



Air Travel Demand

IATA ECONOMICS BRIEFING N° 9



Measuring the responsiveness of air travel demand to changes in prices and incomes



IATA Economics Briefing N° 9:
AIR TRAVEL DEMAND

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00 | Foreword

The impact on demand of every air transport policy decision is an essential consideration. Without it, uncertainty over demand leads to ineffective or counter-productive decisions.

At the present time, the airline industry faces many cost pressures. The industry has made remarkable achievements in improving its efficiency. But cost pressures continue, from record high fuel prices to unjustified increases in charges from monopolistic airports, to further taxes imposed by governments. Higher costs inevitably lead to higher prices for airline passengers.

Therefore, it is crucial that reliable and appropriate estimates are available to assess how higher prices impact on the level of demand for air travel. This impact will, of course, differ according to the level and location at which prices are changed.

This report provides groundbreaking new research into the sensitivity of air travel demand to changes in air travel prices and incomes. It provides clear guidelines for the appropriate use of demand elasticities and robust and reliable estimates of their value.

Air transport provides economic benefits not just for its passengers and cargo shippers, but also for the wider economy by connecting businesses and individuals to global markets. Modern, just-in-time, global supply chains and multinational businesses are made possible by global airline networks. Yet governments often fail to recognise this and continue to implement air transport policies that are not in the best interests of the aviation industry and the wider economy. Monopolistic airports that raise charges but do not improve the services they offer will see passengers quickly shift elsewhere. Governments that impose new taxes on the industry are taking advantage of less sensitive movements in demand at the national level to raise revenues at the industry's expense.



The results in this report also have important implications for environmental policies. The aviation industry is committed to a carbon-neutral – and eventually a carbon-free – future. IATA's 4-Pillar Strategy is already taking action on emissions reduction measures focusing on technology, infrastructure, operations and those brought about by well designed economic instruments.

By contrast, rudimentary demand-side policies, such as “green taxes”, that try to reduce emissions by raising the price of travel for passengers are likely to fail. With passengers having far fewer possibilities to be able to reduce their travel on routes subject to such a tax at a national or supra-national level, such measures will provide easy revenues for governments, but will be ineffective in terms of their main objective.

Understanding the impact on demand is the key to effective policy decisions concerning aviation – for the benefit of the industry, its users, the environment and the wider economy.

A handwritten signature in blue ink that reads "Giovanni Bisignani". The signature is fluid and cursive, written in a professional style.

Giovanni Bisignani
Director General & CEO,
IATA

01 | Executive Summary

The demand for air travel is sensitive to changes in air travel prices and incomes. However, the degree of sensitivity (i.e. its demand elasticity) will vary according to different situations. To ensure that air transport policies are effective, reliable estimates for demand elasticities are essential.

This report provides important new evidence on the size and appropriate use for demand elasticities for air travel. It outlines the key findings from extensive research undertaken on behalf of IATA by InterVISTAS Consulting Inc. to estimate air travel demand elasticities applicable to a wide range of air transport markets¹. It builds upon previous academic research to provide new estimates of air travel demand elasticities in different locations and scenarios, based on a comprehensive econometric analysis using key air travel databases.

The aim of the study is to provide robust air travel demand elasticity estimates to ensure that policy decisions related to issues such as liberalisation, airport charges, taxation, emissions schemes, are made on the basis of appropriate and reliable evidence. It provides important new estimates to ensure that price elasticity estimates do not underplay the sensitivity of passengers to price and are used correctly.

DEFINITION OF DEMAND ELASTICITIES

Demand elasticities measure the change in the quantity demanded of a particular good or service as a result of changes to other economic variables, such as its own price, the price of competing or complementary goods and services, income levels and taxes. They provide a key insight into the proportional impact of different economic actions and policy decisions.

This report estimates the demand elasticity of air travel under various scenarios and locations. It focuses on three main types of demand elasticity:

¹ The full report "InterVistas (2008), Estimating Air Travel Demand Elasticities" contains more details on the econometric results and can be found at www.iata.org/economics.

- Own price elasticity is a measure used to capture the sensitivity of consumers demand for a good or service in response to changes in the price of that particular good or service. Goods with elasticities less than one in absolute value are inelastic or price insensitive. Goods with elasticities greater than one in absolute value are elastic or price sensitive.
- Cross price elasticity measures the interaction or the sensitivity of demand for a particular good to changes in the price of another good. When the cross price elasticity is positive, the two goods are substitutes, when it is negative the goods are complementary.
- Income elasticity measures the sensitivity of demand for a good to changes in individual or aggregate income levels.

AIR TRAVEL DEMAND ELASTICITIES

The elasticity of air travel demand varies according to the coverage and location of the market in which prices are changed and the importance of the air travel price within the overall cost of travel. The appropriate elasticity to use will depend on the type of question being asked. What is the price that is being changed (e.g. an individual airline ticket price or prices within the market as a whole)? What is the unit of demand that is being assessed (e.g. demand for an individual airline or demand for total air travel)? Examining the traffic impact of a price increase on a given route requires a different elasticity than when examining the impact of an across-the-board price increase on all routes in a country or region.

There often appears to be some confusion in policy discussions about the sensitivity of airline passengers to the price of travel. This has increased as the industry has changed, with the Internet increasing price transparency, deregulated markets and no frill carriers increasing competition and corporate travel buyers becoming more price sensitive. In particular, there is an apparent paradox whereby:

- Passengers are becoming increasingly sensitive to price, led by the boom in low cost travel, the transparency brought by the Internet and the intense competition on deregulated markets.
- But, passengers are also becoming less sensitive to price, as increasingly lower air travel prices, in real terms mean that the air travel price itself becomes a smaller and less important part of the total cost of a typical journey.

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. But there are two main explanations for this. Firstly, as the air travel component of the journey can be relatively easily substituted between airlines, routes, modes, etc, the price elasticity for the air travel price can be much higher than suggested by the price elasticity of the overall journey cost. Secondly, passengers (especially for short leisure journeys) can use a “two-stage” decision-making process, selecting a flight destination based on the level of air travel price offered and then considering the other costs associated with the journey.

The appropriate value of a demand elasticity will vary in accordance to the context in which they are considered. For air transport there are five main levels (for the scope of the market) for which demand elasticities can be estimated:

- Price Class Level. This the most disaggregate level, where passengers make a choice between different price classes (e.g. first class, business class, economy class) on individual airlines.
- Airline / Air Carrier Level. This reflects the overall demand curve facing each airline on a particular route.
- Route / Market Level. At the route or market level (e.g. London Heathrow–Paris CDG or London–Paris), travellers faced with a price increase on all carriers serving a route (e.g. due to an increase in airport fees and charges), and have fewer options for substitution.
- National Level. At the national level, travel prices are increased on all routes to and from a particular country (e.g. due to a higher national departure tax), giving travellers fewer options for avoiding the price increase.
- Supra-National Level. This represents a change in travel prices that occurs at a regional level across several countries (e.g. an aviation tax imposed on all member states of the European Union). In this case, the options for avoiding the price increase are even further reduced.

In each of the five levels of aggregation, different cross-price elasticities exist, reflecting the availability of substitute options. The own price elasticity at one level of aggregation can reflect both the own price and cross price elasticities at other levels of aggregation. The interaction between these effects adds significant complexity to the analysis, requiring clarity on which own price and cross

price elasticities were measured and controlled for. For example, an analysis of route-level elasticities which does not control for route substitution effects may be more appropriate for a national-level elasticity.

The evidence and discussion provided in this report focuses on the appropriate elasticities for the route, national and supra-national level of aggregation.

EXTENSIVE REVIEW OF PREVIOUS STUDIES

InterVISTAS Consulting reviewed the available literature on demand elasticities. The review of previous studies helps to provide a greater understanding of air travel price elasticities and provides important insights for the new econometric analysis. The different studies produced a wide range of air travel price elasticity estimates, varying in accordance with the markets analysed, the time period assessed, the methodology used and the available data. Even within some particular studies, a range of elasticities are estimated for different markets.

Nevertheless, the previous studies do show a number of consistent themes. All of the studies reviewed found that there was a significant demand response to changes in air travel prices. This indicates that any policy action that results in higher air travel prices (e.g. passenger taxes, increased landing fees) will result in a decline in demand. Critically, however, the extent of that decline will depend on a number of factors:

- **Business vs. Leisure Passengers.** In general, all else being equal, business travellers are less sensitive to price changes (less elastic) than leisure travellers. Business travellers generally have less flexibility to postpone or cancel their travel than leisure travellers.
- **Short-Haul vs. Long-Haul Travel.** Price 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.
- **Airline vs. Market vs. National Elasticities.** Some of the studies supported the concept that the demand elasticity faced by an individual airline is higher than that faced by the whole market.
- **Income Elasticities.** Including income as an explanatory variable of demand isolates the effects of a shift along the demand curve (caused by a change in air travel price) from the effect of a shift of the whole demand curve (caused by a change in incomes or GDP).

The studies including the income term all produced positive income elasticities, with air travel increasing at a higher rate than income growth.

DATA SOURCES

The new econometric analysis undertaken by InterVISTAS Consulting used three different datasets:

- **US Department of Transport database 1B (DB1B).** DB1B provides data on the US domestic aviation market. Traffic figures reflect the actual number of passengers on a particular route, while average price reflects the estimated average one-way travel price paid (in USD).
- **IATA's Passenger Intelligence Service (PaxIS) database.** This database captures market data through IATA's Billing and Settlement Plan (BSP). It provides traffic and travel price estimates for airport-pair routes around the world (e.g. JFK-LHR, CDG-FRA). However, data is only available from 2005 onwards.
- **UK International Passenger Survey (IPS).** The IPS is a survey of passengers entering or leaving the UK by air, sea or the Channel Tunnel. This report exclusively used outbound to Western Europe leisure air passenger traffic data from the IPS. Traffic figures reflect the estimated number of passengers on a particular airport-pair route, while average travel price reflects the estimated average price paid (in GBP).

ECONOMETRIC RESULTS

The new econometric analysis is comprehensive, based on over 500 regression models. Building on the previous studies, the new econometric analysis develops a set of in-depth guidelines, and guideline elasticities, that can be applied to the analysis of different air markets. Base elasticity estimates are developed for the different levels of aggregation (route, national and supra-national level). Multiplicative estimates were then developed to adjust the elasticities to reflect specific geographical markets.

i) Level of Aggregation

In summary, the econometric results found that at the route level (where competition between airlines or city-pair markets is high) the sensitivity of demand to price is very high. However, at the national or regional level, air travel is relatively price insensitive. The results support demand elasticities of:

- Route Level: -1.4
- National Level: -0.8
- Supra-National Level: -0.6

Route Level. The review of previous research found route level elasticities ranging from -1.2 to -1.5. Regressions using the US DB1A data, which allows the use of route dummies and variables to capture the price of route substitutes, produced a similar air travel price elasticity of -1.4. This elasticity estimate is applicable to a situation where the price of an individual route changes (e.g. higher airport charges at Paris CDG raising the price of travel from London and diverting leisure traffic to another destination, such as Frankfurt). Using distance as an instrument variable within the 2SLS (Two Stage Least Squares) statistical model produces results that further support this elasticity, though there still is some concern over the use of distance in this way due to its perceived exogenous influence on demand.

National Level. Estimates of national elasticities using all three datasets found that, without the route substitution term, elasticities fell to around -0.8. This inelastic result was found over a range of model specifications which excluded route dummies. The national level elasticity applies to a situation such as the doubling of a national passenger departure tax, affecting all departing routes equally but leaving the cost of travel from elsewhere unchanged. Its value reflects a combination of the route own price elasticities with cross price elasticities, when all national routes have prices which vary in the same way. The inelastic result is consistent with observations that part of the price elasticity observed from low cost carriers (LCCs) involves substitution from other routes. When this is controlled for, LCCs have a lower level of market stimulation, consistent with less elastic national elasticities.

Supra-National Level. At the supra-national level (e.g. the European Union) estimates show an even less elastic air travel price elasticity of -0.6. This is because as the number of routes covered expands the number of choices for passengers to avoid any travel price increase diminishes. There is less opportunity for traffic to be diverted.

ii) Short-Haul vs. Long-Haul

- The review of previous research found consistent results showing that air travel price elasticities on short-haul routes were higher than on long-haul routes. This largely reflects the greater opportunity for inter-modal substitution on short haul routes

(e.g. travellers can switch to rail or car in response to air travel price increases). While the geographical breakdowns outlined in the next section 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 an elasticity multiplier of 1.1 is used to adjust air travel price elasticities for short-haul markets. This does not apply to the analysis of trans-Atlantic or trans-Pacific markets, which are entirely long-haul, with virtually no opportunity for modal substitution.

iii) Geographic Market Analysis

The econometric analysis of the IATA PaxIS Plus data found statistically significant differences between different geographic air travel markets. The estimated elasticity multipliers for each market, along with the reasons for why it is needed, are:

- **Intra North America.** This is our reference point with an elasticity multiplier of 1. The market is well established with relatively high levels of capacity and traffic. Prices tend to be low, while distances are short to medium haul.
- **Intra Europe.** Traffic in this region is estimated to be more elastic, with an elasticity multiplier of 1.4. Intra European routes typically have shorter average travel distances, strong competition from other transport modes and the use of very low prices in several markets. The high market share of charter airlines is being eroded by very low fare LCCs.
- **Intra Asia.** Moderately more inelastic estimates were found in this region, with an elasticity multiplier of 0.95. LCCs are now emerging in Asia but average distances are longer, and the key middle class is still relatively small in many markets in this region.
- **Intra Sub-Saharan Africa.** This region is estimated to have a relatively inelastic demand compared to North America, with an elasticity multiplier of 0.6. African economies have a much smaller middle class. Travel is concentrated among higher income individuals who are less price-sensitive.
- **Intra South America.** This region is estimated to be at the more elastic end of the scale, with an elasticity multiplier of 1.25. There is an emerging middle class making the region more price elastic plus LCCs are emerging in Brazil, Chile and Mexico.

- **Trans Atlantic (North America – Europe).** A high price elasticity was found for this market, with an elasticity multiplier of 1.2. This market has long been developed by low fare charter airlines. Price is likely more important than frequency in this market than in US domestic markets
- **Trans Pacific (North America – Asia).** By contrast, markets across the Pacific are estimated to have a much less elastic response, with an elasticity multiplier of 0.6. There are no charter services and there remain markets with less liberal pricing regulation. There are early signs of long-haul LCCs emerging but at present this market shows much less sensitivity to travel price than the US domestic market or the trans Atlantic market.
- **Europe-Asia.** This market is estimated to be slightly less price sensitive, with an elasticity multiplier of 0.9. 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.

By way of illustration, elasticities for different situations can be developed by selecting the relevant base price elasticity and applying the relevant multipliers. For example:

- 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 (supra-national)
- Geographic market: 1.4 (Intra Europe)
- Short-haul adjustor: 1.1

The price elasticity would then be calculated as:
 $-0.6 \times 1.4 \times 1.1 = -0.92$

- 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 price elasticity would then be calculated as:
 $-0.8 \times 1.2 = -0.96$

- To examine the 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 price elasticity would then be calculated as:
 $-1.4 \times 0.95 \times 1.1 = -1.46$

APPLYING THE ELASTICITY ESTIMATES AND MULTIPLIERS

Table 1 provides a guideline for the estimated price demand elasticity by level of aggregation and by region. It multiplies the estimate for the relevant level of aggregation by the relevant short-haul and geographic elasticity multipliers.

Table 1: Estimated Price Elasticities of Passenger Demand

	Route/Market level		National level		Supra-national level	
	Short-haul	Long-haul	Short-haul	Long-haul	Short-haul	Long-haul
Intra N America	-1.5	-1.4	-0.9	-0.8	-0.7	-0.6
Intra Europe	-2.0	-2.0	-1.2	-1.1	-0.9	-0.8
Intra Asia	-1.5	-1.3	-0.8	-0.8	-0.6	-0.6
Intra Sub-Saharan Africa	-0.9	-0.8	-0.5	-0.5	-0.4	-0.4
Intra S America	-1.9	-1.8	-1.1	-1.0	-0.8	-0.8
Trans-Atlantic	-1.9	-1.7	-1.1	-1.0	-0.8	-0.7
Trans-Pacific	-0.9	-0.8	-0.5	-0.5	-0.4	-0.4
Europe-Asia	-1.4	-1.3	-0.8	-0.7	-0.6	-0.5

INCOME ELASTICITIES

The main focus of the research was on price elasticities. Nevertheless, the analysis also considered the sensitivity of demand to changes in incomes. The econometric research and review of previous estimates found that air transport income elasticities were consistently positive and greater than one. This suggests that as households and individuals get more prosperous, they are likely to devote an increasing share of their incomes to discretionary spending such as air travel.

The statistical evidence suggests:

- Developed country travel markets have base income elasticities for short-haul routes of around 1.5. At the national level, this declines to an estimated income elasticity of 1.3.
- US travel markets have slightly higher income elasticities with air travel perhaps less budget-oriented than in other developed economies. Using the DB1A data suggests short-haul route income elasticities of 1.8 at the route level and 1.6 at the national level.

- There is some evidence that income elasticities decline as countries become richer and markets mature. Developing countries typically have a greater responsiveness, with an estimated short-haul income elasticity of around 2.0 at the route level and 1.8 at the national level.
- There is also evidence that long-haul journeys are seen by passengers as different, more desirable, to the more commoditised short-haul markets, and so income elasticities are higher the longer the distance. This suggests that middle to lower income individuals are more likely to travel on short to medium haul routes, with higher incomes leading to a higher frequency of long haul travel.

The income elasticity results are based on information from the review of previous studies and results from the new econometric research. Table 2 outlines the estimated income elasticities for different markets at the route and at the national level.

Table 2: Estimated income elasticities of passenger demand

Route / Market level	Short-haul	Medium-haul	Long-haul	Very long-haul
US	1.8	1.9	2.0	2.2
Developed economies	1.5	1.6	1.7	2.4
Developing economies	2.0	2.0	2.2	2.7
National level	Short-haul	Medium-haul	Long-haul	Very long-haul
US	1.6	1.7	1.8	2.0
Developed economies	1.3	1.4	1.5	2.2
Developing economies	1.8	1.8	2.0	2.5

If passengers are relatively insensitive to air travel prices at a national aggregate market level, and even less so at a supra-national level, this strongly suggests that falling real air travel prices have not been the main driver of air travel growth². Falling real air travel prices are important in passengers switching from one airline to another, and from one destination to another, but are much less important in driving aggregate national-level air travel or tourism growth.

The growth of incomes, often proxied by GDP, has been found to be the fundamental driver of the demand for air travel. During the past twenty years global passenger traffic has expanded at an average annual growth rate of 5.1%, while global GDP grew by an average annual rate of 3.7% over the same period. That implies an average income elasticity of 1.4, similar to the average estimated above for developed economies. The implication is that economic growth can explain most of the expansion in air travel seen in the past twenty years. The fall in real air travel prices has played a part, but mostly in diverting travel between airlines and markets rather than significantly boosting overall travel volumes. In addition, economic growth is now increasingly being driven by developing economies, where income elasticities are higher. Therefore, the underlying drivers for overall air travel growth are likely to remain strong for the foreseeable future.

INBOUND VS OUTBOUND PRICE ELASTICITIES

One further adjustment that may need to be applied to the price elasticity estimates in table 1 is for the case when the passenger flow of concern is inbound or outbound, not the total or average impact. This will be of particular importance when considering the impact on inbound tourism of, for example, a national passenger tax. It also matters when considering the diversion of inbound passengers and consequent reduction of effectiveness of a national or regional environmental tax.

The price elasticity estimates in table 1 are all averages of outbound and inbound passengers. Most databases of passenger numbers and fares do not distinguish between domestic residents travelling overseas then returning, and overseas residents visiting and then returning home. However, their sensitivity to travel prices including taxes will differ.

These estimates will be verified by future research. Meanwhile a reasonable rule-of-thumb multiplier to adjust the price elasticities in table 1 is as follows:

$$\text{Inbound travel by overseas residents} = -1.3/-1.0 \\ = 1.3 * \text{table 1 price elasticity}$$

$$\text{Outbound travel by domestic residents} = -0.8/-1.0 \\ = 0.8 * \text{table 1 price elasticity}$$

² This conclusion was reached in a recent study of the UK market (UK CAA, 2006, No frills carriers; revolution or evolution). It concludes that "despite the spectacular growth of no-frills carriers in the UK, and the perceptions about the impact they have had on travel habits, there has been little change in long-term aggregate passenger traffic growth rates".

³ Building a Greener Future (2007) IATA.

POLICY IMPLICATIONS

The correct elasticity value to use in analysing an air transport policy decision depends on the type of question being asked. The impact on demand of higher travel costs on a given route due to a rise in airport landing charges requires a different (higher) elasticity than when examining the traffic impact of a wider travel cost increase due to a passenger tax on all routes in a country.

Air transport policy decisions run the risk of being ineffective, or even counter-productive, if the correct demand elasticity is not used. For example:

- A revenue-raising policy to raise the price of travel on a route (e.g. higher airport charges) will reduce passenger numbers more than expected if the price elasticity of demand is underestimated. A price elastic response to air travel price increases at the route level means that demand falls at a proportionately higher rate than the increase in price.
- A national passenger tax may damage inbound tourism more than expected if policy-makers do not take into account the greater price elasticity of overseas residents visiting the country, who have a choice of destinations, compared to outbound domestic residents who can either pay the tax or not travel.
- An environmental policy to raise the price of travel (e.g. a national aviation tax) on a national or supra-national basis will be ineffective if the price elasticity of outbound travel is low, as found. A price inelastic response at the national or supra-national level means that the impact in terms of reducing demand will be proportionately less than the increase in price. The greater price sensitivity of inbound overseas residents will result in a diversion to other destinations, a “leakage of carbon”, and thus a reduction in environmental effectiveness.

The focus of existing policy to reduce CO₂ emissions from air travel has been on trying to manage air travel demand by raising the cost of travel for passengers. The results contained in this report show that such policies are likely to fail. Decoupling emissions from travel growth needs to focus not on demand management but on mechanisms to bring about emissions reduction measures from technology, infrastructure and operations.

IATA's 4-Pillar Climate Strategy³, which was endorsed by the Assembly of the International Civil Aviation Organisation in 2007, focuses action on emission reduction measures from technology, infrastructure, operations and those brought about by well designed economic instruments.

Effectively decoupling emissions from air travel growth will require policy-makers and the industry to look beyond simple economic instruments:

- Technological progress will require collaboration across the value chain and across countries.
- Governments will need to play a role in funding fundamental research.
- Political will is perhaps one of the most important mechanisms for delivering emissions reductions from infrastructure improvements.
- The lack of implementation of a Single European Sky is one glaring omission in policy action to reduce emissions from air travel.

IATA is actively promoting collaborative efforts on technology and is lobbying hard for governments to improve infrastructure. For operations, there is a major initiative to spread best practices. More needs to be done about the challenges of climate change, but the airline industry is already stepping up efforts with a bold vision of zero emissions and an important target of carbon-neutral growth. The key lesson for both policy-makers and the industry is to look beyond simple economic instruments for mechanisms to bring about an effective reduction in emissions from air travel.

02 | Report Outline

Air transport is an integral part of the global economy. It is essential to understand the sensitivity of air transport demand to policy and economic decisions, and to ensure that these decisions are made on a more effective and appropriate basis.

This report discusses the key findings from extensive research undertaken on behalf of IATA by InterVISTAS Consulting Inc. to estimate air travel demand elasticities applicable to a wide range of air transport markets. It provides important new evidence for estimating elasticities in different locations and scenarios, based on access to comprehensive air travel databases. It builds upon previous academic research into air travel demand elasticities.

The report is structured as follows:

What are Demand Elasticities?

Chapter 3 provides definitions for different categories of demand elasticities and discusses how each can be interpreted. It outlines three key concepts: price elasticity of demand, cross-price elasticity of demand and income elasticity of demand. It also discusses key factors that influence both the demand for air transport and the sensitivity of this demand to changes in prices and incomes.

How can this be applied to air travel demand?

Chapter 4 discusses the different types of demand elasticity that can be estimated for air travel. It discusses how the relevant demand elasticity can change in relation to the market size and its geographical location.

Previous estimates

Chapter 5 summarises the key findings from the review undertaken by InterVISTAS Consulting Inc. of previous academic studies that have estimated air travel demand elasticities. It outlines the wide range of estimates that have been produced, as well as the common themes between the majority of the studies.

New evidence for air travel demand elasticities

Chapter 6 outlines the key findings from a comprehensive econometric analysis of the data from three key air travel data sources. The results from this analysis provide important new evidence of the relevant demand elasticity in different markets.

What does this mean for air transport policymakers?

Chapter 7 discusses how this new evidence can be applied to air transport policy decisions. It provides guidelines for the application of air travel demand elasticities for different types of decisions. It helps to ensure that policy decisions are made on the basis of appropriate and reliable estimates of their impact on demand.

Chapter 8 provides a summary and conclusions.

03 | The Definition of Demand Elasticities

Elasticity measures the response of one economic variable (e.g. the quantity demanded) to a change in another economic variable (e.g. price). It provides key insight into the proportional impact of different economic actions and policy decisions.

Demand elasticities measure the change in the quantity demanded of a particular good or service as a result of changes to other economic variables, such as its own price, the price of competing or complementary goods and services, income levels, taxes, etc. This report estimates the demand elasticity of air travel under various scenarios and locations. It highlights three main types of demand elasticity: own price elasticity, cross price elasticity and income elasticity.

i) Price Elasticity of Demand

Price elasticity is a measure used to capture the sensitivity of consumer demand for a good or service in response to changes in the price of that particular good or service. The price elasticity is defined as:

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

The quantity demanded generally decreases when the price increases, so this ratio is usually expected to be negative. For example, if a 10% increase in the price of good A results in a 6% fall in the quantity demanded of that good, its own price elasticity is -0.6. By contrast, if a 10% fall in the price of good B leads to a 12% increase in the quantity demanded of good B, its own price elasticity is -1.2.

Goods with elasticities less than one in absolute value are commonly referred to as having inelastic or price insensitive demand. In other words, 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 received by the producer of the good, since the revenue lost by the 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. In other words, 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.

ii) Cross Price Elasticity of Demand

The cross price elasticity measures the interaction in demand between different goods or services. It 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 cross price elasticity is positive, the two goods are substitutes (e.g. Coca-Cola and Pepsi). In other words, an increase in the price of one good will lead consumers to shift demand towards the relatively cheaper substitute good. When the cross price elasticity is negative the goods are complementary goods (e.g. coffee and milk). In other words, an increase in the price of one good will negatively affect both its own demand and the demand of goods that are usually bought to accompany it.

iii) Income Elasticity of Demand

The income elasticity measures the sensitivity of demand for a good to changes in individual or aggregate income levels:

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

An income elasticity between 0 and +1 indicates a normal good, where 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.

An income elasticity greater than +1 indicates what economists call a luxury good, where consumption increases by a greater proportion than income. For example, as discretionary incomes rise consumers can afford to buy higher quality and/or leisure related goods that were previously beyond their reach. This does not mean these goods are the exclusive preserve of the rich, but that as living standards rise consumers value buying these goods the most. It is a measure of a highly valued good in consumer welfare terms.

A negative income elasticity indicates an inferior good, where the quantity demanded decreases as aggregate incomes increase. In other words, with higher incomes, consumers buy less of an inferior good and substitute it with better quality goods (e.g. buying branded goods rather than supermarket own-brands).

Key factors influencing demand elasticities

Demand elasticities can be influenced by several factors. The individual characteristics of a good or service will have an impact, but there are also a number of general factors that will typically affect the sensitivity of demand:

- Availability of substitutes. The elasticity is typically higher the greater the number of available substitutes, as consumers can easily switch between different products.
- Degree of necessity. Luxury or highly valued products typically have a higher elasticity. Some products that are initially a luxury 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 budget consumed by the item. Products that consume a large portion of the consumer’s budget tend to have greater elasticity.
- Time period considered. Elasticities tend to be greater over the long run because consumers have more time to adjust their behaviour.
- Whether the good or service is demanded as an input into a final product or whether it is the final product. 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.

Each of these general factors, along with the specific characteristics of the product, will interact to determine its overall responsiveness of demand to changes in prices and incomes.



12 Arrivals	
12:00	QF 1234 Sydney
12:15	QF 5678 Melbourne
12:30	QF 9012 Perth
12:45	QF 3456 Brisbane
13:00	QF 7890 Adelaide
13:15	QF 2345 Hobart
13:30	QF 6789 Darwin
13:45	QF 1011 Gold Coast
14:00	QF 4321 Cairns
14:15	QF 8765 Townsville
14:30	QF 2109 Mackay
14:45	QF 5432 Bundaberg

13 Arrivals	
13:00	QF 1122 Sydney
13:15	QF 3344 Melbourne
13:30	QF 5566 Perth
13:45	QF 7788 Brisbane
14:00	QF 9900 Adelaide
14:15	QF 2211 Hobart
14:30	QF 4433 Darwin
14:45	QF 6655 Gold Coast
15:00	QF 8877 Cairns
15:15	QF 1099 Townsville
15:30	QF 3210 Mackay
15:45	QF 5431 Bundaberg

14 Arrivals	
14:00	QF 2041 Sydney
14:15	QF 3123 Melbourne
14:30	QF 4205 Perth
14:45	QF 5287 Brisbane
15:00	QF 6369 Adelaide
15:15	QF 7451 Hobart
15:30	QF 8533 Darwin
15:45	QF 9615 Gold Coast
16:00	QF 1097 Cairns
16:15	QF 2179 Townsville
16:30	QF 3261 Mackay
16:45	QF 4343 Bundaberg

Arrivals →

or treatments & other remedies...

SECURITY ADVICE
Passengers are advised that security at Sydney Airport is subject to security screening.

04 | Key Types of Air Travel Demand Elasticities

The elasticity of air travel demand varies according to the coverage and location of the market in which prices are changed and the importance of the air travel price within the overall cost of travel. The appropriate elasticity to use will change according to the precise impact that is being analysed.

The previous chapter provided definitions for the different types of demand elasticity. Yet, when using this methodology to estimate the demand elasticity of air travel it is important to be clear about the precise question that is being asked. What is the price that is being charged (e.g. an individual airline ticket price or prices within the market as a whole)? What is the unit of demand that is being assessed (e.g. demand for an individual airline or demand for total air travel)? Estimating an appropriate demand elasticity requires a clear definition of what is being studied.

AIR TRAVEL PRICES AND TOTAL TRAVEL COSTS

There often appears to be some confusion in policy discussions about the sensitivity of airline passengers to the cost of travel. Some researchers have questioned whether estimated air travel price elasticities are consistent with changes in the total cost of travel (which may also include hotel, ground transport to/from the airport, food, entertainment, etc). In particular, there is an apparent paradox whereby:

- Passengers are becoming increasingly sensitive to price, led by the boom in low cost travel, the transparency brought by the Internet and the intense competition on deregulated markets.
- But, passengers are also becoming less sensitive to price, as increasingly lower air travel prices, in real terms, mean that the air travel price itself becomes a smaller and less important part of the total cost of a typical journey.

The proportion of total spending on an overseas visit by air will vary by country. In particular, air travel prices are likely to represent a higher proportion of travel spending in low income countries, especially where air travel markets have not been liberalised. However, for the bulk of air travel in liberalised OECD markets the air travel price typically represents around 25% of the total travel costs associated with leisure travel (though the exact percentage varies depending on the length and type of travel).⁴

Therefore, assuming an air travel price elasticity of -1.5, a 10% increase in the cost of the air travel price will reduce demand for travel by 15% (if the demand for air travel declines by 15%, it is assumed that the demand for the whole travel package will also decline by 15%). However, a 10% increase in the air travel price represents a 2.5% increase in the total cost of travel. This implies that the price elasticity with respect to total travel costs is -6.0 (-15% / 2.5%), an extremely high elasticity and one which is not matched by the much lower elasticities estimated by previous quantitative research of tourism demand elasticities.

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. Yet everyone in the travel and tourism industries knows they are dealing with very price sensitive customers, and that changing prices does produce a large demand response. There are two main explanations:

- **Substitution of components within an overall package.** 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, changes in an air travel price could result in the passenger changing to a different airline, route or another transport mode while still undertaking a similar journey. Therefore, the elasticity for the overall journey cannot be inferred from the air travel price elasticity and must instead be estimated on a separate basis.
- **A “two-stage” decision-making process.** Travellers are induced to select a destination based on the level of air travel price offered, and having booked the flight then consider the other costs associated with the travel (e.g. booking a low-fare air ticket and then making a separate decision on hotels, etc). In this case, the overall decision to travel is more sensitive to changes in the initial air travel price.

Therefore, passengers can be relatively more sensitive to the cost of the air travel price, even though it is only one component within the overall cost of travel. Air travel itself is a derived demand, based on the demand for passengers to travel to another location for business or leisure purposes. The other components of the journey cost are derived from the decision to travel and are essentially complementary goods to air travel (i.e. they have a cross-price elasticity to air travel prices of less than zero).

Level of Aggregation

The appropriate value of a demand elasticity will vary in accordance to the context in which they are considered. In particular, the scope of the price change and the demand impact being assessed will have a key influence on its value, with demand typically being more sensitive to price when a greater amount of substitutes are available.

⁴ For example, the International Passenger Survey by the UK Office of National Statistics estimates that for UK residents travelling to Europe by air, the travel price represented 27% of the total journey cost in 2004. This proportion has declined in the last ten years, led by the growth of no-frills LCC airlines.

For air transport there are five main levels (for the scope of the market) for which demand elasticities can be estimated:

- **Price Class Level.** This is the most disaggregate level, where passengers make a choice between different price classes (e.g. first class, business class, economy class) on individual airlines. At this level, the elasticities are arguably highest, with passengers easily able to switch between price-class levels and airlines, while also (in some cases) having the option to use another mode of travel or simply to choose to not travel (i.e. other activities act as a substitute for air travel).
- **Airline / Air Carrier Level.** This reflects the overall demand curve facing each airline on a particular route. Where there are a number of airlines operating on a route, the demand elasticity faced by each airline is likely to be fairly high. If an airline increases its price unilaterally, it is likely to lose passengers to other airlines operating on that route.⁵
- **Route / Market Level.** At the route or market level (e.g. London Heathrow–Paris CDG or London–Paris), the elasticity response is expected to be lower than at the price class or carrier level. Travellers faced with a travel price 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 still choose to travel on an alternative route, while also (in some cases) having the option to use another mode of travel or simply choose to not travel.
- **National Level.** At the national level, travel price elasticities are expected to be lower, as travellers have fewer options for avoiding the price increase. For example, if a national government imposed a new or increased tax on aviation, travellers could only avoid this increase by travelling elsewhere, using another mode (which may not always be possible), or choosing not to travel. For example, if the UK government imposed an increased tax on aviation departures, UK residents travelling to mainland Europe could respond by travelling by Eurostar or by ferry, or choose not to travel. Similarly, travellers in France could respond by travelling to the UK by another mode or by switching their destination to another country, such as Germany or Spain.
- **Supra-National Level.** This represents a change in prices that occurs at a regional level across several countries. For example, an aviation tax imposed on all member states of the European Union. In this case, the elasticity is expected to be even lower, as the options for avoiding the price increase are even further reduced.

The evidence and discussion provided in this report focus on the appropriate elasticities for the route, national and supra-national level of aggregation.

The Interaction between Own-Price and Cross-Price Elasticities

In each of the five levels of aggregation, different cross-price elasticities exist, reflecting the availability of substitute options. For example:

- At the price class level, an increase in the full economy price could increase the demand for both business class tickets and discount tickets.
- At the airline level, a unilateral increase in the travel price of one particular airline 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 price of travel from London Heathrow to Paris CDG can increase the demand for travel on London Gatwick to Paris CDG or London Heathrow to Paris Orly.
- At the national level, an increase in the price of air travel to/from a given country may increase demand for air travel to/from other countries.
- At the supra-national level, an increase in the price of 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 US).
- At all levels of aggregation, there may exist cross elasticity effects with other modes of transport. An increase in the price of air travel may increase demand for ground transportation and vice versa.
- There may also be cross elasticity effects between air travel and other leisure or consumption activities. In some cases it may not exist at all (e.g. there is generally no substitute for air travel on long-haul routes).

The own price elasticity at one level of aggregation can reflect 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 price class and carrier levels of aggregation⁶. The interaction between these effects adds significant complexity to the analysis, requiring clarity on which own price and cross price elasticity were measured and controlled for. For example, an analysis of route-level elasticities which does not control for route substitution effects may be more appropriate for a national-level elasticity.

⁵ Even in a situation where an 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. passengers could travel from London to Delhi via Paris or Dubai rather than direct).

⁶ See Annex A for more details.



05 | Previous Estimates of Air Travel Demand Elasticities

The results from previous studies of air travel demand elasticities vary in accordance with the type of elasticity that is estimated. Nevertheless, there are several key themes that can be identified that provide insights into the sensitivity of air travel demand.

There is a substantial amount of evidence on air travel demand elasticities available from previous studies. However, these studies have also produced a wide variety of results, reflecting large differences in the nature and scope of the elasticities that have been looked at. As part of its research, InterVISTAS Consulting reviewed the available literature on demand elasticities. This chapter summarises the key themes that can be identified across the different studies.

Overview of Previous Studies

The review of previous studies helps to provide a greater understanding of air travel price elasticities and provides important insights for the new econometric analysis by InterVISTAS Consulting (discussed in the next chapter).

The review looked at several academic and government commissioned studies. The different studies⁷ produced a wide range of air travel price elasticity estimates, varying in accordance with the markets analysed, the time period assessed, the methodology used and the available data. Even within some particular studies, a range of elasticities are estimated for different markets.

For example, a commonly referenced study by Gillen, Morrison and Stewart⁸ found demand elasticities ranging from -0.1 to -1.7, depending on the relevant market. It identified various elasticity estimates for several distinct markets for air travel, such as:

Long-Haul Price Elasticities

- International Business: -0.3
- Domestic Business: -1.1
- International Leisure: -1.0
- Domestic Leisure: -1.1

Short-Haul Price Elasticities

- Business: -0.7
- Leisure: -1.5

Key Themes

A review of the existing literature of previous studies on air travel price elasticities shows a number of consistent themes. All of the studies reviewed, spanning a period of over 25 years, found that there was a significant demand response to changes in air travel prices. The consistency of this result strongly indicates that any policy action that results in higher prices (e.g. passenger taxes, increased landing fees) will result in a decline in demand. However, critically, the extent of that decline will depend on a number of factors:

- **Business Versus Leisure Passengers.** In general, all else being equal, business travellers are less sensitive to travel price 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 price increases, albeit not to the same extent as leisure travel.
- **Short-Haul Versus Long-Haul Travel.** Another consistent result was that air travel price 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 travel price increases).
- **Airline Vs Market Vs National Elasticities.** Some of the studies supported the concept that the demand elasticity faced by an individual airline 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 Israel and the UK respectively and produced even lower elasticity values (-0.27 and -0.7, respectively).
- **Income Elasticities.** Many of the studies also included income as an explanatory variable of air travel demand. This will isolate the effects of a shift along the demand curve (caused by a change in air travel price) from the effect of a shift of the whole demand curve (caused by a change in incomes or GDP). 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 income growth. This has important implications for policies seeking to manage air travel demand by raising the price of travel.

⁷ See Annex B for a list of the studies that were reviewed.

⁸ Gillen, Morrison and Stewart (2002), Air Travel Demand Elasticities: Concepts, Issues and Measurements.

06 | New Estimates of Price and Income Elasticities of Air Travel Demand

New econometric research builds on the work of previous studies to show that demand elasticities vary according to the level of aggregation and the location of the market. It develops guideline demand elasticity estimates to use for different situations.

The literature review highlighted that air travel price elasticities vary depending on a number of factors such as location, distance and level of market aggregation. InterV/STAS Consulting used this guidance to undertake new econometric analysis using three different datasets. The new analysis is comprehensive, based on over 500 regression models. Building on the previous research, the new econometric analysis develops a set of in-depth guidelines, and guideline elasticities, that can be applied to the analysis of different air markets, broken down by geographic market, length of haul and level of aggregation (route, national and supra-national).

Data Sources

InterV/STAS Consulting used three different databases for the econometric research:

- **US Department of Transport's database 1B (DB1B).** DB1B provides data on the US domestic aviation market. It is a very reliable source of data, representing a 10% sample of origin-destination passengers and air travel price for each airline on each city-pair route (e.g. New York-Los Angeles). Quarterly traffic and price 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, while average travel price reflects the estimated average one-way price paid (in USD).
- **IATA's Passenger Intelligence Service (PaxIS) database.** 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. It provides traffic and price estimates for airport-pair routes around the world (e.g. JFK-LHR, CDG-FRA). However, data is only available from 2005 onwards.
- **UK International Passenger Survey (IPS).** The IPS is a survey of passengers entering or leaving the UK by air, sea or the Channel Tunnel. This report exclusively used outbound to Western Europe leisure air passenger traffic data from the IPS. Quarterly traffic and price data was taken for the period from 2003 Q2 to 2006 Q2. Traffic figures reflect the estimated number of passengers on a particular airport-pair route during the given quarter, while average price reflects the estimated average price paid (in GBP).

Model Specifications

The new econometric research tested a number of different estimation methods and model specifications to provide explanations of economic phenomena within each given market. In all models, traffic was the dependent variable. The different specifications used were⁹:

- **Ordinary Least Squares (OLS).** OLS is a method relating passenger traffic to air travel prices, income levels and other variables, while minimising the variance (randomness) of the estimates. The regression analysis allows the relationship between traffic and air travel prices to be isolated and quantified while controlling for other factors that may impact air travel, such as GDP, population levels, route distance and seasonality.
- **Two-Stage Least Squares (2SLS).** 2SLS is often used to improve the consistency of elasticity estimates when explanatory variables are believed to be correlated with the regression model's error term.
- **Autoregressive Distributed Lag (ARDL).** An autoregressive ARDL model uses similar explanatory variables to the OLS model, but also uses lagged values of the traffic variable. The inclusion of lagged values accounts for the slow adjustment of supply (in the form of capacity) to changes in the explanatory variables.

Explanatory Variables

The econometric research estimated regression models that included a variety of explanatory variables to search for the best fit:

- **Average Price.** Average air travel price was used to measure the price of air travel, reflecting average route prices over the period reported. The average price variable appears in all model specifications.
- **Gross Domestic Product.** GDP is used to measure the effect of income on air travel. GDP estimates are widely available, providing a variable that can be consistently defined between regions and over time. Within the US, GDP estimates are available at the city pair level. Regression models using the IPS data set used UK national GDP. Regression analysis for all other regions used national GDP values,

⁹ See Annex C for more details on each type of specification.

converted into US dollars. GDP appears in all model specifications.

- **Population.** Population has a direct effect on the size of a market and may cause a bias in the estimates if omitted. For example, a large increase in traffic may reflect a sudden boom in population rather than other effects. Population was tested in all model specifications but the best results tended to be at the city pair level, so it is only included in the US domestic regression results.
- **Route Distance (Trip Length).** The use of route distance is based on its ability to reflect the value of travel time savings and availability of substitutes. As distance increases, the viability of other transport modes as a substitute decreases. The use of route distance as an instrumental variable in 2SLS requires that distance be uncorrelated with traffic. This is most likely in the domestic US market.
- **Substitute Goods.** The inclusion of a substitute travel price variable was tested on a subset of routes and was found to increase price elasticities. Estimates that exclude a meaningful substitute in the regression model will produce more inelastic estimates than a correctly specified model would produce. Route substitutes can be defined as a different airport serving the same catchment area (e.g. Chicago-O'Hare or Chicago-Midway) or a different destination serving the same purpose (e.g. Las Vegas or Reno).
- **Real Exchange Rates.**¹⁰ In theory, as the foreign country becomes more expensive (inexpensive), leisure travellers will travel to the foreign country less (more). However, the econometric research was unable to obtain robust estimates using this variable, possibly due to difficulties in obtaining an accurate measure of the variable. Therefore, real exchange rates were excluded from the final model specifications.
- **Time Variables.** The use of several different forms of time variables was explored, but only quarterly (seasonal) time dummy variables were found to increase the explanatory power of the model. This suggests that both travel prices and demand are inherently seasonal (at least on a quarterly basis).
- **Route Dummies.** These dummy variables were found in many cases to increase the explanatory power of the model, suggesting that some other route-specific factors are important for demand (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). The use of route dummy variables controls for these variables without the need to quantify them.

ECONOMETRIC RESULTS

The new econometric research supports the discussion from previous chapters that the sensitivity of passengers to the level of air travel prices depends significantly on the level of the market being considered and its location. The results are based on a synthesis of the new econometric results and the review of previous research. Base elasticity estimates are developed for the different levels of aggregation (route, national and supra-national level). Multiplicative estimates were then developed to adjust the elasticities to reflect specific geographical markets.

i) Level of Aggregation

In summary, the econometric results found that at the route level (where competition between airlines or city-pair markets is high) the sensitivity of demand to price is very high. However, at the national or regional level, air travel is relatively price insensitive. The results support demand elasticities of:

- Route Level: -1.4
- National Level: -0.8
- Supra-National Level: -0.6

Route Level. The review of previous research found route level elasticities ranging from -1.2 to -1.5. Regressions using the US DB1A data, which allows the use of route dummies and variables to capture the price of route substitutes, produced a similar air travel price elasticity of -1.4. This elasticity estimate is applicable to a situation where the price of an individual route changes (e.g. higher airport charges at Paris CDG raising the price of travel from London and diverting leisure traffic to another destination, such as Frankfurt). Using distance as an instrument variable within the 2SLS model produces results that further support this elasticity, though there still is some concern over the use of distance in this way due to its perceived exogenous influence on demand.

National Level. Estimates of national elasticities using all three datasets found that, without the route substitution term, elasticities fell to around -0.8. This inelastic result was found over a range of model specifications which excluded route dummies. The national level elasticity applies to a situation such as the doubling of a national

¹⁰ 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).

passenger departure tax, affecting all departing routes equally but leaving the price of travel from elsewhere unchanged. Its value reflects a combination of the route's own price elasticities with cross price elasticities, when all national routes have prices which vary in the same way. The inelastic result is consistent with observations that part of the price elasticity observed from low cost carriers (LCCs) involves substitution from other routes. When this is controlled for, LCCs have a lower level of market stimulation, consistent with less elastic national elasticities.

Supra-National Level. At the supra-national level (e.g. the European Union) estimates show an even less elastic air travel price elasticity of -0.6. This is because as the number of routes covered expands, the number of choices for passengers to avoid any travel price increase diminishes. There is less opportunity for traffic to be diverted.

ii) Short-Haul Vs Long-Haul

The review of previous research found consistent results showing that air travel price elasticities on short-haul routes were higher than on long-haul routes. This largely reflects the greater opportunity for inter-modal substitution on short-haul routes (e.g. travellers can switch to rail or car in response to air travel price increases). While the geographical breakdowns outlined in the next section 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 an elasticity multiplier of 1.1 is estimated and used to adjust air travel price elasticities for short-haul markets. This does not apply to the analysis of trans Atlantic or trans Pacific markets, which are entirely long-haul, with virtually no opportunity for modal substitution.

iii) Geographic Market Analysis

The econometric analysis of the IATA PaxIS Plus data found statistically significant differences between different geographic air travel markets. The estimated elasticity multipliers for each market, along with the reasons for why it is needed, are:

- **Intra Europe.** Traffic in this region is estimated to be more elastic, with an elasticity multiplier of 1.4. Intra European routes typically have shorter average travel distances, strong competition from other transport modes and the use of very low prices in several markets. The high market share of charter airlines is being eroded by very low fare LCCs.
- **Intra Asia.** Moderately more inelastic estimates were found in this region, with an elasticity multiplier of 0.95. LCCs are now emerging in Asia but average distances are longer, and the key middle class is still relatively small in many markets in this region.
- **Intra Sub-Saharan Africa.** This region is estimated to have a relatively inelastic demand compared to North America, with an elasticity multiplier of 0.6. African economies have a much smaller middle class. Travel is concentrated among higher income individuals who are less price-sensitive.
- **Intra South America.** This region is estimated to be at the more elastic end of the scale, with an elasticity multiplier of 1.25. There is an emerging middle class making the region more price elastic plus LCCs are emerging in Brazil, Chile and Mexico.
- **Trans Atlantic (North America – Europe).** A high price elasticity was found for this market, with an elasticity multiplier of 1.2. This market has long been developed by low fare charter airlines. Price is likely more important than frequency in this market than in US domestic markets
- **Trans Pacific (North America – Asia).** By contrast, markets across the Pacific are estimated to have a much less elastic response, with an elasticity multiplier of 0.6. There are no charter services and there remain markets with less liberal pricing regulation. There are early signs of long-haul LCCs emerging but at present this market shows much less sensitivity to travel cost than the US domestic market or the trans Atlantic market.
- **Europe – Asia.** This market is estimated to be slightly less price sensitive, with an elasticity multiplier of 0.9. 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.
- **Intra North America.** This is our reference point with an elasticity multiplier of 1. The market is well established with relatively high levels of capacity and traffic. Air travel prices tend to be low, while distances are short to medium haul.

Applying the Elasticity Estimates and Multipliers

Table 3 provides a guideline for the estimated price demand elasticity by level of aggregation and by region. It multiplies the estimate for the relevant level of aggregation by the relevant short-haul and geographic elasticity multipliers.

Table 3: Estimated Price Elasticities of Passenger Demand

	Route/Market level		National level		Supra-national level	
	Short-haul	Long-haul	Short-haul	Long-haul	Short-haul	Long-haul
Intra N America	-1.5	-1.4	-0.9	-0.8	-0.7	-0.6
Intra Europe	-2.0	-2.0	-1.2	-1.1	-0.9	-0.8
Intra Asia	-1.5	-1.3	-0.8	-0.8	-0.6	-0.6
Intra Sub-Saharan Africa	-0.9	-0.8	-0.5	-0.5	-0.4	-0.4
Intra S America	-1.9	-1.8	-1.1	-1.0	-0.8	-0.8
Trans-Atlantic	-1.9	-1.7	-1.1	-1.0	-0.8	-0.7
Trans-Pacific	-0.9	-0.8	-0.5	-0.5	-0.4	-0.4
Europe-Asia	-1.4	-1.3	-0.8	-0.7	-0.6	-0.5

Inbound vs Outbound Price Elasticities

One further adjustment that may need to be applied to the price elasticity estimates in table 3 is for the case when the passenger flow of concern is inbound or outbound, not the total or average impact. This will be of particular importance when considering the impact on inbound tourism of, for example, a national passenger tax. It also matters when considering the diversion of inbound passengers and consequent reduction of effectiveness of a national or regional environmental tax.

The price elasticity estimates in table 3 are all averages of outbound and inbound passengers. Most databases of passenger numbers and fares do not distinguish between domestic residents travelling overseas then returning, and overseas residents visiting and then returning home. However, their sensitivity to travel prices including taxes will differ.

Faced by a passenger or environmental tax the outbound passenger must either pay or not travel. However, the inbound overseas passenger can choose to travel to a different destination or transit by another hub and avoid the tax. This is particularly the case for holiday travel or transfer and transit passengers, which are much more price sensitive than travel for business or visiting friends and relatives. Inbound travel originating from overseas will be more price sensitive i.e. will have a larger price elasticity in absolute terms, than outbound travel.

For example the UK in 2006 had 185.5 million international arrivals or departures from UK airports, 61% of which were arrivals or departures by UK residents and 39% by overseas residents or passengers transferring and transiting. Of these passengers 77% were travelling on short-haul trips to Europe, 9% transatlantic and 14% other long-haul. Using the elasticities in table 3 an average price elasticity for UK inbound and outbound travel can be derived of -1.0.

Njegovan (2006) found that UK residents travelling overseas for leisure had a price elasticity of -0.7 to -0.8. Business travel will be less elastic. So a conservative estimate for the price elasticity (P^e) of inbound travel by overseas residents can be derived as follows:

$$P^e_{\text{overseas residents}} * \% \text{ overseas residents} + P^e_{\text{UK residents}} * \% \text{ UK residents} = \text{average } P^e$$

$$P^e_{\text{overseas residents}} * 39\% + -0.8 * 61\% = -1.0$$

$$P^e_{\text{overseas residents}} = -1.3$$

These estimates will be verified by future research. Meanwhile a reasonable rule-of-thumb multiplier to adjust the price elasticities in table 3 is as follows:

$$\text{Inbound travel by overseas residents} = -1.3 / -1.0$$

$$= 1.3 * \text{table 3 price elasticity}$$

$$\text{Outbound travel by domestic residents} = -0.8 / -1.0$$

$$= 0.8 * \text{table 3 price elasticity}$$

By way of illustration, elasticities for different situations can be developed by selecting the relevant base elasticity and applying the relevant multipliers. For example:

- 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 (supra-national)
- Geographic market: 1.4 (Intra Europe)
- Short-haul adjustor: 1.1

$$\text{The price elasticity would then be calculated as:}$$

$$-0.6 \times 1.4 \times 1.1 = -0.92$$

- 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)

$$\text{The price elasticity would then be calculated as:}$$

$$-0.8 \times 1.2 = -0.96$$

- To examine the impact of the same tax on overseas visitors and tourism:

- Overseas resident adjustor: 1.3

$$\text{The price elasticity would then be calculated as:}$$

$$-0.96 \times 1.3 = -1.25$$

- To examine the 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

$$\text{The price elasticity would then be calculated as:}$$

$$-1.4 \times 0.95 \times 1.1 = -1.46.$$

Income Elasticities

The main focus of the research was on price elasticities. Nevertheless, the analysis also considered the sensitivity of demand to changes in incomes. The econometric research and review of previous estimates found that air transport income elasticities were consistently positive and greater than one. This suggests that as households and individuals get more prosperous, they are likely to devote an increasing share of their incomes to discretionary spending such as air travel.

The statistical evidence suggests:

- Developed country travel markets have base income elasticities for short-haul routes of around 1.5. At the national level, this declines to an estimated income elasticity of 1.3.
- US travel markets have slightly higher income elasticities with air travel perhaps less budget-oriented than in other developed economies. Using the DB1A data suggests short-haul route income elasticities of 1.8 at the route level and 1.6 at the national level.
- There is some evidence that income elasticities decline as countries become richer and markets mature. Developing countries typically have a greater responsiveness, with an estimated short-haul income elasticity of around 2.0 at the route level and 1.8 at the national level.
- There is also evidence that long-haul journeys are seen by passengers as different, more desirable, to the more commoditised short-haul markets, and so income elasticities are higher the longer the distance. This suggests that middle to lower income individuals are more likely to travel on short to medium haul routes, with higher incomes leading to a higher frequency of long-haul travel.

The income elasticity results are based on information from the review of previous studies and results from the new econometric research. Table 4 outlines the estimated income elasticities for different markets at the route and at the national level.

Table 4: Estimated income elasticities of passenger demand

Route/market level	Short-haul	Medium-haul	Long-haul	Very long-haul
US	1.8	1.9	2.0	2.2
Developed economies	1.5	1.6	1.7	2.4
Developing economies	2.0	2.0	2.2	2.7
National level	Short-haul	Medium-haul	Long-haul	Very long-haul
US	1.6	1.7	1.8	2.0
Developed economies	1.3	1.4	1.5	2.2
Developing economies	1.8	1.8	2.0	2.5

If passengers are relatively insensitive to air travel prices at a national aggregate market level, and even less so at a supra-national level, this strongly suggests that falling real air travel prices have not been the main driver of air travel growth¹¹. Falling real air travel prices are important in passengers switching from one airline to another, and from one destination to another, but are much less important in driving aggregate national-level air travel or tourism growth.

The growth of incomes, often proxied by GDP, has been found to be the fundamental driver of the demand for air travel. During the past twenty years global passenger traffic has expanded at an average annual growth rate of 5.1%, while global GDP grew by an average annual rate of 3.7% over the same period. That implies an average income elasticity of 1.4, similar to the average estimated above for developed economies. The implication is that economic growth can explain most of the expansion in air travel seen in the past twenty years. The fall in real air travel prices has played a part, but mostly in diverting travel between airlines and markets rather than significantly boosting overall travel volumes. In addition, economic growth is now increasingly being driven by developing economies, where income elasticities are higher. Therefore, the underlying drivers for overall air travel growth are likely to remain strong for the foreseeable future.

¹¹ This conclusion is reached in a recent study of the UK market (UK CAA, 2006, No frills carriers; revolution or evolution). It concludes that "despite the spectacular growth of no-frills carriers in the UK, and the perceptions about the impact they have had on travel habits, there has been little change in long-term aggregate passenger traffic growth rates".



07 | Policy Implications

Air transport policy decisions run the risk of being ineffective, or even counter-productive, if the correct demand elasticity is not used. A revenue-raising policy to raise the cost of travel on a route will be ineffective if the demand elasticity is underestimated. An environmental policy to raise the price of travel on a national or supra-national basis will be ineffective if the demand elasticity is overestimated.

ADDRESSING THE CORRECT ELASTICITY TO THE APPROPRIATE QUESTION

This report shows how the sensitivity of air travel demand to prices and incomes can vary according to different situations. Therefore, the appropriate elasticity to use will depend upon the level of aggregation and the location of an air transport policy proposal. For example:

- **At the Route level.** To examine the impact of an increase in airport landing fees on a particular short-haul market in South America, the price elasticity would be derived as:

**Base elasticity -1.4 (route)
multiplied by 1.25 (intra South America)
multiplied by 1.1 (short-haul multiplier)
which equals -1.93**

A 10% rise in the airport landing fee would reduce passenger numbers on short-haul markets serving that airport by over 19%.

- **At the National level.** To look at the impact of the doubling of UK passenger tax on trans Atlantic traffic, the price elasticity would be derived as follows:

**Base elasticity -0.8 (national)
multiplied by 1.2 (trans Atlantic geographical multiplier)
which equals -0.96**

For outbound traffic from the UK this implies the resulting 3.7% rise in the cost of long-haul travel will cut demand by 3.6%. For inbound traffic from N America the UK only represents a 20% market share, so while the UK will lose inbound tourists many will just be diverted to other destinations.

- **At the Supra-national level.** To look at the demand impacts of higher travel costs caused by extending the EU Emissions Trading Scheme just to intra-EU travel i.e. short-haul markets, the relevant price elasticity would be derived as follows:

**Base elasticity -0.6 (supra-national) multiplied by
1.4 (intra-Europe geographic multiplier) multiplied
by 1.1 (short-haul multiplier) which equals -0.92**

So a 10% rise in intra-EU travel costs would lead to a relative inelastic 9.2% reduction in air travel.

Demand Elasticities and Environmental Policy

The focus of existing policy to reduce CO₂ emissions from air travel has been on trying to manage air travel demand by raising the price of travel for passengers. Even the recent debate on emissions trading in Europe has focused on the costs it will impose on airlines and their passengers.

The results contained in this report show that policies that aim to reduce emissions by managing demand, through raising the price of air travel, are likely to fail. Tourists are shown to be very sensitive to prices for air travel on competing airlines or to alternative destinations. However, at the national or supra-national level these choices cancel each other out and the overall market is much less sensitive to the cost of air travel. It is economic growth and incomes that are found to have been the key drivers of air travel demand, and those drivers are expected to remain particularly strong in the developing markets of Asia. Decoupling emissions from travel growth needs to focus not on demand management but on mechanisms to bring about emission reduction measures from technology, infrastructure and operations.

Climate policies will need to focus on creating incentives where there can be effective investment in emissions reductions. The major potential would appear to be on decoupling emissions from travel growth, through supply-side innovations, rather than trying to manage demand through raising the price of travel.

There is a need to look beyond rudimentary economic instruments (e.g. passenger taxes) that seek to manage demand by raising the price of travel for the passenger in order to incentivise effectively the various players along the air transport value chain who can invest in emission reduction.

IATA's four pillar climate strategy¹², which was endorsed by the Assembly of the International Civil Aviation Organisation in 2007, focuses action on emission reduction measures from technology, infrastructure, operations and those brought about by well designed economic instruments.

¹² Building a Greener Future (2007) IATA.

By contrast, Table 5 shows that:

- Passenger taxes are ineffective for reducing CO₂ emissions. This is not just because demand is relatively price insensitive at a national and supra-national level. It is also because raising the cost of travel for the passenger does nothing to incentivise the manufacturer to produce new airframes or engines, nothing to incentivise the fuel company to produce a clean fuel, nothing to incentivise the EU to implement a Single European Sky, nothing to incentivise ANSPs to straighten routes and reduce stacking, nothing to incentivise airports to reduce taxiing emissions, and nothing to incentivise airlines to improve operations and renew their fleet.
- Emissions trading can be more effective, if well designed. By a direct linkage to emissions it incentivises operational and fleet improvements. If well designed, to be open to trading with other industries and global, it allows the reduction of CO₂ emissions to take place in industries where reductions are most efficient. However, even emissions trading has little impact on the key technology and infrastructure pillars.

Effectively decoupling emissions from air travel growth will require policy-makers and the industry to look beyond simple economic instruments:

- Technology progress will require collaboration across the value chain and across countries.
- Governments will need to play a role in funding fundamental research.
- Political will is perhaps one of the most important mechanisms for delivering emissions reductions from infrastructure improvements.
- The lack of implementation of a Single European Sky is one glaring omission in policy action to reduce emissions from air travel.

IATA is actively promoting collaborative efforts on technology and is lobbying hard for Governments to improve infrastructure. On operations there is a major initiative to spread best practice. More needs to be done in the face of the challenge of climate change, but the airline industry is already stepping up its efforts with a bold vision of zero emissions and an important future milestone of carbon-neutral growth. The key lesson for both policy-makers and the industry is to look beyond simple economic instruments for mechanisms to bring about an effective reduction in emissions from air travel.

Table 5: The effectiveness of existing economic instruments

Emission cut measure	Player	Passenger tax	Emissions trading
TECHNOLOGY	Manufacturer	No impact	No impact
	Fuel company	No impact	No impact
INFRASTRUCTURE	Government	No impact	No impact
	ANSP	No impact	No impact
	Airport	No impact	No impact
OPERATIONS/FLEET	Airline	No impact	Impact
REDUCED DEMAND	Passenger	Minor impact	Minor impact
CUTS ELSEWHERE	Other industry	No impact	Impact



08 | Conclusions

The correct elasticity value to use in analysing an air transport policy decision depends on the type of question being asked. The impact on demand of higher travel prices on a given route due to a rise in airport landing charges requires a different (higher) elasticity than when examining the traffic impact of a wider travel price increase due to a passenger tax on all routes in a country.

This report uses new econometric research and a review of previous studies to provide guidelines on the appropriate level and type of demand elasticity to use when analysing a policy proposal. It provides robust elasticity estimates to ensure that policy decisions related to issues such as liberalisation, airport charges, taxation, and emissions schemes, are made on the basis of appropriate and reliable evidence. It provides important new estimates to ensure that price elasticity estimates do not underestimate the sensitivity of passengers to price and are used correctly.

Different air travel demand elasticities are associated with different uses. When consumers are choosing between airlines on a route, or even between destinations for travel, 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 are:

- For an airline on a given route, increasing price is likely to result in a more than proportionate decrease in air travel. Lower travel prices will greatly stimulate traffic and raise revenues. Airline specific travel price charges are price elastic.
- If all airlines on a given route increase travel prices 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 but still proportionately more than the change in price. Route specific travel prices are price elastic.
- If all airlines on a wide set of routes increase travel prices 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. National or Supra-National increases in airline travel prices, that take place across a broad range of markets, are 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 (i.e. larger) the change in demand. The more general the applicability of a price change (perhaps due to higher costs or taxes) the less elastic (i.e. smaller) the change in demand.

ANNEX A: THE INTERACTION BETWEEN PRICE ELASTICITIES

The relationship between the price sensitivity at the aggregate market level E and at destination-specific route levels (own-price elasticity E_{ii} and cross-price elasticity E_{ij}) is described in a study carried out by the UK CAA¹³ as:

$$E = \sum_i S_i (\sum_j E_{ij})$$

where S_i is the traffic share of destination i .

An hypothetical example will help illustrate the implications for policy. Assume there are just two routes for a national market, A and B with own-price elasticities $E_A = -1.4$ and $E_B = -1.4$. Own-price elasticities indicate for instance that a 10% rise in air fares just on route A would lead to a 14% decline in passengers on that route. Cross-price elasticities are, say, $E_{AB} = 0.6$ and $E_{BA} = 0.6$. This means that, for instance, the 10% rise in air fares just on route A would, as well as causing a 14% decline in passengers on route A, boost passengers on route B by 6%. Therefore, a price rise does not just suppress demand, it diverts it to another route. This clearly affects the overall net impact.

If both routes have a market share S_i of 50% then the weighted average national own-price price elasticity is -1.4. This might suggest that a policy that raises the cost of air travel nationwide by 10% would reduce air travel volumes by 14%. However, that conclusion would be wrong. To see why, using the expression for aggregate elasticity above:

$$E = S_A(E_A + E_{AB}) + S_B(E_B + E_{BA}) = 0.5(-1.4 + 0.6) + 0.5(-1.4 + 0.6) = -0.8$$

This shows that the aggregate price elasticity is not -1.4 but -0.8 i.e. the reduction in passengers to a 10% rise in air fares is not 14% but 8%. This is a relatively inelastic or price insensitive response. Table A1 uses the same example to work through the effects:

Table A1: Impact of fare increases at the route and market level

	Effect on route A	Effect on route B
10% rise in air fare A	-14%	+6%
10% rise in air fare B	+6%	-14%
Net effect	-8%	-8%

The effect of a 10% fare increase on both routes (for instance caused by a rise in a national passenger tax) would be to reduce the total traffic in the market by 8% (the weighted average of the route net effects), which is exactly what is implied by the aggregate market elasticity of -0.8. Using the weighted average elasticity of -1.4, on the other hand, would incorrectly imply a 14% decrease in aggregate air travel.

This example considers the impact on outbound leisure passengers, where a rise in passenger tax will affect all destination choices. That is not the case for inbound tourists. The choice facing US residents in travelling to destination A, say the UK, or destination B, say Italy will be significantly affected by national passenger taxes. For example, the recent doubling of the UK passenger departure tax added roughly 4% to the cost of travel. This will have had a relatively inelastic impact (-3.2%) on UK residents departing on overseas holidays, for the reasons set out above. However, it will have led to an elastic impact (-5.6%) on the choice of US residents travelling to the UK. Many will have been diverted to holiday in, say, Italy. In total, this demand response would significantly limit the effectiveness of national passenger taxes as a way of managing demand or limiting the rise of greenhouse gas emissions from air travel.

¹³ Demand for Outbound Leisure Air Travel and its Key Drivers (December 2005) UK CAA.

ANNEX B: LIST OF PREVIOUS STUDIES REVIEWED

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ANNEX C: ECONOMETRIC MODEL SPECIFICATIONS

Ordinary Least Squares

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

InterVISTAS used OLS techniques with a log-log model formulation, as follows¹⁴:

$$\ln(\text{Traffic}) = \text{Constant} + a_1 \times \ln(\text{Price}) + a_2 \times \ln(\text{Var2}) + \dots + a_n \times \ln(\text{VarN}) + a_{n+1} \times \text{Dummies}$$

Where:

- Traffic is the dependent variable,
- Price is the average economy or leisure air travel price.
- 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.

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.

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 estimators¹⁵. 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.

InterVISTAS experimented with the use of two-stage least squares techniques to improve the consistency of elasticity estimates. The natural logarithm of distance and the natural logarithm of 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 travel prices 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 believed to have an impact on traffic). Fuel prices were found to be poor IVs. Fuel prices exhibited low correlations with traffic and travel prices.

¹⁴ 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.

¹⁵ A consistent estimator in a regression analysis is defined as an estimator that converges in probability to the correct parameter as the sample size grows.

Autoregressive Distributed Lag

An autoregressive distributed lag (ARDL) model was developed and used with OLS regression analysis. Traffic was regressed onto similar explanatory variables as in prior models, but also onto lagged values of traffic. The inclusion of lagged values of the dependent variable (traffic) is done to account for 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 was therefore excluded from ARDL estimation¹⁶.

InterVISTAS 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:

$$\begin{aligned} \ln(\text{Traffic}_t) = & \\ & \text{Constant} + b_1 \times \ln(\text{Traffic}_{t-1}) + b_2 \times \ln(\text{Price}_t) \\ & + b_3 \times \ln(\text{Var3}_t) + \dots + b_n \times \ln(\text{VarN}_t) \\ & + b_{n+1} \times \text{Dummies}_t \end{aligned}$$

Where:

- Traffic t is the dependent variable,
- Traffic $t-1$ is the traffic in the same month (or quarter) of the previous year
- Price is the average economy or leisure air travel price.
- 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.

Since traffic appears on both sides of the equation, the coefficients on the explanatory variables cannot be directly interpreted as long-run elasticities. The long-run elasticities are defined as when traffic across time periods stabilise. In general, the use of ARDL models tended to produce more elastic price elasticity estimates with much higher goodness of fit values.

¹⁶ 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 (travel price, income, and population).





Understanding the impact on demand is the key to effective policy decisions concerning aviation.



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