity would be developed as follows:

    - Base multiplier: -0.6 (pan-national)

    - Geographic market: 1.4 (Intra Europe)

    - Short-haul adjustor: 1.1

    The multiplier would then be calculated as: -0.6 x 1.4 x 1.1 = -0.924.

2.   To examine the impact of a UK tax on aviation on Trans Atlantic traffic, the elasticity
        should be developed as follows:

   - Base multiplier: -0.8 (national)

   - Geographic market: 1.2 (Trans Atlantic)

   The multiplier would then be calculated as: -0.8 x 1.2 = -0.96.

3.   To examine the impact of impact of an increase in airport landing fees on a particular
        short-haul route in Asia, the elasticity should be developed as follows:

   - Base multiplier: -1.4 (route)

   - Geographic market: 0.95 (Intra Asia)

   - Short-haul adjustor: 1.1

   The multiplier would then be calculated as: -1.4 x 0.95 x 1.1 = -1.46.

The full range of possible elasticities is presented in the table below. The route level elasticities
range from -0.84 to -1.96 depending on the geographic market and length of haul. The national
level elasticities range from -0.48 to -1.23, while the pan-national elasticities range from -0.36 to -
0.92.

	Route/Market Level		National Level		Pan-National Level	
	Short-haul	Long-haul	Short-haul	Long-haul	Short-haul	Long-haul
Intra North America	-1.54	-1.40	-0.88	-0.80	-0.66	-0.60
Intra Europe	-1.96*	-1.96	-1.23	-1.12	-0.92	-0.84
Intra Asia	-1.46	-1.33	-0.84	-0.76	-0.63	-0.57
Intra Sub-Sahara Africa	-0.92	-0.84	-0.53	-0.48	-0.40	-0.36
Intra South America	-1.93	-1.75	-1.10	-1.00	-0.83	-0.75
Trans Atlantic (North America – Europe)	-1.85	-1.68	-1.06	-0.96	-0.79	-0.72
Trans Pacific (North America – Asia)	-0.92	-0.84	-0.53	-0.48	-0.40	-0.36
Europe-Asia	-1.39	-1.26	-0.79	-0.72	-0.59	-0.54

*The short-haul adjustor has not been applied to the Intra Europe short-haul elasticity in order to maintain elasticities below 2.0

Conclusions – Reconciling the Findings

As described in the literature review, the consensus among most aviation economists has been that demand for airline services is generally both price and income elastic. The latter suggests that air transport has the characteristics of a luxury good.[1] A natural question is how an income elastic good can also be price elastic.

This report has revealed that there are different price elasticities associated with different uses. When consumers are choosing between airlines on a route, or even between destinations for holidays, conference locations, etc., there is a degree of price elasticity for airline seats. However, if all competitors on a route, or if a wide range of routes all experience the same proportionate price increase, the demand for airline services becomes less elastic. As a price increase is extended to ever larger groups of competing airlines or competing destinations, then the overall demand for air travel is revealed to be somewhat inelastic.

The implications of this are as follows:

- For an airline on a given route, increasing price is likely to result in a more than proportionate decrease in air travel. Lower fares will greatly stimulate traffic and raise revenues.
  (i.e., airline specific fare changes are price elastic).

- If all airlines on a given route increase fares by the same amount (e.g., due to the imposition of passenger based airport fees that are passed on to the consumer), then the decrease in traffic will be less than the former case.

- If all airlines on a wide set of routes increase fares by roughly similar amounts (e.g., due to the imposition of new market-wide taxes or to the working through of higher fuel or security costs) then the decrease in traffic may be less or much less than proportional to the increase in fares.
  (i.e., general increases in airline fares across a broad range of markets appear to be price inelastic.)

Thus, the particular elasticity value to be used for analysing price effects in airline markets depends on the question being asked. The narrower the applicability of a price change, the more elastic the response. The more general the applicability of a price change (perhaps due to higher costs or taxes) the less elastic the response.

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[1] "Luxury good" is a term of art in economics that merely indicates that demand increases more than proportionately with income. Education, medical services, entertainment and other goods fit this category. The vernacular use of the term "luxury" may have value judgements attached, which are not intentional in the context of this report.

Glossary of Terms/Abbreviations

Autoregressive Distributed Lag: A regression technique using lagged values of the dependent and/or independent variable(s)

ARDL: Autoregressive Distributed Lag

BSP: IATA's Billing and Settlement Plan.

CAA: The United Kingdom Civil Aviation Authority

Consumer Price Index (CPI): A measure of inflation within a given country using consumer prices of a basket of goods

Cross Price Elasticity: The sensitivity of demand for a particular good to changes in the price of another good

DB1B: U.S. Department of Transport Database 1B. One of three databases used in this study.

Demand Elasticity: See Price Elasticity

Dummy Variable: An explanatory variable in regression analysis used to capture qualitative factors. Assumes the value of '1' when the factor is observed and '0' otherwise

Fare Elasticity: See Price Elasticity

Goodness of Fit: A measure of the explanatory variables' ability in regression analysis to explain changes in the dependent variable. Assumes a value between 0 and 1, with 1 denoting a perfectly explained relationship and 0 reflecting no relationship.

Gross domestic product (GDP): A measure of the money value of final goods and services produced as a result of economic activity in the nation.

Income Elasticity: The sensitivity of demand for a good to changes in income.

IPS: International Passenger Survey. One of three databases used in this study.

LCC: Low Cost Carrier

Luxury Good: A good with an income elasticity above one.

O/D: Origin/Destination

Ordinary Least Squares (OLS): A regression technique that minimizes the sum of squared residuals from the explanatory variables.

PaxIS: IATA passenger intelligence services. One of three databases used in this study.

Population Elasticity: The sensitivity of demand for a good to changes in population size.

Price Elasticity: Consumers' sensitivity to price changes for a particular good or service.

Regression: A statistical process of relating one or more variables with another.

R-Squared: See Goodness of Fit

Two-Stage Least Squares (2SLS): A regression technique used when certain OLS assumptions are violated.

U.S. DOT: The United States Department of Transportation

Table of Contents

1.0 Introduction

This report documents the findings from extensive research undertaken by Inter*VISTAS* Consulting Inc. to determine air travel demand elasticities applicable to a wide range of air transport markets. The research included:

- A literature review of previous research into air travel demand elasticities.
- Comprehensive econometric analysis using three major datasets:
    - The U.S. DB1B database of domestic air travel 1994-2005.
    - The IATA PaxIS database of world air travel from 2005 onwards.
    - The UK International Passenger Survey (IPS) of outbound air travel from 2003 to 2006.
- Development of a set of guidelines, and guideline elasticities, to be applied to the analysis of different air markets, broken down by geographic market, length of haul and level of aggregation (route, national and pan-national).

1.1   Report Outline

The report is structured as follows:

- **Chapter 2** provides a general discussion on elasticity concepts, particularly in the context of air transportation.
- **Chapter 3** summarises the findings from a literature review of previous research work on air transport demand elasticities.
- **Chapter 4** details the econometric analysis of three different dataset, including the elasticities estimated.
- **Chapter 5** uses the results of the literature review and econometric analysis to develop guidelines for the application of air fare elasticities.

Additional information on the study methodology and study findings is provided in the appendices.

2.0 Elasticity Concepts

In economics, elasticity measures the response or sensitivity of one economic variable to the change in another economic variable. Elasticities are a useful concept as they allow decision makers insight into the impact of different economic actions. A common elasticity concept is *demand elasticity*. This measures the change in quantify demanded of a particular good or service as result of changes to other economic variables, such as the price of the that good or service, the price of competing or complimentary goods/services, income levels, taxes, etc.[2]

The section below outline three elasticity concepts that are relevant to this study: price elasticity, cross price elasticity and income elasticity.

2.1   Price Elasticity

Price elasticity is a measure economists use to capture consumers' sensitivity to price changes for a particular good or service. The price elasticity is defined as:

$$\text{Price Elasticity} = \frac{\text{\% Change in Quantity Demanded}}{\text{\% Change in Price}}$$

Since the quantity demanded generally decreases when the price increases, this ratio is usually expected to be negative. However, sometimes analysts report the *absolute* value and therefore the elasticity is often quoted as a positive number.[3]

As an example, suppose a good has a price elasticity of -0.6; a 10% increase in the price will result in an 6% decline in the quantity demanded. For a good with a price elasticity of -1.2, a 10% increase in the price will result in a 12% decline in the quantity demanded.

Goods with elasticities less than one in absolute value are commonly referred to as having inelastic or price insensitive demand – the proportional change in quantity demanded will be less than the proportional change in price. In this situation, increasing the price will increase the revenue of the producer of the good, since the revenue lost by the relatively small decrease in quantity is less than the revenue gained from the higher price.

Goods with elasticities greater than one in absolute value are referred to as having elastic or price sensitive demand - the proportional change in quantity demanded will be greater than the proportional change in price. A price increase will result in a revenue decrease to the producer since the revenue lost from the resulting decrease in quantity sold is more than the revenue gained from the price increase.

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[2] A equivalent concept is supply elasticity, which measures the change in the quantity supplied as a result of changes in other economic variables, etc.

[3] As the calculation uses proportionate changes, the result is a unitless number and does not depend on the units in which the price and quantity are expressed. Therefore, elasticities for different goods or markets can be directly compared.

A number of factors affect the price elasticity of a good or service:

- Availability of substitutes: the more possible substitutes, the greater the elasticity. Note that the number of substitutes depends on how broadly one defines the product. For example, Chevrolet cars have a high price elasticity as they can be substituted by other brands of car (Ford, BMW, Honda etc). If one considers the market for cars as a whole, the elasticity for cars is lower as there are fewer substitutes (bus, taxi, cycling, etc).

- Degree of necessity or luxury: luxury products tend to have greater elasticity. Some products that initially have a low degree of necessity are habit forming and can become "necessities" to some consumers. Bread has a low elasticity as it is considered a necessity, as does tobacco because it is habit forming.

- Proportion of the purchaser's budget consumed by the item: products that consume a large portion of the purchaser's budget tend to have greater elasticity.

- Time period considered: elasticity tends to be greater over the long run because consumers have more time to adjust their behaviour. For example, short-term demand for gasoline is very inelastic (approximately -0.2)[4] as consumers have little choice but to continue consuming in order that they can travel to work, school etc., although they can cut down on some leisure or discretionary trips or use other modes. The long-term elasticity is higher (about -0.7 – still inelastic) as consumers can purchase smaller cars, move nearer to work and other behavioural changes in order to reduce consumption.

- Whether the good or service is demanded as an input into a final product or whether it is the final product (e.g., fuel is demanded as an input into production processes, transportation, etc.). If the good or service is an input into a final product then the price elasticity for that good or service will depend on the price elasticity of the final product, its cost share in the production costs, and the availability of substitutes for that good or service.

2.2 Cross Price Elasticity.

The cross price measures the sensitivity of demand for a particular good to changes in the price of another good:

$$\text{Cross Price Elasticity} = \frac{\text{\% Change in Quantity of Good A Demanded}}{\text{\% Change in Price of Good B}}$$

When the elasticity is positive, the two goods are substitutes (e.g. Coca-Cola and Pepsi); when the elasticity is negative the goods are compliments (e.g. coffee and milk).

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[4] Source: *Economics: Private and Public Choice*, James D. Gwartney and Richard L. Stroup, 1997

2.3   Income Elasticity

The income elasticity measures the sensitivity of demand for a good to changes in income:

$$\text{Income Elasticity} = \frac{\text{\% Change in Quantity Demanded}}{\text{\% Change in Income}}$$

"Normal" goods have an income elasticity between 0 and +1: the quantity demanded increases at the same or a lesser rate than the increase in income. For example, a good where a 10% increase in income results in a 0-10% increase in consumption would be considered a "normal" good.

Goods with negative elasticities are referred to as inferior goods – as a person's income increases they buy less of that good and substitute with it with better quality goods (e.g. buy branded goods rather than supermarket own-brands).

Luxury goods have an income elasticity above unity (one): consumption increases by a greater proportion than income.[5] Foreign travel is an example of such a good.

2.4   Demand Elasticities in the Context of Air Transportation

2.4.1   Level of Aggregation

In air transportation, as in many other sectors of the economy, the context in which the elasticities are considered can affect the value of the elasticities. In particular, the elasticity can vary depending on the availability of substitutes. In this study, five different levels of aggregation (representing five different contexts) have been identified, as summarised in **Figure 2-1**.

Figure 2-1: Air Transport Elasticities and the Level of Aggregation

Level of Aggregation	Description
Fare Class Level	This the most disaggregate level. In this context, travellers are choosing between different fare classes (first class, business class, full economy, discount economy, etc.) on particularly airlines. At this level, the elasticities are arguably highest. Travellers can easily switch between fare-class levels, airlines, use of another mode of travel (in some cases), or simply chose to not travel (i.e., other activities act as a substitute for air travel). For example, in response to an increase in the full economy fare on a given airline, the traveller can respond by booking a discount economy fare on the same airline, or book with another airline, or travel by another mode.
Carrier Level	The elasticities at this level of aggregation reflect the overall demand curve facing each air carrier on a given route. In situations where there are a number of air carriers serving the route, the demand

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[5] "Luxury good" is a term of art in economics that merely indicates that demand increases more than proportionately with income. Education, medical services, entertainment and other goods fit this category. The vernacular use of the term "luxury" may have value judgements attached, which are not intentional in the context of this report.

Level of Aggregation	Description
	elasticity faced by each carrier is likely to be fairly high - if an air carrier increases it fare unilaterally, it is likely to lose passengers to other carriers operating on that route.[6]
Route/Market Level	At the route or market level (e.g., Heathrow–Paris CDG or London-Paris), the elasticity response might be expected to be generally lower than at the fare class or carrier level. Travellers faced with a fare increase on all carriers serving a route (e.g., due to an increase in airport fees and charges), have fewer options for substitution. However, they can chose to travel on an alternative route (e.g., travel Gatwick-CDG or Heather-Orly rather than Heathrow-CDG), travel by another mode (in some cases), or not travel.
National Level	At the national level, fare elasticities would be expected to be lower still, as travellers have fewer options for avoiding the fare increase. For example, if a national government imposed a new or increased tax on aviation, travellers could only avoid this increase by using another mode (which may not always be possible), or not travelling (or possibly travelling elsewhere). For example, if the UK government imposed an increased tax on aviation, UK residents travelling to mainland Europe could respond by travelling by Eurostar or ferry, or by not travelling. Similarly, travellers in France could respond to the tax by travelling to the UK by rail/ferry or by travelling to another country, such as Germany or Spain.
Pan-National Level	This represents the most aggregate level considered, in which a fare increase is imposed at some pan-national level; for example, the European Union imposing an aviation tax on all its member states. In this case, the options for avoiding the fare increase are even further reduced, so therefore the elasticity would be expected to be lower.

Given the economic and policy focus of this study, the first two levels of aggregation (fare class and carrier level) are outside the scope of this study. This study focuses largely on elasticities appropriate for the route, national and pan-national level of aggregation.

2.4.2   Cross Price Elasticites

In noted previously, cross price elasticity measures the response in demand for a given good or service to changes in the price of substitute or complimentary goods and services. In each of the five levels of aggregation discussed in the previous section, differing cross elasticities exist, reflecting the various substitute options available. For example:

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[6] Even in a situation where air carrier has a monopoly on a route, it may still face a fairly high demand elasticity as connecting options can also act as a substitute. E.g., travel London-Delhi via Paris or Dubai rather than direct.

- At the fare class level, an increase in the price of the full economy fare could increase the demand for both business class tickets and discount tickets.

- At the carrier level, an unilateral increase in the fare of one particular carrier on a route can increase the demand for other carriers on the route (and the demand for connecting alternatives).

- At the route level, an increase in the cost of travel from Heathrow to CDG can increase the demand for travel on Gatwick-CDG or Heathrow-Orly.

- At the national level, an increase in the cost of air travel to/from a given country may increase demand for air travel to/from other substitute countries.

- At the pan-national level, an increase in the cost air travel to/from a particular region may increase demand for air travel to/from other regions. E.g., an increase in the cost of air travel to the EU may increase demand for air travel to the U.S.

- At all levels of aggregation, there may exist cross elasticity effects with other modes of transport. An increase in the cost of air travel may increase demand for ground transportation and vice versa.

- There may also cross elasticity effects between air travel and other leisure or consumption activities.

The degree of cross elasticity effects will differ depending on the specific circumstances involved, and in some cases may not exist at all (e.g., in long-haul markets there generally are no substitutes for air travel). It is also worth noting that while the examples above focus on substitution effects (i.e., positive cross elasticities), there may also exist complimentary (i.e., negative) cross elasticities. For example, the price of hotels may impact on the demand for air travel.

It can also be shown that the own price elasticity at one level of aggregation reflects both the own price and cross price elasticities at other levels of aggregation. For example, the price elasticity at the route level is a function of the own price and cross price elasticities at the fare class and carrier levels of aggregation.

Clearly, the cross elasticity effects and the interaction between own price and cross price elasticities at different levels of aggregation adds significant complexity to any analysis of air travel demand elasticities. Any econometric analysis of air fare elasticities needs to be clear as to which own price and cross price elasticity were being measured and controlled for. An analysis of price elasticities which does not include cross elasticity terms may represent a price elasticity at a different level of elasticity. For example, an analysis of route-level elasticities which does not control for route substitution effects may be more akin to national-level elasticity.

2.4.3 Air Fares and Total Travel Costs

Some researchers have questioned whether estimated air fare elasticities are consistent with the total cost of travel (which may also include hotel, ground transport to/from the airport, food,

entertainment, etc.) and whether any analysis of air fare elasticities should also include total travel costs.[7]   The argument around this issue can be characterised as follows:

> *Air transport typically represents approximately 25% of the total travel costs associated with leisure travel (the exact percentage varies depending on the length and type of travel). This percentage has declined in recent years, due to the development of Low Cost Carriers (LCCs). If, say, the air fare elasticity is around unity then a 10% increase in the air fare will reduce demand for travel by 10% (if the demand for air travel declines by 10%, it is anticipated that the demand for the other components of the travel package will also decline by 10%).*

> *However, a 10% increase in the air fare represents a 2.5% increase in the total cost of travel. This then implies that the demand elasticity with respect to total travel costs is:*

> *-10% / 2.5% = -4.0*

> *This represents an extremely high elasticity and one which is not matched by quantitative research of tourism demand elasticities (which generally find much lower elasticities). Therefore, there appears to be an inconsistency between the size of price elasticities estimated for the air transport industry and those estimated for the overall travel and tourism industry.*

However, there two explanations for this apparent inconsistency:

- The approach above to calculating the tourism elasticity is applicable only where there are limited opportunities for substitution. In situations where one component of a package can be substituted for an adequate alternative then the price elasticity for that component can be much higher than suggested by the price elasticity of the overall package. For example, the air transport component could be substituted with air travel on another route (e.g., flying Gatwick-CDG rather than Heathrow-CDG), travel on another mode, or air travel to another destination (e.g., flying to Italy for a ski vacation rather than flying to France).

- There is some evidence that some travellers do not fully consider the total cost of their travel but instead apply a "two-stage" process in their decision making. Travellers are induced to select a destination based on the level of air fare offered, and having booked the flight then consider the other costs associated with the travel. For example, LCCs such as Ryanair offer seat-sales with zero or very low costs (e.g., 1 pence) which have been successful in attracting passengers despite the fact that passengers will incur substantial additional costs associated with airport parking, ground transportation, accommodation, etc. While not all travellers engage in this "two-stage" process, a significant proportion may do so, which is reflected in the air fare elasticities.

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[7] For example, see the UK Civil Aviation Authority report, *Demand for Outbound Leisure Air Travel and its Key Drivers*, December 2005.

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3.0 Previous Evidence – Literature Review

3.1 Overview of the Literature

A literature of previous research into air fare demand elasticities was undertaken in order to provide a greater understanding of air fare elasticities and to aid the econometric analysis conducted later in the study. A review of this nature enables the econometrician to obtain insight into how different aspects of markets may affect results; it also can provide conceivable solutions to standard and non-standard issues that arise. In total, 22 studies were reviewed, including two-meta analyses of multiple publications. Most papers were retrieved from peer reviewed academic publications or were the product of government-related commissions. Summaries of these studies are provided in **Section 3.2.**

As can be seen in the table, the research produced a wide range of air fare elasticity estimates, depending on the markets analysed, time period, methodology and data. This illustrated by the meta-study conducted in 2002 by Gillen, Morrison, Stewart, *Air Travel Demand Elasticities: Concepts Issues and Measurement*. The range of elasticities found by the authors is summarised in **Figure 3-1**. The figure shows the range of values estimated in the studies surveyed and the most-likely value (the black dot) determined by Gillen et al. This meta-study found elasticities ranging from -0.198 to -1.743, depending on the market.

Figure 3-1: Own-Price Elasticities of Demand (Gillen et al., 2002)
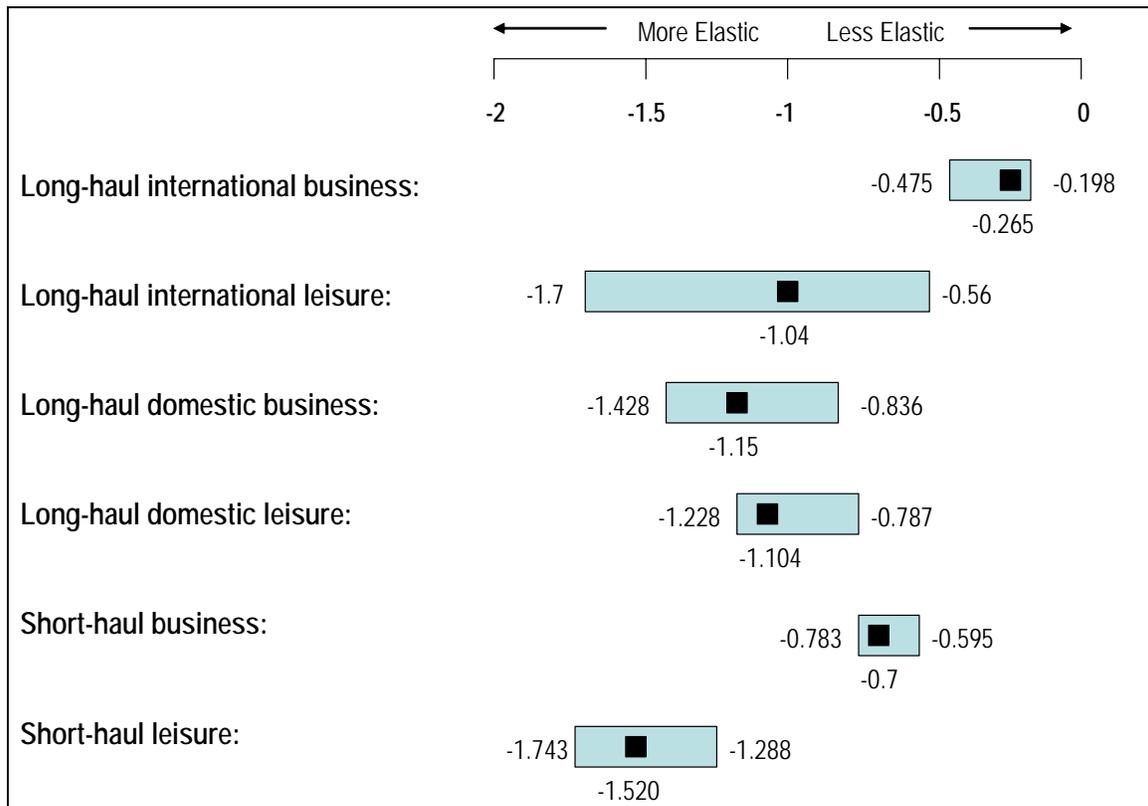
Reproduced from *Air Travel Demand Elasticities: Concepts, Issues and Measurement*, D. Gillen, W.G. Morrison and C. Stewart, 2002.

Although there is a considerable range of elasticities, some generalised findings can be drawn from the literature review:

Sensitivity to Air Fare Changes

All of the studies reviewed, spanning a period of over 25 years, found that there was a significant demand response to changes in air fares, such that increases in air fare lead to lower passenger traffic demand. The consistency of this result strongly indicates that any policy action that results in higher fares (e.g., taxes, increased landing fees) will result in a decline in demand. The actual decline in demand will depend on a number of factors, as discussed below.

Business Versus Leisure Passengers

In general, the results show that, all else being equal, business travellers are less sensitive to fare changes (less elastic) than leisure travellers. Intuitively, this result is plausible – business travellers generally have less flexibility to postpone or cancel their travel than leisure travellers. Nevertheless, the studies do show that even business travel will decline in the face of fare increases, albeit not to the same extent as leisure travel.

Short-Haul Versus Long-Haul Travel

Another fairly consistent finding was that fare elasticities on short-haul routes were generally higher than on long-haul routes. In part, this reflects the opportunity for inter-modal substitution on short haul routes (e.g., travellers can switch to rail or car in response to air fare increases).

Carrier Versus Market Versus National Elasticities

Some of the studies supported the concept that the demand elasticity faced by individual air carriers is higher than that faced by the whole market. For example, Oum, Zhang, and Zhang (1993) estimated firm-specific elasticities in the U.S. and estimated values ranging from -1.24 to -2.34, while studies estimating market or route elasticities ranged from -0.6 to -1.6. In contrast, Alperovich and Machnes (1994) and Njegovan (2006) used national-level measures of air travel in Isreal and the UK respectively and produced even lower elasticity values (-0.27 and -0.7, respectively).

Income Elasticities

Many of the studies also including an income variable, in part, to isolate the effects of a shift *along* the demand curve (such as would be caused by a price change) from the effect of a shift *in* the demand curve (as might be caused by a change in income levels). The studies including the income term all produced positive income elasticities, as would be expected (air travel increases as incomes increase). Virtually all of these studies estimated income elasticities above one, generally between +1 and +2. This indicates air travel increases at a higher rate than incomes.

3.2   Summary of the Papers Reviewed

The table in **Figure 3-2** provides a summary of each of the papers reviewed, including the elasticity estimated produced, dependent and explanatory variables used, and a short description of the methodology and key findings.

Figure 3-2: Summary of the Air Fare Elasticity Literature Review

Author / Paper	Elasticity Estimates	Dependent Variables	Explanatory Variables	Findings
Taplin - A Coherence Approach to Estimates of Price Elasticities in the Vacation Travel Market (1980)	Price (leisure): -0.9 to -3.3 Income: 1.0 to 2.6	Results synthesized from other studies.	Results synthesized from other studies.	Cross-elasticities of various substitute and compliment goods were inferred based on the results observed in other studies. Accommodations, domestic travel, car costs, and prices of other consumer goods were analysed as for effects on foreign air travel.
Abrahams - A Service Quality Model of Air Travel Demand: An Empirical Study (1983)	Price: -0.36 to -1.81 Income: 0.46 to 1.6	Expected schedule delay time. Price elasticity of demand is calculated indirectly.	Traffic. lowest unrestricted fare. product of city pair populations. % change in GNP. perceived price of air transport relative to auto transport.	Found rapid growth of hotel and recreation facilities in Hawaii in response to the introduction of low cost jet service; expansion of business activity in Reno as a result, in part, of the sharply increased service quality in airline services. Long-haul routes appeared to be more elastic than short and vacation traffic to be more elastic than business traffic. A negative correlation was found between the reduction in 1980 fare levels from the official CAB fare and the estimated service quality elasticity.
Oum, Gillen, and Noble - Demands for Fareclasses and Pricing in Airline Markets (1986)	Price: -1.152 (all routes) Income: -1.445 (all routes)	Route aggregate demand.	Average fare. Per capita incomes between city pairs. Population between city pairs. Vacation route dummies.	Derived partial elasticities for three fare classes using a translog demand system in a first stage then the second stage involves estimating a log-lin demand function to measure total price elasticities. Ramsey-optimal fare class prices were also computed by minimizing estimated airfare index functions subject to breakeven constraints. Intra-U.S. routes were used as data sources.

Author / Paper	Elasticity Estimates	Dependent Variables	Explanatory Variables	Findings
Oum - Alternative Demand Models and their Elasticity Estimates (1989)	No aviation elasticities estimated.	No aviation elasticities estimated.	N/A	Examined linear demand, Log-Lin demand, Box-Cox, logit, and translog demand models for effectiveness in demand analysis and forecasting. The translog model was shown to be the model that produces the most reasonable results – elasticities exhibit stability and predictability, smaller standard errors than from log-lin model.
Oum, Zhang, and Zhang - Inter-Firm Rivalry and Firm-Specific Price Elasticities in Deregulated Airline Markets (1993)	Price: -1.24 to -2.34 on domestic U.S. routes	Route aggregate demand by carrier.	Average fare. Total income. Seasonality dummies. Vacation route dummies. Cost per passenger mile.	Firm specific price elasticities were measured, and were found to increase with distance. Vacation routes were found to have higher elasticity values. In addition, the analysis found that firms were shown to behave uniquely in a duopoly environment.
Alperovich and Machnes - The Role of Wealth in the Demand for International Air Travel (1994)	Price: -0.27 (all routes) Income: 1.64 to 2.06	Travelers per capita.	Financial assets. Non-financial assets. Wages. Consumer price index.	Authors examine air travel out of Israel. Price was found to be inelastic while income was highly elastic. Used log-lin models. Inclusion of wealth variables is found to reduce serial correlation, correct bias, and improve estimate precision. Total assets (including financial and non-financial assets) were determined to be significant in demand.
Australian Bureau of Transport and Communications Economics - Demand Elasticities for Air Travel to and from Australia (1995)	Price: -0.14 to -1.19 (Aus. leisure) -0.5 to -1.86 (foreign leisure) -0.01 to -0.4 (Aus. Business)	Total O/D leisure passenger; Total O/D business passengers	Real household disposable income. Price index of domestic holiday travel and accommodations. Annual average exchange rates. Relative prices of holiday travel and accommodations.	Airfares, income and relative prices found to be important determinants of leisure travel to and from Australia. Income and relative prices were important for business travel. Real exchange rate elasticities are also examined. Airfare elasticities differed between passenger type and O/D market. Linear and Log-Log models were employed.

Author / Paper	Elasticity Estimates	Dependent Variables	Explanatory Variables	Findings
	-0.16 to -0.62 (Foreign business) Income: 0.21 to 11.58 (Aus. leisure) 1.88 to 5.51 (foreign leisure)		Per capita figures are used to account for population effects.	
Cohas, Belobaba, and Simpson - Competitive Fare and Frequency Effects in Airport Market Share Modeling (1995)	Price: -0.37 to -0.83	Airline market share	Quarterly Origin/Destination traffic data from 1979/1 to 1992/2.	Paper looked at competitive effects in duopoly markets. The elasticity of market share with respect to frequency of service was positive; the direct elasticity of market share with respect to price was negative; the cross-elasticity of market share with respect to price was positive.
Jorge-Calderon - A Demand Model for Scheduled Airline Services on International European Routes (1997)	Price: -0.534 (all economy) Frequency: 0.79 to 1.26 Aircraft Size: 0.55 to 1.74	Total scheduled traffic between two cities. Taken from ICAO Traffic by Flight-Stage Survey.	Population of O/D cities. Incomes of O/D cities. Distance. Frequency. Average aircraft size. Unrestricted economy fares. Dummies: Travel over sea water; proximity of nearby hub airport; discounted restricted fares; holiday resort destination.	International European routes were examined using a demand model that used several independent variables. Various stage lengths were examined separately. Overall, demand was shown to be price inelastic with a tendency for elasticities to increase with distance but fall in the long-haul sector. Highly discounted fares have a positive effect on traffic. Discounted fares were used more often in short-haul markets (presumably to compete with other modes); longer distance flights were more price sensitive due to the reduced use of discounted fares.

Author / Paper	Elasticity Estimates	Dependent Variables	Explanatory Variables	Findings
Taplin - A Generalised Decomposition of Travel-Related Demand Elasticities into Choice and Generation Components (1997)	Price: -1.7 to -2.1 (leisure) Income: 1.1 to 2.1	Estimates from Taplin (1980)	Estimates from Taplin (1980)	Firm specific price elasticities were measured, and were found to increase with distance. Vacation routes were found to have higher elasticity values. Cross elasticities between domestic and international vacation choices were examined. Expenditure choice and generation elasticities were derived separately.
Hamal - Australian Outbound Holiday Travel Demand Long-haul Versus Short-haul (1998)	Price: -0.35 to -2.23 Income: 0.63 to 0.84	Short-term resident departures for holiday purposes.	Real per capita household income. Price index of domestic holiday travel and accommodation over domestic CPI. Price index of foreign country holiday travel and accommodation over foreign CPI. Foreign/domestic exchange rate. Exchange rate weighted by prices of overseas and domestic travel and accommodations.	Paper makes use of four log-log models with different explanatory variable combinations to measure elasticities for travel demand to various markets outside of Australia. Income elasticities were shown to vary depending on the market. Cross price elasticity with domestic demand and accommodations were positive and above one for all markets.
Carlsson - Private vs. Business and Rail vs. Air Passengers: Willingness to pay for Transport Attributes (1999)	Price: -1.09 to -1.43 (total) -0.94 to -1.28 (business) -2.95 to -3.04 (personal).	Number of trips.	Elasticities were inferred indirectly through the use of a logit model that accounts for mode choice decision making.	A stated preference survey was used to generate data for passenger's willingness to pay for improvements to various transport modes through a conditional logit model. Routing were limited to travel between Stockholm and Gothenburg, Sweden. Air Arlanda and Air Bromma estimates were generated separately. Business travelers are found to value time more highly and were less price elastic than private passengers.

Author / Paper	Elasticity Estimates	Dependent Variables	Explanatory Variables	Findings
Abed, Ba-Fail, Jasimuddin - An Econometric Analysis of International Air Travel Demand in Saudi Arabia (2001)	No elasticity estimates.	Demand for international air travel.	Population size. Expenditures.	A proposed econometric model of demand was derived for Saudi Arabia international air travel. Population and expenditures were found to be the primary determinants of international air travel in Saudi Arabia.
Gillen, Morrison, Stewart - Air Travel Demand Elasticities: Concepts Issues and Measurement (2002)	Price: -0.27 (long-haul int. business) -1.04 (long-haul int. leisure) -1.15 (long-haul dom. business) -1.10 (long-haul dom. leisure) -0.7 (short-haul business) -1.52 (short-haul leisure) Income: 1.39 *Median Values Reported*	Survey of a large group of studies.	Survey of a large group of studies.	The report was based on an extensive survey of literature related to provide air travel elasticity estimates. Six distinct markets for air travel were identified: business and leisure travel; long-haul and short-haul travel; and international and North American long-haul travel. Estimates vary significantly, reflecting the range of studies that were examined.

Author / Paper	Elasticity Estimates	Dependent Variables	Explanatory Variables	Findings
Brons, Pels, Nijkamp, Rietveld - Price Elasticities of Demand for Passenger Air Travel: A Meta-Analysis (2002)	No direct measures.	Price-elasticity.	Transfer distance. Fare Class. Geographic location. Research method (time, cross-section, or pooled). Time horizon. Period of data collection	This paper is a meta-analysis of the factors affecting price elasticities in the aviation sector. Long-run price elasticities were higher in absolute value; passengers became more price sensitive over time; Business passengers were less sensitive to price – the difference is about 0.6; European passengers were not more price sensitive than U.S. passengers and Australian passengers.
New Zealand Commerce Commission - Final Report Part IV Inquiry into Airfield Activities at Auckland, Wellington and Christchurch International Airports (2002)	Price: -1.3 (domestic) -1.8 (international)	Estimates obtained from other studies.	Estimates obtained from other studies.	Report cites that the price elasticity of the derived demand by airlines for airfield services can be inferred from the elasticity of the demand for airline travel – requires an assumption made about what portion of any change in landing charges is passed to passengers by airlines.
Castelli, Pesenti, Ukovich - An Airline-Based Multilevel Analysis of Airfare Elasticity for Passenger Demand (2003)	Price: -1.058 (all routes) Ranged from -0.75 to -1.62 on specific routes Frequency: 0.862	Number of passengers travelling on a route, in fare class, on a given day. No distinction is made between origin and destination.	Fare. Population of the total metropolitan are served by airports. GDP per capita in the two airport catchment areas. Distance between the two airports. A measure of the cost faced by travellers in other modes of transportation. Daily frequency of flights. Aircraft size. Hub (dummy).	Price elasticity of a specific airline (Air Dolimiti – the largest Italian regional carrier) was estimated. Nine routes were examined, price elasticity was found to vary significantly across the various routes – from -0.75 to -1.62.

Author / Paper	Elasticity Estimates	Dependent Variables	Explanatory Variables	Findings
PriceWaterhouseCoopers - Aviation Emissions and Policy Instruments, Final Report (2005)	Price: -0.73 (business) -1.52 (leisure) -1.23 (full service) -1.38 (low cost) -1.02 (cargo) *Estimates derived from Gillen et al. (2001)*	No information provided.	No information provided.	Impacts on competitiveness and economic performance were estimated for the European Union based on the prospected introduction of certain environmental policy changes. The authors conducted their own estimates of elasticities but reject their estimates in favour of figures derived from Gillen et al. (2001).
Rubin and Joy - Where are the Airlines Headed? Implications of Airline Industry Structure and Change for Consumers (2005)	Price: -2.4 (leisure) *Estimates from 1997 study – Mackinac Center for Public Policy, Price Elasticity of Demand*	No information provided.	No information provided.	Authors postulate that demand for air travel has become more elastic with the advent of online purchasing making prices more transparent – heightened competition and increased awareness. Due to the high price elasticity for leisure travel, airlines pass these charges forward as surcharges to consumers.

Author / Paper	Elasticity Estimates	Dependent Variables	Explanatory Variables	Findings
Goolsbee and Syverson - How Do Incumbents Respond to the Threat of Entry? Evidence from the Major Airlines (2006)	Price: -0.64 to -1.12	Total passengers or mean fares. DB1A files from Q1 1993 to Q4 2004.	Time dummies: Southwest establishing presence at both endpoints of route w/o flying route; Southwest flying route. Various control variables are used in the different model specifications.	The paper shows that the threat of Southwest entering a market was sufficient to encouraging incumbents to lower their prices – this was also said to cause an increase in demand prior to Southwest beginning service. The fare and quantity changes from this period implies a demand elasticity between -0.64 and -1.12.
Njegovan - Elasticities of Demand for Leisure Air Travel: A System Modelling Approach (2006)	Price: -0.7 (all routes) Income: 1.5 (all routes)	Share of household budget spent on leisure air travel.	Price of air travel. Price of tourism abroad. Price of domestic tourism. Total expenditures on leisure.	Analysis of leisure travel demand elasticities in the United Kingdom. Estimated that domestic leisure market has income elasticity of 0.6. Elasticity with respect to air fare changes is inelastic. The cross-price elasticities in the air travel equation were relatively large compared to the value of the own-price elasticity. The finding of a relatively low aggregated market own-price elasticity is not inconsistent with some relatively large own-price elasticities which are estimated from route-specific data where low cost airlines have been successful in attracting large volumes of traffic by offering low fares.

4.0 Econometric Analysis

4.1 Data Sources

4.1.1 U.S. Domestic (DB1B)

U.S. domestic market data was obtained from the U.S. DOT's Data Base 1B (DB1B). The DB1B data is widely used throughout the aviation industry and as a result any errors are generally noticed very quickly and brought to the attention of the U.S. DOT for correction. Also, the database has been used extensively by other researchers to generate reasonable estimates of demand elasticities. As a result, the DB1B data is a very reliable source of data.

Within the U.S. all large domestic carriers are required to provide the DOT with information about every tenth itinerary, for both domestic and international flights, to the U.S. DOT.[8] Thus, the DB1B represents a 10% sample of origin-destination passengers and airfare for each airline on each route. Quarterly traffic and fare data was taken for the period from 1994 Q1 to 2005 Q4 for the top 1000 city pair routes (by traffic). Traffic figures reflect the actual number of passengers on a particular route during the given quarter.[9] Average fare reflects the estimated (based on a 10% sample) average one-way fare paid (in USD) on a particular route.

4.1.2 World Regions (PaxIS)

The analysis of world regions was done using IATA's Passenger Intelligence Service (PaxIS) database. The database captures market data through IATA's Billing and Settlement Plan (BSP) and uses statistical estimates to address missing direct sales, low cost carriers, charter flight operators, under-represented BSP markets, and non-BSP markets. The advantage of data series is that traffic and fare estimates are available for routes around the world. However, this dataset is limited by the short time series (data is available from 2005) and the comparative lack of use in prior studies.

For the purposes of this report, select regions were chosen to describe the distinct marketplaces that exist in modern air travel:[10]

- Intra-Europe;
- Intra South Asia and South East Asia;
- Trans Atlantic (Europe to/from North America);
- Trans Pacific (South Asia and South East Asia to/from North America);

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[8] A large carrier is defined as an air carrier holding a certificate issued under 49 U.S.C.41102, as amended, that: (1) Operates aircraft designed to have a maximum passenger capacity of more than 60 seats or a maximum payload capacity of more than 18,000 pounds; or (2) conducts operations where one or both terminals of a flight stage are outside the 50 states of the United States, the District of Columbia, the Commonwealth of Puerto Rico and the U.S. Virgin Islands.

[9] Since data comes from a 10% sample the actual number of passengers can be accurately calculated simply by multiplying the number of passengers reported in the DB1B by a factor of 10.

[10] Further description of the countries included in the various regions can be found in Appendix F.

- Intra Sub Sahara Africa (Central/Western Africa and Eastern Africa);

- Intra Latin America (Non-Caribbean Central America and South America);

4.1.3   UK Outbound (IPS)

The data set used for analysis of the UK outbound travel market was the UK International Passenger Survey (IPS). The International Passenger Survey is a face to face survey of a random sample of passengers entering or leaving the UK by air, sea or the Channel Tunnel. In terms of air passenger surveying, regular staggered shifts are scheduled at Heathrow's four terminals, Stansted's two terminals, and Manchester's two terminals. In addition, a number of small shifts are scheduled on a quarterly basis at the other international UK airports. The sampling technique represents about 1 in every 500 passengers and reflects about 90% of all travelers into and out of the UK.

This report exclusively used *outbound* to Western Europe leisure air passenger traffic data from the IPS. Quarterly traffic and fare data was taken for the period from 2003 Q2 to 2006 Q2. Traffic figures reflect the estimated number of passengers on a particular route during the given quarter. Average fare reflects the estimated average fare paid (in GBP) on a particular route, in the given quarter.

4.2   Overview of Econometric Issues

### 4.2.1   Between, within and total variation

The data in each database consists of observations on city pair passenger itineraries for each quarter (or month, in the case of PaxIS). These time-series cross-section databases are referred to as panel data sets.

Panel data has two primary types of variation. Between variation is that based on differences between the cross sectional units (OD pairs). Within variation is based on variation over time for a given cross sectional unit.

It is important to recognise the different variances and their implication for estimation. For example, a classic study of airline costs (data is by airline for a number of time periods) reveals data with the following pattern:
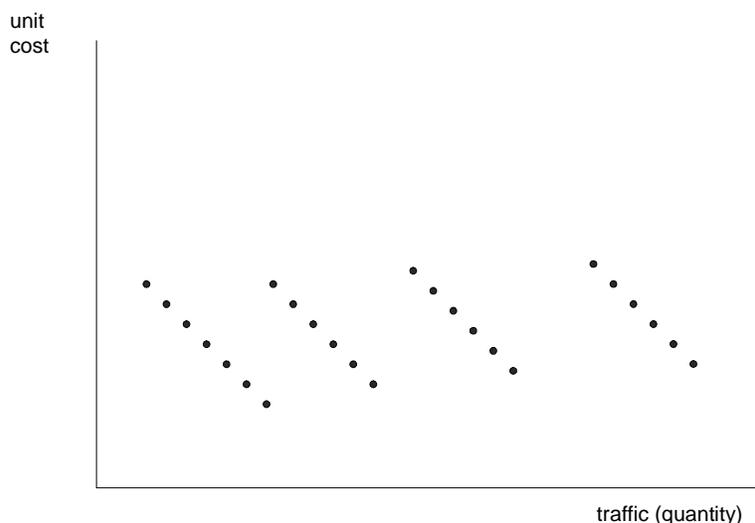
If a regression line is estimated with using all the data (total variation), then it may look like the following:

unit
cost

traffic (quantity)
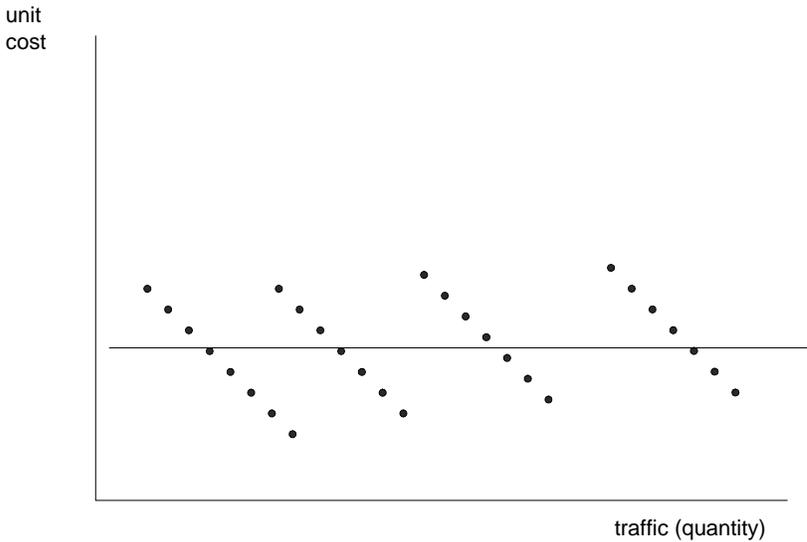
An alternative to estimation with total variation is to use within variation. This can be done, for example, by using indicator (dummy) variables for air carriers or by doing the regression only using data for a single route.[11] If the regression uses within variation via dummy variables, then estimated relationship will look like diagram below, which reveals the presence of economies of traffic density. That is, the dummy variable for the airline controls for differences between the carriers (such as size of network) and reveals how unit costs change with traffic within a given network.

unit
cost

traffic (quantity)

---
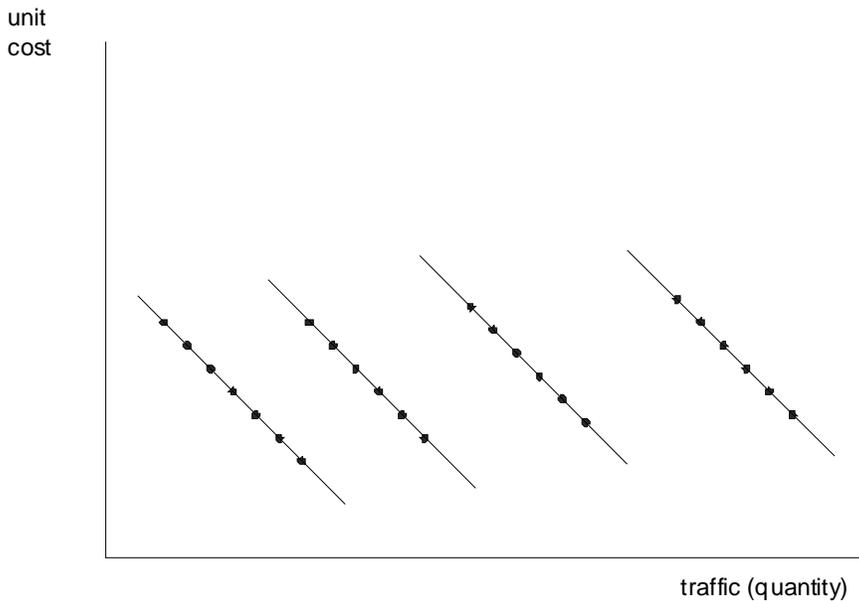
[11] Another approach may be to introduce a lagged value of the dependent variable into the regression.

Estimation can be done using between variation, e.g., by introducing a measure of network size, or by doing the regression on data for a single time period but with data for different airlines. In this case, the regression results might look like the following:

unit
cost

traffic (quantity)
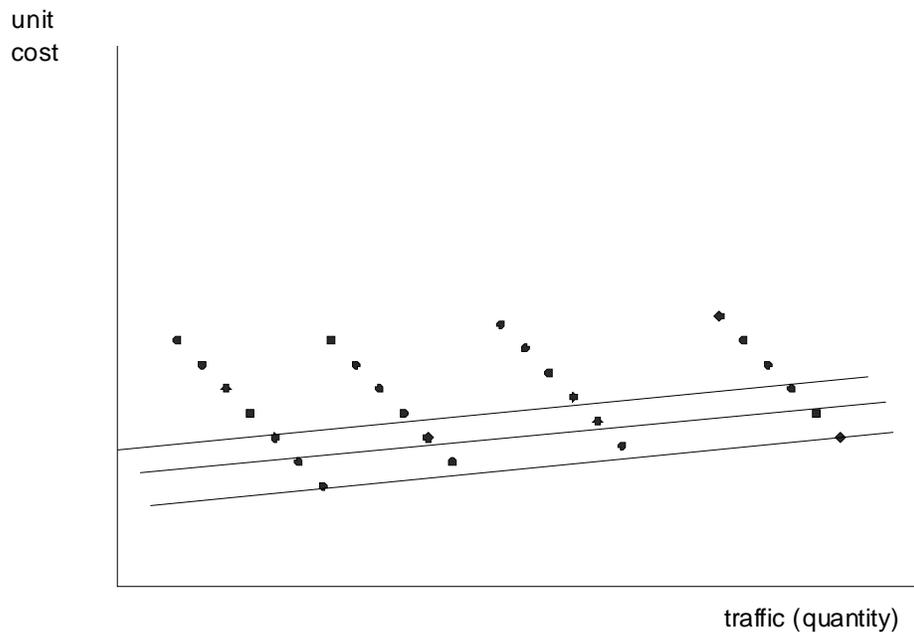
This regression might suggest the presence of mild diseconomies of network size. The main point is that revealing the true cost relationship with panel data can be challenging, and simple regressions may be misleading of the true phenomena.

4.3   Model Specifications

To estimate the elasticities of air travel, econometric analysis of the data was undertaken. A number of different model specifications were tested to provide explanations of economic phenomena within each given market.   In all models, traffic was the dependent variable. In the DB1B data set, traffic was taken at the city pair level (e.g., New York-Los Angeles). In the IPS and PaxIS data sets, traffic was taken at the airport pair level (e.g., JFK-LHR, CDG-FRA). The sub-sections below describe the broad set of models employed in this analysis.

4.3.1   Ordinary Least Squares

Ordinary Least Squares (OLS) regression analysis is a method relating passenger traffic to air fares, income (GDP) levels, and other variables that have an intuitive and measured impact on air travel, while minimizing the variance (randomness) of the estimates. The regression analysis allows the relationship between traffic and airfares to be isolated and quantified while controlling for other factors that may impact air travel, such as gross domestic product, population levels, route distance, seasonality, etc.

The OLS models used a log-log formulation, as follows:[12]

ln(Traffic) = Constant + a₁ x ln(Fare) + a₂ x ln(Var2) + … + aₙ x ln(VarN) + aₙ₊₁ x Dummies

Where:

- Traffic is the dependent variable,
- Fare is the average economy or leisure fare.
- Var2 to VarN are other quantifiable explanatory variables that affect traffic levels.
- ln() refers to the variables inside of the parentheses transformed by the natural logarithm.
- The dummies are variables that take the form of 1 or 0 in any observation and capture any remaining structural reasons for traffic differences between routes. For example, a dummy for the month of July would take the value of 1 for any observations from July and 0 during all other months' observations.

The regression analysis estimates the value of the parameters (constant, a_1, a_2, a_3, a_4, a_5, etc.) on each of the variables, which reflect the relative impact of each of the variables on traffic levels. As log formulations approximate percentage changes in impacts, the parameters of the logged independent variables can be directly interpreted as elasticities.[13]

4.3.2   Two-Stage Least Squares

Two-stage least squares (2SLS) is a regression technique that is used when explanatory variables are believed to be correlated with the regression model's error term used to obtain consistent estimators.[14] One or more instrumental variables (IVs) that are correlated with the endogenous explanatory variable, but uncorrelated with the dependent variable are used to isolate the effects of the endogenous explanatory variable. This process increases consistency (relative to OLS), at the expense of increasing sample variance.

In this study, Inter*VISTAS* experimented with the use of two-stage least squares techniques to improve the consistency of elasticity estimates. The natural logarithm of distance (distance) and the natural logarithm of fuel prices (fuel prices) were used separately and combined as potential IVs. In some data sets, distance was found to be a worthwhile IV, exhibiting high correlations with fares and low correlations with traffic. However, there is some concern that distance should be used as an explanatory variable instead of an instrument (if route distance is believe to have an impact on traffic). The reasonable use of distance as an IV is described in section 4.4. Fuel prices were found to be poor IVs. Fuel prices exhibited low correlations with traffic and fares.

4.3.3   Autoregressive Distributed Lag

An autoregressive distributed lag (ARDL) model was also developed and used with OLS regression analysis. Traffic was regressed onto similar explanatory variables as in prior models,

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[12] Log-log model formulations refer to a model specification where both the dependent (left hand side) and independent (right hand side) variables have been transformed by the natural logarithm.   Additional regression analysis results are provided in Appendix D.

[13] This formulation is also referred to as a Cobb-Douglas functional form.

[14] A consistent estimator in regression analysis is defined as an estimator that converges in probability to the correct parameter as the sample size grows.

but also onto lagged values of traffic. The inclusion of lagged values of the dependent variable (traffic) is done to account for stickiness, that is, the slow adjustment of supply (in the form of capacity) to changes in the explanatory variables. The applicability of this assumption is less reasonable for the U.S. domestic market as the barriers to expanding capacity are fewer than on international routes; the U.S. domestic market has therefore been excluded from ARDL estimation.[15]

Inter*VISTAS* experimented with the use of 'prior period' and 'year over year' lags. Although both showed some degree of success in controlling for these factors, 'year over year' lags had higher correlations with current traffic levels than 'prior period' lags, and were determined to be the preferred form of lagged variable.

The ARDL models used a formulation as follows:[16]

$$ln(Traffic_t) = Constant + b_1 \times ln(Traffic_{t-1}) + b_2 \times ln(Fare_t) + b_3 \times ln(Var3_t) + \ldots + b_n \times ln(VarN_t)$$

$$+ b_{n+1} \times Dummies_t$$

Where:

- Traffic $_t$ is the dependent variable,
- Traffic $_{t-1}$ is the traffic in the same month (or quarter) of the previous year
- Fare is the average economy or leisure fare.
- Var2 to VarN are other quantifiable explanatory variables that affect traffic levels.
- ln() refers to the variables inside of the parentheses transformed by the natural logarithm.
- The dummies are variables that take the form of 1 or 0 in any observation and capture any remaining structural reasons for traffic differences between routes. For example, a dummy for the month of July would take the value of 1 for any observations from July and 0 during all other months' observations.

Since traffic appears on both sides of the equation, the coefficients on the explanatory variables cannot be directly interpreted as long-run elasticities (as is the case in the other OLS and 2SLS models). The long-run elasticities are defined as when traffic across time periods stabilize.[17] In general, the use of ARDL models tended to produce more elastic fare elasticity estimates with much higher goodness of fit values.

4.4   Explanatory Variables

The following section describes the explanatory variables used in the regression analysis. Data sources are provided in Appendix F.

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[15] The U.S. domestic market is not constrained by air bilateral agreements, has a wide access to capital, and high levels of competition, all of which increase responsiveness to changes in the explanatory variables (fare price, income, and population).

[16] Log-log model formulations refer to a model specification where both the dependent (left hand side) and independent (right hand side) variables have been transformed by the natural logarithm.   Additional regression analysis results are provided in Appendix C.

[17] The derivation of the equation for long-run elasticities can be found in Appendix C.

4.4.1   Average Fare

Average fare price was used to measure the price of air travel. Although there are other components to air travelers total cost of travel (taxes, fees, costs of commuting to/from airports, etc.), fare prices provide a reasonable indication of own-price elasticities – as seen extensively in prior literature.

Fare prices used in the regression analysis reflect average route fares over the period reported. In the cases where data needed to be aggregated, a weighted average fare was calculated based on traffic levels. Average fare appears in all model specifications.

4.4.2   Gross Domestic Product

Gross domestic product (GDP) was used to measure the effect of income on air travel. In general, an increase in income will make air travel more affordable and therefore increase traffic. GDP estimates are widely available, and thus provide a variable that can be consistently defined between regions and over time.

Inter*VISTAS* experimented with the use of several forms of GDP to obtain the variable that provided high levels of explanatory power and was an economically intuitive form. Within the U.S., GDP estimates are available at the city pair level, and a geometric mean is used as the explanatory variable in the domestic U.S. regression analysis.[18] Regression analysis using the IPS data set used UK national GDP as the explanatory variable, as the dataset was exclusive to outbound passengers. Regression analysis for all other regions used the geometric mean of GDP at the national level. GDP estimates were obtained from the World Bank, which converted the levels from local currency to U.S. dollars at annual average market rates. Although a smaller level of aggregation would be preferred, the costs to obtain GDP estimates at such a level would be quite large. GDP appears in all model specifications.

It should be noted that although many of the international models produced low or even negative income elasticities, this should not necessarily be interpreted as the population's air travel sensitivity to changes in income. Due to data limitations of GDP only appearing at the national level, there may not be adequate variation in the figure to produce reasonable results. While the income elasticities given for the U.S. domestic market and the UK outbound market can be interpreted as relatively robust estimates, Inter*VISTAS* cautions the use of results found in other markets.

4.4.3   Population

In many models, population is used as an explanatory variable in regression analysis. Population has a direct effect on the size of a market and if omitted from the model specification, may cause a bias in the estimates. For example, a large increase in traffic may reflect a sudden boom in population rather than a change in the sensitivity to price or other effects. If population is omitted from the model, a bias will occur in the estimates of the other variable coefficients. The geometric

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[18] The geometric mean of GDP is defined as the square root of the GDP of the origin region multiplied by the GDP of the destination region: $\sqrt{OriginGDP \times DestinationGDP}$

mean of population at the city level was used where possible and at the national level elsewhere. Population was tested in all model specifications for statistically significant and reasonable results. The best results tended to be at the city pair level, and this parameter therefore only appears in U.S. domestic regressions (where city pair population figures are easily obtainable for all observations).

4.4.4 Route Distance (Trip Length)

The use of route distance was used explored as both an explanatory variable in OLS regression and as an instrumental variable in 2SLS regression.

The intuition behind the use of distance as an explanatory variable reside in its ability to address value of travel time savings and availability of substitutes. That is, as haul length increases, the travel time savings over other modes becomes progressively larger and the viability of other modes to circumvent obstacles that may arise (such as oceans, poor terrain, unfriendly states, etc.) becomes progressively smaller. Inter*VISTAS* experimented with the use of different forms of distance including the form taken in gravity models where travel is defined as a function of the inverse square of distance; none of the different forms were found to cause a change in conclusions, therefore the easily interpretable Cobb-Douglas formulation was used.

The use of route distance as an instrumental variable in 2SLS requires a completely different set of assumptions about its effect on air travel. 2SLS requires that distance be exogenous to the model (uncorrelated with traffic). Although there are many situations where this will not be the case, domestic travel in the continental U.S. may be a reasonable market to assert this assumption. There are fewer travel obstacles within a country with extensive infrastructure than there are between countries with less infrastructure. Also, once airport commute and check in times are added to in flight time, the time savings difference between the shortest routes in the U.S. and the longest become less significant. The use of distance as an IV is also supported by correlation figures obtained: the correlation between distance and traffic is relatively small at -0.086, while the correlation between distance and fare is 0.552.

4.4.5 Substitute Goods

Inter*VISTAS* conducted regression analysis on a subset of routes using substitute goods as explanatory variables. The theory behind this specification is as follows: The demand for a good is influenced by own price elasticities *and* cross price elasticities. In the case of air travel, own price elasticity refers to the sensitivity to changes in fares on a given route, while the cross price elasticity would be any substitute for travel on the given route. In these specifications, a route substitutes could be defined as a different airport serving the same catchment area (e.g. Chicago-O'Hare versus Chicago-Midway) or a different destination serving the same purpose (e.g. Las Vegas versus Reno both serving as recreation destinations).

When variables that should be included as explanatory variables are omitted from the model employed, a bias in the estimates of the other coefficients will occur under most circumstances.[19] In the case of air travel, the exclusion of a proper substitute will bias the fare elasticity estimates

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[19] A bias will occur in all cases except when the omitted variable is uncorrelated with the included explanatory variables.

obtained in regression analysis.   The extent of this bias in a simple linear regression of traffic onto fare will be equal to the coefficient of the substitute (the cross price elasticity of the substitute) multiplied by the correlation between fare and the fare substitute.[20]

Since the coefficient on the missing substitute variable is known to be positive (an increase in the price of the substitute fare will tend to increase the traffic on the target route) and the correlation between a fare and a substitute fare is positive (a decrease in the price of a substitute fare will tend be accompanied by a decrease in the price of the targeted fare) *the bias of the fare elasticity estimate is known to be positive.* This implies that a fare elasticity estimate that excludes a meaningful substitute in the regression model will produce more inelastic estimates than a correctly specified model would produce. That is, the fare elasticities produced will have an inelastic bias.

Inter*VISTAS* experimented with the use of fares on similar routes as the value of a substitute good in a small subset of the DB1B data set.[21] The results were consistent with what the theory described above would suggest; the inclusion of a substitute fare was found to increase fare elasticity estimates.

To produce estimates that would apply to the full data set would require careful selection of proper substitutes for each route examined and is beyond the scope of this project. However, the general conclusions supported by theory and the results from the subset analysis provide an indication that previous estimates will have a bias towards inelastic results.

4.4.6   Real Exchange Rates

Inter*VISTAS* experimented with the use of real exchange rates as an explanatory variable in determining the demand for leisure air travel.[22] The real exchange rate is defined as the consumer price index (CPI) in the foreign country divided by the CPI in the domestic country divided by the exchange rate (foreign currency per unit of domestic currency). The intuition behind the use of this variable is that as the foreign country becomes more expensive (inexpensive), leisure travelers will travel to the foreign country less (more).

Inter*VISTAS* was unable to obtain robust estimates using this variable; this is likely attributable to a fundamental error in the variable's original design. By using CPIs as units to determine relative costs of travel, there is an implicit assumption that changes in the cost of tourism are equal to changes in the average cost of goods in the country, and this is not necessarily the case. For example, a country with 10% inflation in the general economy, but zero inflation in the tourism sector would have a high real exchange rate while there would be little effect on the cost of travel to that country.[23] Real exchange rates were excluded from final model specifications.

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[20] A proof of this statement can be found in Appendix B.

[21] An example of a substitute good in the data subset would be the use of fares from New York to Fort Lauderdale serving as a substitute for travel from New York to Miami.

[22] Real exchange rates have also been referred to as the 'Effective Price of Tourism' in other studies.

[23] Assuming no change in nominal exchange rates.

4.4.7 Time Variables

The use of several different forms of time variables was explored. However, only the introduction of quarterly (seasonal) time dummies was found to consistently increase goodness of fit. The use of quarterly dummies also tended to increase fare elasticities. This suggests that quarterly factors are present in both fares and innate traffic demand. These results suggest potential for future research to model unique quarterly factors for each O/D pair or for types of routes. As such a specification would be complex and coding exceedingly laborious, the specification was excluded from Inter*VISTAS'* analysis and this report.

4.4.8 Route Dummies

The introduction of route dummies in the regressions was found to greatly improve the goodness of fit. That is, fare, population and income alone do not explain much of the difference in traffic levels on O/D pairs. Other factors are important. E.g., whether or not non-stop service is available, whether there are competing carriers operating on non-stop routes, whether there is a low cost carrier, what types of cultural or financial linkages there are between pairs of cities, etc., appear to explain much of the differences in traffic levels. By utilizing route dummy variables, these issues can be controlled without the need to spend extensive resources quantifying them for regression analysis. Furthermore, in the absence of variables capturing the substitute option (cross-elasticities), the dummies can control for the cross-elasticity effects to some degree although provide no information on the values of these cross-elasticities.

The introduction of route dummies was generally found to make fare elasticities more elastic (i.e., makes the elasticities more negative), consistent with the idea that the dummies capture cross-elasticity effects.

4.5 Econometric Results

The following section provides an overview of the results obtained through Inter*VISTAS'* econometric analysis. Elasticity estimates are summarised in Figures 4-1, 4-2, and 4-3.

4.5.1 U.S. DOT Database 1B

Econometric analysis of the U.S. Department of Transport database (DB1B) benefitted from the large volume of research already conducted on data set in previous studies, and also produced the most robust results. Final model specifications used real average fares, geometric mean of city pair real income, distance (explanatory variable in OLS, instrumental variable in 2SLS), time dummies for every quarter, and route dummies.[24] [25]

OLS and 2SLS regression techniques were both used to evaluate the DB1B data set. ARDL regression techniques were not used on this data set as the U.S. domestic market capacity adjustments are deemed to be more responsive to changes in demand than other markets. Price

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[24] 'Real average fares' denote average nominal fares that are adjusted for inflation.

[25] Geometric mean is defined as the square root of the product of the two figures. In the case of city pair incomes, the geometric

mean would be: $\sqrt{IncomeCity1 \times IncomeCity2}$

elasticity estimates were found in the range of -0.8 to -1.5 (mildly inelastic to elastic), income elasticity estimates were between 1.0 and 1.8 (elastic), and population elasticity estimates were between 0.5 and 1.8 (inelastic to elastic). Variation in the elasticity estimates is explained in sections 4.5.4 and 4.5.5..

4.5.2   International Passenger Survey Database

In order to ensure reasonable estimates were produced, this study first sought to replicate the results of the UK Civil Aviation Authority (CAA) report on demand for outbound air travel using the International Passenger Survey (IPS) database.[26] The model prescribed by the CAA was then adjusted by Inter*VISTAS* to provide insight on regional and aggregation issues. In reproducing the results of the CAA, Inter*VISTAS* found that the 'Effective Price of Tourism' variable implemented in the CAA study did not produce robust estimates and also created multicollinearity issues with the GDP (income) variable. This variable was therefore dropped in Inter*VISTAS'* final model specifications.[27] Final model specifications used nominal average fares, real GDP, distance, seasonal dummies, and route dummies.[28]

Analysis using OLS, 2SLS, and ARDL methods was attempted in the IPS data set, however 2SLS results were rejected by Inter*VISTAS* due to poor performance by the instrumental variable. Price elasticity estimates in the IPS database were found in the range of -0.8 to -0.9 (mildly inelastic) while income elasticity estimates were between 1.2 and 1.5 (mildly elastic to elastic). Population variables did not yield statistically significant results and were therefore dropped from the final model specification.

4.5.3   PaxIS Database

PaxIS database analysis differed from DB1B and IPS analysis due to the relatively short time series available (data begins in 2005). However, the global nature of the dataset enabled a wider range of cross-sectional data analysis. Final model specifications of regional subsets used nominal average fares, geometric mean of real GDP, distance, and time dummies for each month of data. Final model specifications of the full (world) data set include geometric mean of population, in addition to the above variables.

Analysis using OLS, 2SLS, and ARDL methods was conducted with the PaxIS data set, however 2SLS results were rejected due to poor instrumental variables. Price elasticities between -0.4 and -2.9 were calculated, with significant variation between regions, and between OLS and ARDL models.[29] Income and population elasticities were determined to be weak estimates since input figures were only available at the national level, not the city pair level. It is noted that national income/population levels do not likely reflect the air catchment area levels under these circumstances.

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[26] Civil Aviation Authority (2005), "Demand for Outbound Leisure Air Travel and its Key Drivers"

[27] Other issues with the 'Effective Price of Tourism' (real exchange rate) variable are described in section 4.4.6.

[28] Nominal fares were used as the CAA study did not note any adjustment of IPS fare data for inflation.

[29] Regional variations are described in section 4.5.6.

4.5.4   Route Level Analysis

The outcomes from Inter*VISTAS* econometric analysis supports a route level elasticity near -1.4. This finding is likely the result of substitutability between various routes for one another. The results from analysis using route dummies (which may be capturing all or part of the effect of the price of substitutes) and experiments on a sample set of routes with price of substitutes support this finding.

Regressions on the U.S. DB1B data set using 2SLS are especially revealing in this regard. However, as discussed in section 4.3.2, the 2SLS technique is difficult to implement with a limited budget and with global data, as it requires the assembly of one or more instruments from the supply equation. Using distance as an instrument produced results that further supported an elasticity near this level. Nevertheless, there still is some concern over distance's use as an instrument, due to its perceived exogenous influence on demand.

4.5.5   Aggregate Level Analysis

Inter*VISTAS* econometric analysis supports the finding that elasticities (associated with price changes) at more aggregated levels (E.g. National/Pan-National) should be substantially more inelastic than route level changes. Based on the results seen in all three data sets, a reasonable range of fare elasticities would be from -0.6 to -0.85, with the more inelastic end of the range describing pan-national effects and the more elastic end of the range describing national effects.

Inelastic results were found over a range of model specifications which excluded route dummies. This elasticity range is essentially a combination of the route own price elasticity with cross price elasticities, when all routes have prices that vary identically. The less elastic result is consistent with observations that part of the price elasticity observed from low cost carriers (LCCs) at secondary airports involves diversion from primary airports in the catchment area, or from diversion from trips on other routes. When this is controlled for, LCCs have a lower level of market stimulation, consistent with less elastic national elasticities.

4.5.6   Geographic Market Analysis

Elasticity estimates were found by Inter*VISTAS* to vary by a statistically significant level in different geographic regions. This section describes the regional socio-economic characteristics that affect key travel markets and provides an overview of findings from Inter*VISTAS'* econometric analysis:[30]

Intra North America: Elasticity estimates were broadly consistent with what was found in the literature review. The market is well established with relatively high levels of capacity and traffic. Fares tend to be low, while haul lengths are short to medium.

Intra Europe: Higher elasticities were observed in the Intra Europe market. Intra Europe flights are noted by shorter average distances and use of very low fares that result in significant market stimulation. The low fares in Europe are not observed in North America, this is consistent with the

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[30] Elasticity comparisons are noted to be relative to results observed in Intra North America analysis.

higher elasticities observed in Europe. In the past, the European market had high charter carrier share, which today is merely being converted to very low fare LCCs.

Intra Asia: Moderately more inelastic estimates were found in Intra Asia. The LCC phenomena is emerging in Asia, but a modest sized middle class in many markets suggests somewhat weaker non-business demand levels and less elastic demand. This provides context for the estimates obtained in the region.

Intra Sub-Saharan Africa: This market supports a relatively inelastic demand estimate as compared to North America. These economies have a small middle class population, resulting in a high weight of traffic being driven by higher income individuals, which are less elastic.

Intra South America: Estimates obtained from regression analysis produced highly elastic fare elasticities, however this result may be anomalous. There is an emerging middle class which makes the market more elastic than sub-Saharan Africa, and LCCs are emerging in Brazil, Chile, and Mexico, but econometric findings suggested that this market has highest elasticity in the world. It is suggested that use some caution be used with Intra South America elasticity estimates.

Trans Atlantic (North America – Europe): A high price elasticity was found in the Trans Atlantic market. This market is often observed to have fares only slightly higher than domestic US fares, consistent with high price elasticity. The market has also been well developed by charter carriers, which is also consistent with high price elasticity. Price is likely more important than frequency in this market than in Intra North America.

Trans Pacific (North America – Asia): A lower price elasticity was observed in the Trans Pacific travel market. Travel in the market has had no charter services, and continues to have major markets with less liberal pricing provisions (Japan, China). There has been some recent emergence of long haul LCCs (e.g., Oasis) but the present environment supports a market less elastic than Intra North America (since long haul traffic tends to be less elastic) and less elastic than trans Atlantic (since trans Atlantic serves a substantial middle class).

Europe-Asia: A moderately inelastic price elasticity was found in the market for travel between Europe and South/South-East Asia (Europe-Asia). This result is in contrast to the results found in the respective intra markets of Europe and Asia, and provides further evidence for lower elasticities on long-haul and intercontinental air transportation.

4.6   Econometric Results

This section provides the elasticity estimates from the final model specifications. Full regression outputs are provided in Appendix D. It should be noted that the most robust results were obtained for the U.S. Domestic market. These figures can therefore be interpreted as the most reliable. Figures for other regions provide a base of reference, but should be jointly interpreted with conclusions from the literature and key results from the U.S. regression analysis. **Figure 4-1** provides elasticity estimates for the final OLS regression equations. **Figure 4-2** presents the results of 2SLS regression analysis on the U.S. domestic market. 2SLS results for other regions are not reported as no suitable IV is available. **Figure 4-3** presents the results of ARDL regression analysis.

Figure 4-1: Ordinary Least Squares Regression Results

Region	Price Elasticity	Income Elasticity	Population Elasticity	Goodness of Fit
U.S. Domestic	-0.83	1.00	0.45	0.95
World	-0.62	0.03	0.10	0.61
UK to Western Europe	-0.82	1.45	N/A	0.61
Intra-Europe	-1.30	0.09	N/A	0.71
Intra South and East Asia	-0.86	-0.08	N/A	0.10
Intra Latin America	-1.20	0.10	N/A	0.22
Intra Sub-Saharan Africa	-0.56	0.19	N/A	0.60
Transatlantic	-1.06	0.32	N/A	0.60
Transpacific	-0.36	0.19	N/A	0.60
Europe-Asia	-0.73	0.22	N/A	0.40

Figure 4-2: Two-Stage Least Squares Regression Results

Region	Price Elasticity	Income Elasticity[*]	Population Elasticity	Goodness of Fit[**]
U.S. Domestic	-1.46	1.76	1.80	N/A

*See Section 4.4.2 (Gross Domestic Product) for information on interpreting income elasticities.
**The R-Squared value is excluded since 2SLS seeks to obtain proper parameter estimates, not maximize goodness of fit (unlike OLS).

Figure 4-3: Autoregressive Distributed Lag (OLS) Regression Results

Region	Price Elasticity	Income Elasticity[*]	Population Elasticity	Goodness of Fit
U.S. Domestic	N/A	N/A	N/A	N/A
World	-2.03	-0.34	N/A	0.88
UK to Western Europe	-0.86	1.18	N/A	0.70
Intra Europe	-2.78	-0.28	N/A	0.87
Intra South and East Asia	-2.90	-1.48	N/A	0.88
Intra Latin America	-1.80	-0.43	N/A	0.86
Intra Sub-Saharan Africa	-1.33	0.06	N/A	0.61
Transatlantic	-1.42	-0.73	N/A	0.88
Transpacific	-1.08	-2.2	N/A	0.84
Europe-Asia	-1.24	0.23	N/A	0.86

*See Section 4.4.2 (Gross Domestic Product) for information on interpreting income elasticities.

5.0 Conclusion: Synthesising the Findings

5.1 Introduction

The literature review and econometric analysis demonstrated that air fares elasticity varies depending on a number of factors such as geography, distance and level of aggregation. Ultimately, the determining the right elasticity value to use depends on the type of question being asked. Examining the traffic impact of a fare increase on a given route requires a different elasticity than when examining the impact of an across-the-broad fare increase on all routes in a country or region.

This chapter attempts to synthesise the results of the literature review and econometric analysis to develop some general guidelines on the use and application of air fare elasticities. While the literature review and econometrics did not provide a full set of elasticities covering all possibilities, they did provide sufficient information to infer a full set of elasticities. In particular, the following characteristics were identified as affecting the elasticity values, as discussed below.

Level of Aggregation

As noted previously, the level of aggregation affects the elasticity value:

- **Fare-class Level**: this the most disaggregate level, where travellers are choosing different fare classes on particularly airlines. At this level, the elasticities are arguably highest, as travellers can easily switch between fare-class levels.

- **Carrier Level**: the literature review found that the fare elasticity facing a particular carrier on a given route can be quite high (e.g., -1.5 to -2.5). If an air carrier increases it fare unilaterally, it is likely to lose passenger to other carriers operating on that route.

- **Route/Market Level:** at the route or market level, the elasticity response is generally lower, as evidenced by both the literature review and the econometric analysis. Travellers faced with a fare increase on all carriers serving the route (e.g., due to an increase in airport fees and charges), have the option of not travelling, travelling to another destination, traveling on another route (e.g., LGW-CDG rather than LHR-CDG) or travelling by another mode.

- **National Level:** at the national level, fare elasticities would be expected to be lower, as travellers have less options for avoiding the fare increase. For example, if a national government imposed a new or increased tax on aviation, traveller could only avoid this increase by using another mode (which may not always be possible) or not travelling (or travelling elsewhere).

- **Pan-National Level:** at the pan-national level (e.g., the European Union), the options for avoiding the fare increase are even further reduced, so therefore the elasticity would be expected to be lower.

Given the economic and policy focus of this study, the first two levels of aggregation are outside the scope of this study. Nevertheless, elasticity values for these levels of aggregation can be found in the literature review in Chapter 3.

Length of Haul

The literature review consistently found that the fare elasticities on short-haul routes were generally higher than on long-haul routes. In part, this reflects the opportunity for inter-modal substitution on short haul routes (e.g., travellers can switch to rail or car in response to air fare increases). Therefore, in this study a differentiation has been made between short-haul and long-haul elasticities.

Geographic Aviation Market

The characteristics of the market or region being examined can also affect the fare elasticity used. This reflect a number of a number of factors such as economic development, aviation market structure, government regulation (e.g., regulated vs liberalised), demographic factors, historical factors, etc. In develop the guideline elasticities, the following major geographic markets have been identified:

- Intra North America
- Intra Europe
- Intra Asia
- Intra Sub-Sahara Africa
- Intra South America
- Trans Atlantic (North America – Europe)
- Trans Pacific (North America – Asia)
- Europe – Asia

5.2   General Guidelines on Air Fare Elasticity Values

The following elasticities have been developed as a synthesis of the literature review and the econometric analysis. The approach taken was to develop three base elasticities reflecting the levels of aggregation (route, national and pan-national level). Multiplicative adjustors were then developed to adjust the elasticities to reflect specific markets.

Base Elasticities

The base elasticities were developed from the analysis of the various datasets and the generalised findings from the literature review.

- **Route/Market Level: -1.4**
  The literature review found that elasticities at the route or market level in the range of -1.2 to -1.5. This was verified by our own econometric analysis of the U.S. DB1A where it was possible to capture the effects of route substitution through the use of route dummy variables and experiments using variables capturing the price of route substitutes. These regressions produced fare elasticities in the region of -1.4, which has been used as the base elasticity at the route level.

- **National Level: - 0.8**
  The econometric analysis of all three datasets found that without the route substitution term, the analysis produced elasticities in the region of -0.8. This elasticity is essentially a combination of the route own price elasticity with cross price elasticities when all national routes have prices which vary identically. Thus, less elastic result is consistent with observations that part of the so called price elasticity observed from LCCs at secondary

airports involves diversion from primary airports in the catchment area, or from diversion from trips on other routes. When this is controlled for, LCCs have a lower level of market stimulation, consistent with less elastic national elasticities.

- **Pan-National Level: -0.6**
  This result is conceptually derived from the same mathematics which show the relationship between route and national elasticities. In this case, a much broader set of routes (e.g., across a continent) experience an identical price change.

Thus the route elasticity is applicable to a situation where the price of an individual route changes, for example, the fare on Warsaw-Coventry increases with the price of routes from Warsaw to other UK and other European points remain unchanged. The national elasticity applies to situation such as all Warsaw-UK prices changing identically, but price from Warsaw to other European points being unchanged. Pan national changes apply where prices from Warsaw to all points in Europe change identically.

Geographic Aviation Market

The econometric analysis of the IATA PaxIS data found considerable differences between aviation markets. Based on this analysis, the following elasticity multipliers have been developed:

Geographic Market	Elasticity Multiplier	Comment
Intra North America	1.00	Most research uses US data. This is our reference point.
Intra Europe	1.40	Shorter average distances, observed use of very low fares resulting great market stimulation. The significantly low fares in Europe (relative to North America) are consistent with higher elasticities in Europe. Traditionally the European market had high charter carrier share, which today is merely being converted to very low fare LCCs.
Intra Asia	0.95	The LCC phenomena is emerging in Asia, but modest sized middle class in many markets suggests somewhat less elastic than in North America
Intra Sub-Sahara Africa	0.60	These economies have limited middle class, resulting in high weight on higher income individuals who are less elastic
Intra South America	1.25	There is an emerging middle class which makes the market more elastic than sub-Saraha Africa, and LCCs are emerging in Brazil, Chile, and Mexico.
Trans Atlantic (North America – Europe)	1.20	This market is often observed to have fares only slightly higher than domestic U.S. fares, consistent with high price elasticity. Market has been well developed by charter carriers, consistent with high price elasticity. Price is likely more important than frequency in this

Geographic Market	Elasticity Multiplier	Comment
		market than in domestic U.S.
Trans Pacific (North America – Asia)	0.60	TransPacific has had no charter services, and continues to have major markets (Japan, China) with less liberal pricing provisions. Some emergence of long haul LCCs (e.g., Oasis) but at present this market seems to be less elastic than domestic US and than the well developed trans Atlantic which serves a substantial middle class
Europe – Asia	0.90	This market has marginally lower elasticities than the U.S. domestic market.

Short-Haul/Long-Haul Adjustment

The literature review consistently found that the fare elasticities on short-haul routes were generally higher than on long-haul routes. In part, this reflects the opportunity for inter-modal substitution on short haul routes (e.g., travellers can switch to rail or car in response to air fare increases). While the geographic breakdowns capture some variation by length of haul, there is still considerable variation within each market. In particular, very short-haul flights (approximately less than 1 hour flight time) are subject to greater competition from other modes.

On this basis, the following short-haul multiplicative adjustors can be applied to analysis of short-haul routes:

- Short haul: 1.1 (+10%).

Note that this adjustor does not apply to analysis of the trans-Atlantic and trans-Pacific market, which are considered entirely long haul, with virtually no opportunity for modal substitution.

Application of Adjustors

Elasticities for different situations can be developed by selecting the relevant base elasticity and applying the relevant multipliers, for example:

1. To examine the impact of an EU-wide aviation tax on short-haul markets, the elasticity would be developed as follows:

   - Base multiplier: -0.6 (pan-national)

   - Geographic market: 1.4 (Intra Europe)

   - Short-haul adjustor: 1.1

   The multiplier would then be calculated as: -0.6 x 1.4 x 1.1 = -0.924.

2. To examine the impact of a UK tax on aviation on Trans Atlantic traffic, the elasticity should be developed as follows:

   - Base multiplier: -0.8 (national)

   - Geographic market: 1.2 (Trans Atlantic)

   The multiplier would then be calculated as: -0.8 x 1.2 = -0.96.

3.   To examine the impact of impact of an increase in airport landing fees on a particular short-haul route in Asia, the elasticity should be developed as follows:

- Base multiplier: -1.4 (route)

- Geographic market: 0.95 (Intra Asia)

- Short-haul adjustor: 1.1

The multiplier would then be calculated as: -1.4 x 0.95 x 1.1 = -1.46.

The full range of possible elasticities is presented in the table below. The route level elasticities range from -0.84 to -1.96 depending on the geographic market and length of haul. The national level elasticities range from -0.48 to -1.23, while the pan-national elasticities range from -0.36 to -0.92.

	Route/Market Level		National Level		Pan-National Level	
	Short-haul	Long-haul	Short-haul	Long-haul	Short-haul	Long-haul
Intra North America	-1.54	-1.40	-0.88	-0.80	-0.66	-0.60
Intra Europe	-1.96*	-1.96	-1.23	-1.12	-0.92	-0.84
Intra Asia	-1.46	-1.33	-0.84	-0.76	-0.63	-0.57
Intra Sub-Sahara Africa	-0.92	-0.84	-0.53	-0.48	-0.40	-0.36
Intra South America	-1.93	-1.75	-1.10	-1.00	-0.83	-0.75
Trans Atlantic (North America – Europe)	-1.85	-1.68	-1.06	-0.96	-0.79	-0.72
Trans Pacific (North America – Asia)	-0.92	-0.84	-0.53	-0.48	-0.40	-0.36
Europe-Asia	-1.39	-1.26	-0.79	-0.72	-0.59	-0.54

*The short-haul adjustor has not been applied to the Intra Europe short-haul elasticity in order to maintain elasticities below 2.0

5.3   Comment on Income Elasticities

The focus of this study was on fare elasticities. Nevertheless, the analysis also considered income elasticities as part of the analytical process, albeit in less detail than fare elasticities. The literature review found a wide range of income elasticities, generally in the range +1.0 to +2.0. That is, air travel is generally found to be income elastic.

This is supported by more casual analysis which plots air travel per capita against income per capita across a wide range of nations, and finds a strong, positive relationship between the two. That is as income per capita grows, air travel per capita grows, and the growth in air travel is faster than the growth in income. These types of two dimensional analysis typically show some taper among the nations with the highest per capita incomes. That is, the income elasticity appears to decline somewhat at higher incomes, although staying elastic above 1.0.

Our statistical analysis produced mixed results.

▪   Analysis with the well developed U.S. data produced income elasticities generally in the range of +1.6 to +1.8. We do note that the income elasticity results are not robust, in that small changes in model specification can result in sizeable changes in the income elasticity.

Correlation between income and time trends or shifts, and correlation between income and the use of route specific indicators (i.e., route dummy variables) appear to affect the results.

- When experimental analysis was done with the price of travel on substitute routes, we generally found slightly higher income elasticities. That is, at the "route level", income elasticity was higher than at the "national level".

- The UK IPS data generally found slightly lower income elasticities than the U.S., data, with ranges from +1.2 to +1.6 typically found.

- The UK IPS data also revealed higher income elasticities for long haul routes. This would be consistent with an hypothesis that middle to lower income individuals are apt to travel on short to medium haul routes, but far less likely to travel on long haul. However, long haul sunspot travel is not uncommon from the UK, even for lower middle income individuals. The reconciliation may be that higher income leads to higher frequency of long haul travel.

- Results using the global PaxIS database were largely unsuccessful. In part, this was due to data challenges, as assembling income data on individual cities around the world was not possible. Outside of the developed world, GDP and income measures are generally not available at a city level, at least from global information sources which are constructed on a consistent basis. Analysis thus used national incomes as proxies for city incomes, but this introduced its own statistical bias. Results showed no stability to model specification and thus were rejected.

Based on the above findings, we recommend the use of the income elasticities in the tables below. These were constructed using professional judgement, based on information from the literature review, new results obtained in this study, and the two-dimensional analysis of travel propensity versus national income across a wide range of nations.

Route level

Length of Haul	U.S.	Other Developed Nations	Developing Economies
Short haul	1.8	1.5	2.0
Medium haul	1.9	1.6	2.0
Long haul	2.0	1.7	2.2
Ultra long haul	2.2	2.4	2.7

National level

Length of Haul	U.S.	Other Developed Nations	Developing Economies
Short haul	1.6	1.3	1.8
Medium haul	1.7	1.4	1.8
Long haul	1.8	1.5	2.0
Ultra long haul	2.0	2.2	2.5

5.4   Conclusions

As described in the literature review, the consensus among most aviation economists has been that demand for airline services is generally both price and income elastic. The latter suggests that air transport has the characteristics of a luxury good. A natural question is how an income elastic good can also be price elastic.

This report has revealed that there are different price elasticities associated with different uses. When consumers are choosing between airlines on a route, or even between destinations for holidays, conference locations, etc., there is a degree of price elasticity for airline seats. However, if all competitors on a route, or if a wide range of routes all experience the same proportionate price increase, the demand for airline services becomes less elastic. As a price increase is extended to ever larger groups of competing airlines or competing destinations, then the overall demand for air travel is revealed to be somewhat inelastic.

The implications of this are as follows:

- For an airline on a given route, increasing price is likely to result in a more than proportionate decrease in air travel. Lower fares will greatly stimulate traffic and raise revenues.
  (i.e., airline specific fare changes are price elastic).

- If all airlines on a given route increase fares by the same amount (e.g., due to the imposition of passenger based airport fees that are passed on to the consumer), then the decrease in traffic will be less than the former case.

- If all airlines on a wide set of routes increase fares by roughly similar amounts (e.g., due to the imposition of new market-wide taxes or to the working through of higher fuel or security costs) then the decrease in traffic may be less or much less than proportional to the increase in fares.
  (i.e., general increases in airline fares across a broad range of markets appear to be price inelastic.)

Thus, the particular elasticity value to be used for analysing price effects in airline markets depends on the question being asked. The narrower the applicability of a price change, the more elastic the response. The more general the applicability of a price change (perhaps due to higher costs or taxes) the less elastic the response.

Appendix A - Final Model Specifications

The following section describes the models used to provide the figures seen in Section 4.0 of the report. Error terms are excluded from the specifications for ease of reading.

Ordinary Least Squares

U.S. Domestic:

$$\ln(Traffic) = Constant + a_1 \times \ln(Fare) + a_2 \times \ln(GeometricCityIncomePerCapita)$$
$$+ a_3 \times \ln(GeometricCityPopulation) + a_4 \times \ln(RouteDistance)$$
$$+ \sum_{i=5}^{m-1} a_i \times (TimePeriodDummies) + \sum_{j=m}^{n} a_j \times (RouteDummies)$$

UK to Western Europe:

$$\ln(Traffic) = Constant + a_1 \times \ln(Fare) + a_2 \times \ln(UKGDP) + a_3 \times \ln(RouteDistance)$$
$$+ \sum_{i=4}^{6} a_i \times (QuarterlyDummies)$$

Other:

$$\ln(Traffic) = Constant + a_1 \times \ln(Fare) + a_2 \times \ln(GeometricGDPPerCapita)$$
$$+ a_3 \times \ln(GeometricCountryPopulation) + a_4 \times \ln(RouteDistance)$$
$$+ \sum_{i=5}^{n} a_i \times (TimePeriodDummies)$$

Two Stage Least Squares

U.S. Domestic:

ln(RouteDistance) used as instrument in analysis.

$$\ln(Traffic) = Constant + a_1 \times \ln(Fare) + a_2 \times \ln(GeometricCityIncomePerCapita)$$
$$+ a_3 \times \ln(GeometricCityPopulation) + \sum_{i=4}^{m-1} a_i \times (TimePeriodDummies) + \sum_{j=m}^{n} a_j \times (RouteDummies)$$

Autoregressive Distributed Lag

UK to Western Europe:

$$\ln(Traffic_t) = Constant + a_1 \times \ln(Traffic_{t-1}) + a_2 \times \ln(Fare_t) + a_3 \times \ln(UKGDP_t)$$
$$+ a_4 \times \ln(RouteDistance) + \sum_{i=5}^{7} a_i \times (QuarterlyDummies)$$

Where 't' is the period of the current observation and 't-1' is the period of the observation in the same quarter/month of the previous year.

Other Non-U.S. Domestic:

$$\ln(\textit{Traffic}_t) = \textit{Constant} + a_1 \times \ln(\textit{Traffic}_{t-1}) + a_2 \times \ln(\textit{Fare}_t) + a_3 \times \ln(\textit{GeometricGDPPerCapita})$$

$$+ a_4 \times \ln(\textit{RouteDistance}) + \sum_{i=5}^{n} a_i \times (\textit{TimePeriodDummies})$$

Where 't' is the period of the current observation and 't-1' is the period of the observation in the same quarter/month of the previous year.

Appendix B - Omitted Variable Bias

The following section provides a brief proof of the bias that occurs in fare elasticity estimates when the price of a substitute good is excluded from the regression model.

Suppose the true model has a specification:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2$$

Where:

y = Traffic

x_1 = Average Fare

x_2 = The Price of a Substitute

e = An Error Term

An unbiased regression equation would be:

$$\hat{y} = \hat{\beta}_0 + \hat{\beta}_1 x_1 + \hat{\beta}_2 x_2 + e$$

If x_2 is omitted from the regression, then the following 'short regression' equation is estimated:

$$\tilde{y} = \tilde{\beta}_0 + \tilde{\beta}_1 x_1 + u$$

It is useful to know that:[31]

$$\tilde{\beta}_1 = \hat{\beta}_1 + \hat{\beta}_2 \tilde{\delta}_1$$

Where $\tilde{\delta}$ is the sample covariance between x_1 and x_2 divided by the sample variance of x_1.

The bias is therefore:

$$E(\tilde{\beta}_1) - \beta_1 = E(\hat{\beta}_1 + \hat{\beta}_2 \tilde{\delta}_1) - \beta_1 = \beta_2 \tilde{\delta}_1$$

Since $\tilde{\delta}_1$ is interpreted as being positive since the route fare and the substitute fare face the same economic and competitive pressures and β_2 is known to be positive by definition of a substitute, then:

$$\beta_2 \tilde{\delta}_1 > 0$$

That is, fare elasticity estimates have a positive bias.

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[31] Source: "Introductory Econometrics: A Modern Approach", Jeffrey M. Woolridge.

Appendix C - Long-Run Elasticity in ARDL Model

Since traffic appears on both sides of the equation in ARDL models described in Appendix A, the coefficients on the explanatory variables cannot be directly interpreted as long-run elasticities (only short-run elasticities). The long-run elasticities are defined as when traffic across time periods stabilize.

That is, if the ARDL model is defined as an equation with a single lag in the dependent variable and one contemporary independent variable:

$$\ln(y_t) = \beta_0 + \beta_1 \ln(y_{t-1}) + \beta_2 \ln(x_t) + e_t$$

Where 't' is the period of the current observation and 't-1' is the period of the observation in the same quarter/month of the previous year. Long-run elasticities are defined when:

$$y_t = y_{t-1}$$

This implies that:

$$\ln(y_t) = \beta_0 + \beta_1 \ln(y_t) + \beta_2 \ln(x_t) + e_t$$

and therefore,

$$\ln(y_t) = \frac{\beta_0 + \beta_2 \ln(x_t) + e_t}{1 - \beta_1}$$

If derivatives are taken on both sides with respect to $\ln(x_t)$, the equality becomes:[32]

$$\frac{\partial \ln(y_t)}{\partial \ln(x_t)} = \frac{\beta_2}{1 - \beta_1}$$

Which defines the long-run elasticity.

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[32] ∂ s are used instead of ds to reflect the fact that other explanatory variables may be in the final model specification.

Appendix D - Regression Output

Ordinary Least Squares

Model	Region	Ln Fare	Ln Distance	Ln Income	Ln Population	Time Dummy	Route Dummy	Adjusted R²
Model 1	U.S. Domestic (DB1B)	-0.83 (-141.03)	-1.73 (-31.85)	0.99 (22.09)	0.45 (8.76)	For every quarter	Yes	0.95
Model 2	World (PaxIS)	-0.62 (-19.54)	-0.13 (-6.72)	0.03 (2.64)	0.10 (7.30)	For every month	No	0.61
Model 3	UK to Western Europe (IPS)	-0.82 (-36.00)	0.87 (47.56)	1.45 (14.33)	N/A	For every quarter	No	0.61
Model 4	Intra-Europe (PaxIS)	-1.30 (-140.73)	0.13 (5.29)	0.09 (14.70)	N/A	For every month	No	0.71
Model 5	Intra South and East Asia (PaxIS)	-0.86 (-28.04)	0.13 (5.29)	-0.08 (-5.37)	N/A	For every month	No	0.10
Model 6	Intra Latin America (PaxIS)	-1.20 (-52.07)	-0.15 (-11.19)	0.10 (5.05)	N/A	For every month	No	0.22
Model 7	Intra Sub-Saharan Africa (PaxIS)	-0.56 (-7.433)	0.12 (2.34)	0.19 (7.99)	N/A	For every month	No	0.60
Model 8	Transatlantic (PaxIS)	-1.06 (-35.42)	-0.09 (-2.14)	0.32 (13.53)	N/A	For every month	No	0.60
Model 9	Transpacific (PaxIS)	-0.36 (-7.54)	-1.78 (-10.90)	0.19 (6.69)	N/A	For every month	No	0.60
Model 10	Europe-Asia (PaxIS)	-0.73 (-18.28)	0.25 (0.43)	0.22 (11.26)	N/A	For every month	No	0.40

All figures reported are valid at the 95% significance level. Figures in brackets are t-statistics.

Regression Output – Two Stage Least Squares

Model Number	Region	Ln Fare	Ln Distance	Ln Income	Ln Population	Time Dummy	Route Dummy	Adjusted R-Squared
Model 1	U.S. Domestic (DB1B)	-1.46 (-46.89)	N/A	1.76 (24.34)	1.80 (35.41)	For every quarter	Yes	N/A

Notes:

All figures reported are valid at the 95% significance level. Figures in brackets are t-statistics.
Ln Distance was used as the instrumental variable in regression
The R-Squared value is excluded since 2SLS seeks to obtain proper parameter estimates, not maximize goodness of fit (unlike OLS).

Inter*VISTAS*

Regression Output – Autoregressive Distributed Lag

Model Number	Region	Year over Year Lag Ln Traffic	Ln Fare	Ln Distance	Ln Income	Time Dummy	Route Dummy	Adjusted R-Squared
Model 1	World (PaxIS)	0.92 (1392.64)	-0.15 (-72.56)	-0.06 (-45.94)	-0.03 (-32.38)	For every month	No	0.88
Model 2	UK to Western Europe (IPS)	0.80 (120.02)	-0.17 (-8.31)	0.19 (12.01	0.43 (4.53)	Quarterly	No	0.70
Model 3	Intra-Europe (PaxIS)	0.903 (810.80)	-0.27 (-70.99)	0.04 (17.72)	-0.03 (-11.53)	For every month	No	0.87
Model 4	Intra South and East Asia (PaxIS)	0.95 (324.34)	-0.16 (-13.98)	0.11 (12.35)	-0.08 (-15.49)	For every month	No	0.88
Model 5	Intra Latin America (PaxIS)	0.90 (325.37)	-0.19 (-18.16)	0.06 (10.08)	-0.04 (-5.41)	For every month	No	0.86
Model 6	Intra Sub-Saharan Africa (PaxIS)	0.72 (76.80)	-0.37 (-7.61)	0.23 (7.17)	0.02 (1.11)	For every month	No	0.61
Model 7	Transatlantic (PaxIS)	0.93 (427.52)	-0.10 (-8.99)	0.02 (1.36)	-0.05 (-5.92)	For every month	No	0.88
Model 8	Transpacific (PaxIS)	0.91 (141.22)	-0.09 (-4.72)	0.21 (2.99)	-0.19 (-16.22)	For every month	No	0.84
Model 9	Europe-Asia (PaxIS)	0.92 (261.66)	-0.10 (-6.10)	-0.14 (-5.99)	0.02 (2.35)	For every month	No	0.86

All figures reported are valid at the 95% significance level. Figures in brackets are t-statistics.

Appendix E - Data Sources

U.S. Domestic Market Data Sources

Variable Name	Source	Units	Time Frequency	Explanation
Traffic	U.S. DOT DB1B	Persons	Quarterly	Origin-destination passengers per quarter for a city pair route.
Real Average Fare	U.S. DOT DB1B and U.S. Bureau of Labor	1994 USD	Quarterly	Calculated by taking reported average fare from DB1B 10% sample then dividing by CPI.
Real MSA Personal Income Per Capita	U.S. BEA and U.S Bureau of Labor	1994 USD	Annually	Calculated by taking personal income for a given Metro Statistical Area then dividing by population and then dividing by the CPI.
MSA Population	Bureau of Labor	Persons	Annually	Number of residency in the given Metro Statistical Area.
Real Fuel Price	U.S. EIA and Bureau of Labor	1994 U.S. cents per U.S. Gallon	Quarterly	Calculated by taking the price of fuel and dividing by the CPI.
Distance	U.S. DOT DB1B	Miles	Constant	Actual distance travelled by route.

UK Outbound Market Data Sources

Variable Name	Source	Units	Time Frequency	Explanation
Traffic	UK International Passenger Survey	Persons	Quarterly	Outbound passengers per quarter for a route. Separated by business and leisure.
Average Fare	UK International Passenger Survey	GBP	Quarterly	Reported average fare from survey.
Real Gross Domestic Product	Office for National Statistics	GBP	Quarterly	UK Real Gross Domestic Product (Not seasonally adjusted).
Distance	Great Circle Mapper	Km	Constant	Airport pair distance based on great circle.

Appendix F - List of Countries by Region

Africa : Central/Western Africa

Benin
Burkina Faso
Cameroon
Cape Verde
Central African Republic
Chad
Congo
Congo Democratic
Republic of
Cote D'Ivoire
Equatorial Guinea
Gabon
Gambia
Ghana
Guinea
Guinea-Bissau
Liberia
Mali
Mauritania
Mayotte
Niger
Nigeria
Sao Tome and Principe
Senegal
Sierra Leone
Togo

Africa : Eastern Africa

Burundi
Comoros
Djibouti
Eritrea
Ethiopia
Kenya
Madagascar
Mauritius
Rwanda
Seychelles
Somalia

Tanzania United Republic
of
Uganda

Africa : North Africa

Algeria
Egypt
Libyan Arab Jamahiriya
Morocco
Sudan
Tunisia

Africa : Southern Africa

Angola
Botswana
Lesotho
Malawi
Mozambique
Namibia
South Africa
Swaziland
Zambia
Zimbabwe

Asia : Central Asia

Bhutan
Kazakhstan
Kyrgyzstan
Tajikistan
Turkmenistan
Uzbekistan

Asia : North East Asia

China
Hong Kong (sar) China
Japan
Korea Democratic People's
Republic of
Korea Republic of
Macao (sar) China

Mongolia
Russian Federation

Asia : South Asia

Afghanistan
Bangladesh
India
Maldives
Nepal
Pakistan
Sri Lanka

Asia : South East Asia

Brunei Darussalam
Cambodia
Indonesia
Lao People's Democratic
Republic
Malaysia
Myanmar
Philippines
Singapore
Thailand
Timor-leste
Viet Nam

Europe : Eastern/Central Europe

Albania
Armenia
Azerbaijan
Belarus
Bosnia and Herzegovina
Bulgaria
Croatia
Czech Republic
Estonia
Georgia
Hungary
Latvia
Lithuania

Macedonia Former
Yugoslav Republic of
Moldova Republic of
Poland
Romania
Russian Federation
Serbia and Montenegro
Slovakia
Slovenia
Ukraine

Europe : Western Europe

Austria
Belgium
Cyprus
Denmark
Faroe Islands
Finland
France
Germany
Greece
Iceland
Ireland Republic of
Italy
Luxembourg
Malta
Monaco
Netherlands
Norway
Portugal
Spain
Sweden
Switzerland
Turkey
United Kingdom

Latin America : Caribbean

Antigua and Barbuda,
Leeward Islands
Aruba
Bahamas
Barbados
Bermuda
Cayman Islands

Cuba
Dominica
Dominican Republic
Grenada, Windward
Islands
Haiti
Jamaica
Netherlands Antilles
Puerto Rico
Saint Kitts and Nevis,
Leeward Islands
Saint Lucia
Trinidad and Tobago
Virgin Islands, Us

Latin America : Central America

Belize
Costa Rica
El Salvador
Guatemala
Honduras
Mexico
Nicaragua
Panama

Latin America : Lower South America

Argentina
Brazil
Chile
Paraguay
Uruguay

Latin America : Upper South America

Bolivia
Colombia
Ecuador
Guyana
Peru
Suriname

North America

United States of America
Canada

Southwest Pacific

American Samoa
Australia
Bulgaria
Fiji
French Polynesia
Guam
Kiribati
Marshall Islands
Micronesia Federated
States of
New Caledonia
New Zealand
Palau
Papua New Guinea
Samoa
Solomon Islands
Tonga