INCIDENCE OF TICKET TAXES AND FEES IN U.S. DOMESTIC AIR TRAVEL

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THESIS

Submitted to the University of New Hampshire

in Partial Fulfillment of

the Requirements for the Degree of

Master of Arts

In

Economics

September, 2006

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DEDICATION

This work is dedicated to my daughter Mia Victoria Karlsson. May her travels be safe, always.

ACKNOWLEDGEMENTS

This work is a continuation of research made possible in part by the MIT Global Airline Industry Program, the Alfred P. Sloan Foundation, and Amadeus, S.A. I wish to thank Professors Arnold Barnett, Peter Belobaba, and Amedeo Odoni at the Massachusetts Institute of Technology; Professors Karen Smith Conway, Richard England, and Robert Mohr at the University of New Hampshire Whittemore School of Business and Economics; and Mr. Scott Nason at American Airlines, for their support and insightful comments. I would also like to acknowledge the tireless efforts of Mr. Shiro Yamanaka and Ms. Célia Geslin at the Massachusetts Institute of Technology, whose work on developing descriptive statistics for ticket taxes and fees in the United States and the European Union sparked many of the research questions addressed here. Most of all, I wish to thank my wife Nicole for her unwavering support and encouragement.

Errors and omissions are solely the responsibility of the author. *Errare humanum est*.

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ABSTRACT

INCIDENCE OF TICKET TAXES AND FEES IN U.S. DOMESTIC AIR TRAVEL

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The United States is currently witnessing a vigorous debate on public funding of air transportation and the role of taxes and fees levied on airline tickets. Yet, there is remarkably little economic literature on taxation in the U.S. airline industry. Analysis of a large sample of tickets for travel in the continental United States shows that the effective tax rate has increased from 11% in 1993 to 16% in 2005. While the tax structure and levels have changed over time, this increase is largely due to a historical decline.

The theory of tax incidence asserts that economic incidence is a function of price elasticity and market power and is independent of statutory incidence. The U.S. ticket tax structure is a mixed policy of ad valorem and unit taxes. Under perfect competition, the incidence of these two types of taxes is identical. The incidence is bounded by the two extremes of the tax burden being shifted entirely onto the producer or entirely on the consumer. Under imperfect competition, incidence of the unit tax and that of the ad valorem tax need not be identical and overshifting is possible.

Empirical analysis of variations in the ad valorem and unit taxes for United States domestic air travel during the 1994-1997 and 2002-2005 periods indicates that the burden of the ad valorem tax is shared by consumers and producers. For the same periods, there is weak evidence of overshifting of the unit tax. The empirical analysis is hindered by the multiplier effect of ad valorem taxes, the lack of simultaneous variation in the ad valorem tax rate and unit taxes, the functional relationship between the two types of taxes, and a number of political and institutional details inherent to the airline industry which are difficult to capture in an econometric model.

INTRODUCTION

The study of taxation is motivated in part by what it is intended to accomplish and in part by its unintended consequences. Taxation is generally intended to achieve one or more of the following: (1) provide public goods; (2) reduce negative externalities; (3) redistribute income; and (4) stabilize macroeconomic fluctuations. In the specific case of air transportation, only the first two objectives usually apply. Indeed, the main objective of air transportation taxation today is to collect revenues to fund aviation infrastructure and security needs. The air transportation infrastructure in the United States and the European Union (EU) is largely self-funded by these taxes and fees. Consequently, this type of taxation is sometimes referred to as a “benefits tax”, as the payees receive certain benefits in the form of air transportation infrastructure and security services.

Taxes and fees added to tickets are the main form of air transportation taxation, at least in the U.S. Consequently, ticket taxes and fees are the focus of this discussion. This funding system needs to cover facility planning, maintenance of the existing infrastructure, capacity expansion, operational costs, safety improvements, mitigation of environmental impacts, and the provision of security services. Note that the regular use of public funds for environmental projects related to airports, such as noise mitigation, somewhat blurs the distinction between the use of taxes to raise revenue for infrastructure vs. the use of taxes to offset environmental externalities. Negative externalities associated with air transportation include noise, noxious emissions and water quality impacts. In the United States and the EU, the objective of reducing externalities through taxation currently ranks a distant second and is only a minor part of the existing national tax structures for air transportation. However, there are clear indications, especially in the EU, that future taxes are likely to be introduced to address environmental externalities.

Several ongoing developments offer further motivation for the study of taxation in the airline industry. In the United States, the Federal Aviation Administration (FAA) is reviewing the federal funding system for aviation, as the Congressional mandate for the existing tax structure is set to expire in 2007 (FAA, 2005a, 2005b). The importance of this issue is evidenced by testimony provided by the FAA, the Air Transport Association (ATA), Airports Council International – North America, the American Association of Airport Executives, the Air Carrier Association of America, the National Air Traffic Controllers Association, the National Air Transportation Association, the Aircraft Owners and Pilots Association, and the National Business Aviation Association (U.S. House of Representatives Committee on Transportation and Infrastructure, 2005). The reauthorization process is also shaping up as a battle between the air carrier industry and general/business aviation over their respective tax burdens (Meckler, 2006, June 1, p. A1). Finally, the political importance of the process has been amplified because it is coinciding with contentious contract negotiations between the FAA and its air traffic controllers (Barr, 2006, May 31, p. D4).

In the EU, several developments have increased the interest in aviation taxation issues. The Swedish government, for example, has included a controversial new ticket tax in its 2006 budget proposal. This would add SEK 50-100 (appr. $7-$14) per ticket in order to account for the environmental impact of air transportation (Swedish Ministry of Finance, 2005). This amount represents 2% to 4% of the average base fare for intra-EU travel originating in Sweden (Yamanaka, Karlsson, and Odoni, 2005, p. 11). The tax is part of a “green tax shift” policy, and would be offset by cuts in broad-based taxes such as the income tax. There is also a proposal for an EU-wide fuel tax, which is supported by environmental groups (European Federation for Transport and Environment, 2005). Finally, an ambitious proposal issued jointly by France, Germany, Spain, Brazil, and Chile calls for “a domestically applied and internationally coordinated levy on air transport travels” in order to combat global hunger and poverty in support of the United Nations Millennium Development Goals (French Ministry of Foreign Affairs, 2005; Doland, 2005, August 29). This proposal has now been approved by several countries (Schroeder, 2006, p. 3).

The recent financial crisis of much of the airline industry adds another dimension to the question of taxation. The industry has developed a seemingly unstable pattern of profit and loss cycles, with losses outweighing profits (Hansman, 2005). This has forced the airlines to focus on the extent to which taxes and fees affect their net revenues. At the same time, fares have been declining. This is due to increased competition, especially from low-cost carriers, and due to the erosion of high value business fares. As a whole, this has resulted in taxes and fees becoming a larger proportion of the total ticket price (Karlsson, Odoni, and Yamanaka, 2004, pp. 291-292).

This trend has caused the industry to voice increasing concern over ticket taxes and fees, leading to the following strongly worded joint statement by the ATA and the Association of European Airlines (2005):

> Aviation taxes and fees have outpaced inflation and fares, and the taxes and fees on an airline ticket purchased either in Europe or the U.S. are higher percentage-wise than the so-called ‘sin-taxes’ on things like alcohol and tobacco. This tax and fee burden threatens the very fiber of the air transportation industry and the economies that rely on it.

It is likely that the growing share of the total ticket price that is made up by taxes and fees has also increased passengers’ sensitivity to air transportation taxation. However, it should be kept in mind that the airlines and their passengers receive air traffic control, airport infrastructure, and security services through the payment of these taxes.

The introduction of any tax has unintended consequences for both consumers and producers. When a tax is added to a ticket, the price of air travel for the consumer is generally increased and, therefore, passengers change their economic decisions. This distortion of the market creates a loss of consumer welfare which may be greater than the tax revenues collected, even when taking into account the value of any benefits provided in return. This potential deadweight loss is inherent in all practical forms of taxation. This excess burden is an important measure when comparing alternative forms of taxation or determining whether the benefits of a specific project outweigh the revenue collected to fund it. A detailed discussion of the efficiency of various tax structures is beyond the scope of this study, but must be part of any comprehensive tax policy debate.

The focus of this research effort is the question of tax incidence. When a government assesses a ticket tax to collect revenue to fund its aviation system, it leaves unanswered the question of whether the producer or the consumer carries the economic burden. The answer depends on the economics of the air transportation market under consideration and not on the intent of the government entity that imposed the tax.

The goal of this study is to review the theory of tax incidence as it applies to air transportation and, to the extent possible, provide empirical measurements of the tax shifting. This study is motivated by the ongoing debate on the funding of air transportation, as well as the general lack of data on the impact of ticket taxes in the U.S., especially in regards to tax incidence.

CHAPTER I

DESCRIPTION OF U.S. TICKET TAXES AND FEES

Ticket Taxes and Fees in the United States

Four types of taxes and fees are currently levied on domestic air fares in the United States: the federal ticket tax (FTT), the federal flight segment tax (FST), the passenger facility charge (PFC), and the federal security service fee (FSSF). Table 1.1 shows the history of changes in these taxes and fees. Note that Table 1.1 only shows enacted changes which last for at least one federal fiscal year. Temporary changes such as the lapse of federal authority to collect taxes in 1996 and the federal security fee holiday of 2003 are not shown. These are addressed separately in Chapter IV (see, for example, Figures 4.1 and 4.2).

Federal Ticket and Segment Taxes

Since the FTT and FST are essentially two components of one tax, they are described together. The FTT and the FST are paid into the Airport and Airway Trust Fund. This fund finances congressional appropriations to cover "those obligations of the United States…which are attributable to planning, research and development, construction, or operation and maintenance of air traffic control, air navigation, communications, or supporting services for the airway system" (Internal Revenue Code, 1986). Together, they accounted for $6.4 billion in 2004 (or 66% of the total revenue of the Airport and Airway Trust Fund), supporting FAA operations, facilities and equipment, and federal grants-in-aid for airports (U.S. House of Representatives Committee on Transportation and Infrastructure, 2005). The federal ticket tax is currently equal to 7.5% of the base fare (the total fare less any taxes and fees). The segment tax, which is inflation adjusted, is currently equal to $3.30 (ATA, 2005).

Table 1.1: Changes in domestic ticket taxes and fees in the U.S. (1941-2006)

Year	FTT (rate)	FST	PFC (max.)	FSSF
1941	5.0%	-	-	-
1942	10.0%	-	-	-
1943	15.0%	-	-	-
1955	10.0%	-	-	-
1956	5.0%	-	-	-
1970	8.0%	-	-	-
1980	5.0%	-	-	-
1982	8.0%	-	-	-
1990	10.0%	-	-	-
1992	10.0%	-	$3.00	-
1997	9.0%	$1.00	$3.00	-
1998	8.0%	$2.00	$3.00	-
1999	7.5%	$2.25	$3.00	-
2000	7.5%	$2.50	$3.00	-
2001	7.5%	$2.75	$4.50	-
2002	7.5%	$3.00	$4.50	$2.50
2003	7.5%	$3.00	$4.50	$2.50
2004	7.5%	$3.10	$4.50	$2.50
2005	7.5%	$3.20	$4.50	$2.50
2006	7.5%	$3.30	$4.50	$2.50

Note: A dash (-) indicates the tax or fee was not applicable. Years with no changes in the tax and fee structure, rates, or levels are not shown.

The federal segment tax did not exist prior to October 1, 1997 (ATA, 2005). Domestic air travel was taxed at a flat rate, which peaked at 10% during the period 1990-1996. The federal ticket tax rate was gradually reduced to 7.5% by 1999, in conjunction with an increase of the segment tax from $1 in 1997 to $3 by 2002 (inflation adjusted to $3.30 by 2006). The change from a flat 10% ticket tax was initiated in part by a coalition of seven large airlines, “motivated by their belief that the current system unfairly subsidize[d] their low-fare competitors” (General Accounting Office, 1996b, p. 4). The adopted system resulted in the 7.5% ad valorem tax and the inflation adjusted segment tax. This differs in several regards from the airline coalition’s own proposal, but had the desired effect of increasing taxes for inexpensive tickets. For example, a round-trip ticket with a $100 base fare would have incurred a $10 federal tax in 1996, compared to a minimum of $14.10 in 2006, plus up to $10 in security fees and $18 in passenger facility charges. Conversely, a round-trip ticket with a $2,000 base fare would have incurred a $200 federal tax in 1996, compared to a maximum of $191.20 in total taxes and fees in 2006 (assuming one connection in each direction).

The Passenger Facility Charge

The PFC was instituted as a means of assisting airports with air carrier service to "finance eligible airport-related projects, including making payments for debt service" (AIR-21, 2000). When the collection of PFCs began after June 1, 1992, airports could apply to the FAA to collect $1, $2, or $3 per enplanement. Effective April 1, 2001, higher PFC levels up to $4.50 were introduced for certain airports (AIR-21, 2000; ATA, 2006b). PFCs are only collected for up to two boardings per each one-way trip, resulting in a maximum collection of $18 per round-trip (AIR-21, 2000). PFCs are charged by airlines at the time a ticket is purchased and are then transferred directly to the appropriate airport(s).

The Federal Security Service Fee

The federal security service fee is the most recently adopted tax on U.S. domestic airline tickets. It was created by the Aviation and Transportation Security Act (2001), with collection beginning February 1, 2002. It consists of a $2.50 tax per enplanement, limited to a maximum of two segments in each direction (i.e., a maximum of $10 for a round-trip ticket). The U.S. Congress temporarily suspended the fee from June 1 to September 30, 2003 in order to provide war-time relief to the airline industry (ATA, 2006e).

Other U.S. Air Transportation Taxes

A number of other federal infrastructure and security taxes and fees are assessed on air carriers. These fall outside the scope of this study, as they apply only to international travel or are not directly added to the price of an airline ticket. Additionally, foreign nations impose taxes and fees on U.S. carriers engaged in international operations. These can be numerous and varied, but do not apply to U.S. domestic travel and are not covered here. Finally, air carriers also pay other infrastructure-related charges such as landing fees and airport leases, but these are not added directly to the price of tickets and also fall outside the scope of this study.

Classification of Ticket Taxes and Fees

It is useful to place aviation taxes within a general classification of different types of taxes. The following classification scheme largely follows that defined by James and Nobes (1999).

Taxes vs. Fees

The terms “taxes” and “fees” are often used interchangeably. A tax is defined as “a compulsory levy made by public authorities for which nothing is received directly in return” (James and Nobes, 1999). Examples of pure taxes exist in aviation: Denmark levies a general-purpose transportation tax, which will, however, be phased out by 2007 (Mandsberg, 2005). The new “green shift tax” proposed by the Swedish government could also be classified as a tax, although it is motivated by environmental policy. However, it can be argued that most ticket taxes should rightly be referred to as “fees” or a “benefits tax”, since infrastructure and services are provided in return. PFCs, in particular, are specific to individual airports and each airport must apply individually to the FAA for authority to use the revenues for one or more clearly identified projects (General Accounting Office, 1999, p. 4).

The Internal Revenue Service uses the term “excise taxes” instead of fees (2005). Mixing the terms “tax” and “fee” is justified by the general difficulty in accounting for the connection between a specific fee and the services provided in exchange. For example, the federal segment and ticket taxes are used to fund airport improvements and the operations of the FAA. However, they are first combined into the Airport and Airway Trust Fund and then disbursed through the federal appropriations process. Also, the FAA allows for considerable cross-subsidies between various segments of aviation. Consequently, it is not at all clear that each dollar levied on an airline ticket directly benefits the airline industry and its passengers. At the time of writing, the airline industry is calling for reductions in its tax burden, based in part on its view that it is subsidizing business aviation (Meckler, 2006, June 1, p. A1).

The difficulty in separating taxes and fees is described in the following language from the Organization of Economic Cooperation and Development (OECD) manual on classifying taxes (OECD, 2004):

> In the OECD classification the term "taxes" is confined to compulsory, unrequited payments to general government. Taxes are unrequited in the sense that benefits provided by government to taxpayers are not normally in proportion to their payments… Apart from vehicle license fees, which are universally regarded as taxes, it is not easy to distinguish between those fees and user charges which are to be treated as taxes and those which are not, since, whilst a fee or charge is levied in connection with a specific service or activity, the strength of the link between the fee and the service provided may vary considerably, as may the relation between the amount of the fee and the cost of providing the service. Where the recipient of a service pays a fee clearly related to the cost of providing the service, the levy may be regarded as requited and…would not be considered as a tax.

The pragmatic solution is to recognize the theoretical distinction between taxes and fees, while in practice admitting that the difference is not always clear. For the remainder of this study, the collective term "taxes and fees" is generally used without further specification. The tax incidence will be identical, as long as airlines cannot reduce the imposition of fees by demanding fewer government services.

Direct vs. Indirect

Ticket taxes and fees are considered indirect taxes in that they are not paid directly by the passenger to the treasury, but rather are collected by the airline in question. All four U.S. ticket taxes and fees are collected by the airlines (or their agents) at the time of purchase. Outside the U.S., for instance in some Latin American nations, there are examples where passengers pay the tax directly at the airport.

Unit vs. Ad Valorem

A unit (or "specific") ticket tax is a fixed monetary amount assessed to each ticket or segment. An ad valorem ticket tax consists of a fixed percentage rate applied to the base fare. Both types are assessed on airline tickets in the U.S. The federal ticket tax is a 7.5% ad valorem tax. The other three U.S. ticket taxes and fees on domestic air travel are all unit taxes.

Progressive vs. Regressive

Progressive taxes are those which "take an increasing proportion of income as the income rises" (James and Nobes, 1999). Regressive taxes have the opposite effect: Their proportion of income declines as income rises. The use of unit taxes and fees on airline tickets generally results in effective tax rates that decline as the total fare increases (although the effective tax rate also depends on the number of connections). However, without formally establishing a link between ticket prices and income it cannot be conclusively demonstrated that airline ticket taxes are regressive.

The Congressional Budget Office (CBO) has established that federal excise taxes are generally regressive. In 2000, total excise taxes constituted 2.2% of the bottom quintile of household income, but only 0.6% of the highest quintile (CBO, 2003, p. 25). Though the CBO includes federal aviation taxes in its analysis, these represent a small portion of federal excise taxes. For example, federal excise taxes on tobacco and alcohol, which are known to be regressive, are double those collected on air travel (The Tax Foundation, 2006).

The regressive nature of a tax does not depend on the type of tax, but rather on the type of good being taxed. Also, there is evidence that excise taxes are less regressive than normally thought, when considering the lifetime burden instead of any single year of income (Poterba, 1989, pp. 325-326). While it is not the goal of this study to conclusively demonstrate that ticket taxes and fees are regressive, there is compelling evidence that air travel is not a luxury good (Adrangi and Raffiee, 2000, p. 493). The income elasticity of demand is estimated around unity (Gillen, Morrison, and Stewart, 2002; Adrangi and Raffiee, 2000). If income and fares scale proportionately, this would suggest that ticket taxes are in fact regressive, since the use of unit taxes in the U.S. ticket tax structure places a higher proportional burden on low fares. A mitigating factor is that the benefits received by each passenger are essentially independent of the base fare. Consequently, the benefits themselves may be regressive, as passengers largely receive the same air traffic control, airport, and security services whether they buy high or low fare tickets.

CHAPTER II

DESCRIPTIVE STATISTICS: THE EFFECTIVE TAX RATE

A convenient measure of the relative magnitude of airline ticket taxes is the effective tax rate (ETR), i.e., the proportion of taxes and fees relative to the base fare. The total fare for a domestic air trip consists of the sum of two parts: the base fare, BF, which is the total fare less any applicable taxes and fees, and the total taxes and fees, TTF, which is the sum of the four ticket taxes and fees described in Chapter I:

$$TTF = FTT + FST + FSSF + PFC \qquad (1)$$

For any sample of tickets, the effective tax rate is defined as:

$$ETR = \frac{E(TTF)}{E(BF)} \qquad (2)$$

where *E*(TTF) and *E*(BF) represent the average values of TTF and BF, respectively, weighted by the number of passengers.

Note that there is no convention in the airline industry as to whether tax rates should be computed on the basis of the producer price (i.e., the base fare) or the consumer price (i.e., the total fare). In this study, all tax rates are computed relative to the base fare per Equation 2. This is similar to the treatment of common consumer taxes such as sales taxes, lodging taxes, and meals taxes. It is also consistent with how the 7.5% federal ticket tax is computed. As shown below, airline industry statements regarding the effective tax rate are sometimes made with reference to the base fare and other times with reference to the total fare.

Prior to a research project initiated in 2003, of which this study is a continuation, practically no broad-based descriptive statistics of U.S. ticket tax rates were available. Numerous industry statements and news media accounts have reported that ticket taxes constitute 25% or more of an airline ticket. For example, Senator John McCain, Chairman of the Senate Committee on Commerce, Science and Transportation, has been quoted as saying that “taxes and fees already make up 26% of the total cost of an airline ticket” (Beavin and Looney, 2003, May).

Former American Airlines CEO Robert Crandall has stated that “the multitude of fees and taxes imposed now accounts for about 25% of the fare paid by the average traveler” (Crandall, 2002, December 10). The same statistic was reported by the International Air Transport Association (IATA) in a recent briefing on aviation taxes and charges: “taxes levied on [U.S.] aviation exceeded US$ 14 billion in 2004, corresponding to 25% of a typical airfare” (IATA, 2005, p. 3).

Perhaps the most striking statement on the level of ticket taxes can be attributed to Lawrence Lindsey, former Assistant to the President for Economic Policy and Director of the National Economic Council (Lindsey, 2003, April 1, p. A14):

> Federal taxes and fees now consume 25% of the cost of a low-priced ticket. That does not include the further tax burden on profits and wages that most businesses face. This tax compares with an 18% federal excise tax on cigarettes and an 11% federal excise tax on whiskey. Is air travel more of a sin than alcohol or tobacco?

Lawrence Lindsey artfully makes his reference to a “low-priced ticket”. This is an important distinction, because the 25% statistic is not based on a representative sample of airline tickets. Instead, it is derived by computing tax examples using what are purported to be typical tickets. However, these tickets do not necessarily correspond to average itineraries and prices. If, for example, the selected fare is lower than the mean for U.S. air travel, the resulting tax rate will appear higher than the actual average. This is because of the presence of unit taxes in the ticket tax structure.

The only known statistical analysis of ticket tax rates outside of this research effort is a report by Morrison and Winston (2003) completed on behalf of the National Business Travel Association. It uses a large sample of ticket data to compute average fare and tax rates, but is limited to business travelers in 3,200 markets. The results of that study indicate a tax rate of 8% in 1989 and 14% in 2002 (Morrison and Winston, 2003, p. 4).

This thesis is a continuation of a research project which estimated historical ETR values using itinerary and fare information from a 10% sample of all tickets (referred to as Data Bank 1A or DB1A) for air travel within the continental U.S. (Karlsson, Odoni, and Yamanaka, 2004; Yamanaka, Karlsson, and Odoni, 2005). A summary of these results follows below.

Overall Effective Tax Rate

Data from the second quarters of 1993, 2002, and 2004 shows that the average ETR on round-trip tickets was 10.9%, 15.9%, and 16.5%, respectively. These results are shown in Table 2.1, which also shows inflation adjusted average fares, taxes, and fees. Although the tax rate appears to be increasing over time, the absolute amount of taxes and fees has decreased slightly when expressed in constant dollars. The principal cause of the apparent increase in the tax rate increase is the significant decrease in average base fare, which declined by $175 or 40% between 1993 and 2004. In 2004Q2, the federal ticket tax, the only ad valorem tax for domestic air travel in the U.S., accounted for just under half the average total taxes and fees.

Table 2.1: Effective tax rate comparison

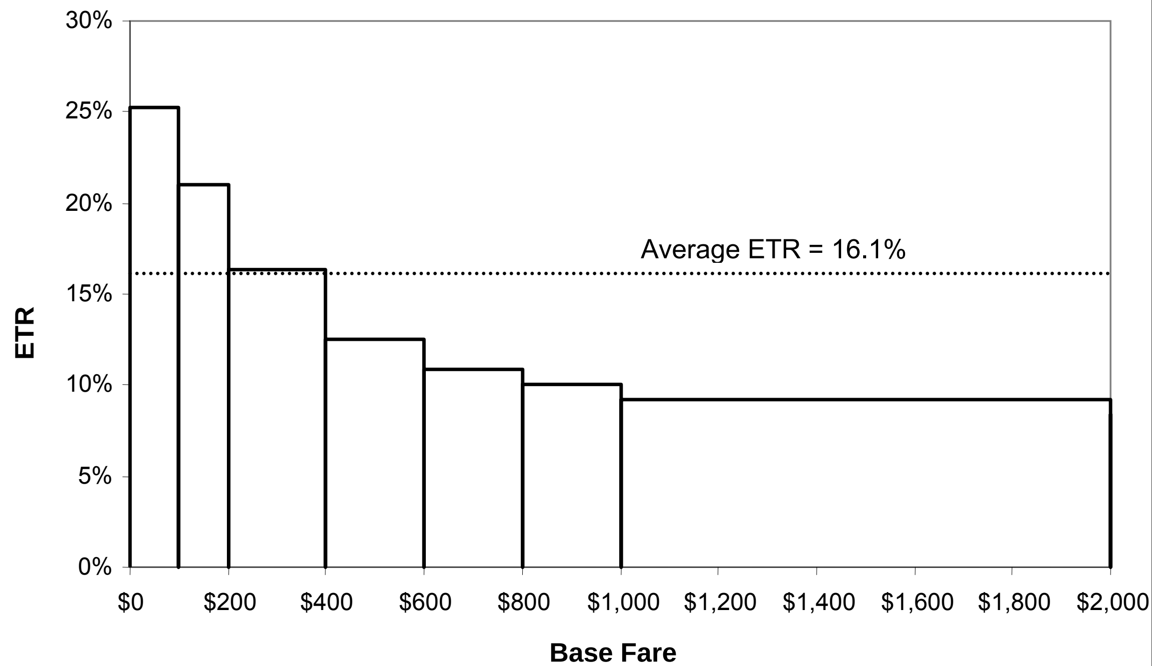
Quarter	No. of tickets in sample	Average Base Fare	Average Total Taxes and Fees	Average Federal Ticket Tax	Average Federal Segment Tax	Average Passenger Facility Charge	Average Federal Security Service Fee	Average ETR
1993Q2	2,164,162	$444.89	$48.40	$44.49	$0.00	$3.91	$0.00	10.9%
2002Q2	3,559,912	$291.74	$46.26	$21.88	$8.35	$9.07	$6.96	15.9%
2004Q2	3,893,783	$268.29	$44.25	$20.12	$8.06	$9.58	$6.50	16.5%

Note: Expressed in 2004 dollars; includes round-trip tickets only.

Distributive Aspects of the Effective Tax Rate

The three unit taxes and fees (i.e., FST, PFC, and FSSF) vary only with the passenger's itinerary, irrespective of the base fare. Consequently, the average ETR decreases as the base fare increases, as shown in Figure 2.1. The least expensive tickets, i.e., those with a base fare of $200 or less, have an ETR greater than 20% (Yamanaka, Karlsson, and Odoni, 2005, p. 4). Roughly 50% of all domestic tickets in 2004Q2 had a base fare of less than $200, which may help explain the widespread impression that taxes and fees on airline tickets are excessively high. In sharp contrast, ETR varied only slightly with base fare in 1993, ranging from 11.9% for base fares less than $100 to 10.1% for base fares greater than $2,000. For base fares greater than $800, the ETR in 2004 and 2002 was under 10%, or lower than in 1993.

Figure 2.1: Distribution of ETR as a function of base fare (2004Q2)



The 2004Q2 data indicates that the average base fare for a low-cost carrier (LCC) was about $185, compared to about $305 for a legacy carrier (see Table 2.2). The legacy carriers in this analysis were American, Continental, Delta, Northwest, United, and US Airways; the low-cost carriers were ATA, jetBlue, and Southwest. However, the ETR for the LCCs was only three percentage points higher than the ETR for legacy carriers. Consequently, the impact of taxes and fees on LCC tickets is smaller than one might expect.

The main reason for this finding is that the average number of segments in a round-trip LCC itinerary is 2.25, as opposed to 2.58 for legacy carriers. Also, LCC routes often bypass the most congested airports in favor of secondary ones. As the most congested airports are also the ones that tend to impose passenger facility charges (and at higher levels), the average PFC paid by LCC passengers is considerably smaller. Because of these two effects, the FST, PFC and FSSF costs are smaller, on average, for low-cost carrier passengers than those of legacy carriers.

Table 2.2: Legacy vs. low-cost carriers (2004Q2)

Carrier type	Average Base Fare	Average Total Taxes and Fees	Average Federal Ticket Tax	Average Federal Segment Tax	Average Passenger Facility Charge	Average Federal Security Service Fee	Average ETR
LCC	$185.91	$34.37	$13.94	$6.99	$7.81	$5.63	18.50%
Legacy	$305.33	$47.00	$22.90	$7.99	$9.66	$6.45	15.40%

Note: Includes round-trip tickets only.

Perhaps surprisingly, ETR varies little with the distance between the origin and destination in each itinerary. One of the reasons is that the average base fare increases less than linearly with the origin-destination distance. For example, the average base fare for a distance of between 1,000 and 2,000 miles is only about 35% greater than for a distance of less than 200 miles in the 2004 sample. A second reason is that longer distances are more likely to be associated with itineraries that include a connection at an intermediate airport. This, in turn, means a greater likelihood of a high FST, FSSF, and PFC.

Comparison with the European Union

A comparison of U.S. effective tax rates with results from the European Union (EU) is instructive to place U.S. tax rates in context. One challenge is that there is no public database in the EU equivalent to that made available by the U.S. Department of Transportation. A data set provided by the global travel distribution system provider Amadeus, S.A. was used to calculate ETR values for intra-EU travel in fifteen nations (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the United Kingdom). This sample consists of complete ticketing records for fifteen days selected from the period January 2004 to February 2005. It should be noted, however, that the data set omits most charter and low-cost carriers operating in the EU. The results, expressed in U.S. dollars, are summarized in Table 2.3.

Table 2.3: Average effective tax rate (15 day EU sample)

Ticket category	No of tickets in sample	Average Base Fare	Average Total Taxes and Fees	Average YQYR	Average ETR
All	3,032,209	$272.27	$44.19	$12.26	11.2%
One-Way	691,841	$166.74	$19.12	$4.50	8.5%
Round-trip	2,340,368	$303.47	$51.60	$14.56	11.6%

EU tickets frequently include two tax codes, YQ and YR (here collectively referred to as YQYR), which are reserved for airline surcharges. To the uninformed consumer, YQYR charges may be indistinguishable from the true taxes and fees that appear on a ticket. In fact, in most cases these charges represent additional revenues for the airlines, primarily in the form of fuel surcharges. This raises a consumer information question as to the passengers' ability to compare fares, as these charges are often not advertised. Indeed, the EU transport commissioner has proposed that airlines be forced to "publicize full fares, including taxes, charges and booking and credit card fees on their websites and in adverts" (Gow, 2006, July 18). In the analysis presented here, the YQYR charges are added to the base fare, and are excluded from the total taxes and fees. Consequently, Equation 2 is modified as follows for the EU analysis:

$$ETR = \frac{E(TTF) - E(YQYR)}{E(BF) + E(YQYR)} \qquad (3)$$

The total amount of YQYR charges observed in the EU ticket sample consists of 27.8% of the sum of all of taxes and fees, and thus significantly affects ETR estimates.

If YQYR instead were treated as part of the total taxes and fees, the overall effective tax rate would change from 11.2% to 16.2%. There is no legitimate justification in treating YQYR as part of the taxes and fees, but this "apparent ETR" may be a better indicator of how the size of taxes and fees is perceived by air transportation consumers. Remarkably, the average YQYR charged to intra-EU tickets appears to have more than doubled over the sample period, from an average of $8 per ticket in January 2004 to just below $20 by February 2005.

The aggregate results, as presented above, mask the fact that there is great variability in ETR across individual EU nations. This is demonstrated in Table 2.4, which shows that ETR ranges from a high of 20.4% for travel originating in the United Kingdom to a low of 6.3% for Luxembourg. Note that a high tax rate can result from either high taxes or from low fares.

One major difference between the U.S. and the EU is that U.S. ticket taxes fund air traffic control, while EU taxes generally do not. Instead, carriers operating in EU airspace are billed directly by the various providers of air traffic control services, such as Eurocontrol. Any comparison of ETR values between the U.S. and the EU must take this difference into consideration, as air traffic control costs are substantial on both sides of the Atlantic. Unfortunately, there is no European data collection mechanism comparable to the U.S. carriers' monthly filings, which can readily identify the amounts paid by individual airlines for international air traffic control services.

Table 2.4: Effective tax rate by origin country (15 day EU sample)

Origin Country	No of tickets in sample	Average Base Fare	Average Total Taxes and Fees	Average YQYR	Average ETR
United Kingdom	277,268	$191.01	$56.18	$14.30	20.4%
Greece	25,550	$199.57	$46.59	$9.68	17.6%
Denmark	81,951	$282.24	$72.88	$21.25	17.0%
Ireland	10,881	$206.17	$44.73	$13.01	14.5%
Finland	117,728	$301.65	$58.24	$12.78	14.5%
Sweden	138,691	$297.38	$66.89	$21.71	14.2%
The Netherlands	30,690	$364.76	$62.42	$12.62	13.2%
Belgium	39,683	$349.26	$57.26	$12.26	12.4%
Austria	43,020	$394.44	$76.47	$26.57	11.9%
France	616,651	$329.57	$56.06	$15.47	11.8%
Portugal	20,850	$263.84	$33.82	$4.47	10.9%
Germany	537,799	$343.90	$59.91	$22.15	10.3%
Italy	127,859	$289.88	$39.77	$13.51	8.7%
Spain	953,583	$198.06	$14.81	$1.15	6.9%
Luxembourg	10,005	$375.77	$44.10	$19.16	6.3%

Using supplemental data collected from two European airlines, Lufthansa and SAS Group, indicates that air traffic control costs would add roughly 7% to the effective tax rate. Both Lufthansa and SAS have flights throughout the EU and are based in countries where the effective tax rate is close to the EU-15 average of 11.2% (with the exception of Denmark). This suggests the conjecture that the effective tax rate in the EU would be approximately 18-19% with air traffic control costs taken into account. This would be slightly higher than the 2004Q2 value of 16.1% for U.S. domestic air travel. However, this is a very preliminary estimate, which serves primarily as a good launching point for future investigation. For example, this comparison does not take into account that a portion of U.S. air traffic control costs are subsidized by general tax revenues. Another substantial limitation is that the EU data set excludes practically all charter and low-cost carriers.

CHAPTER III

ANALYTICAL FRAMEWORK

Who carries the burden of the ticket taxes and fees – the passengers or the airlines? That is the question of tax incidence. The purpose of this discussion is to present the economic theory of tax incidence as applied to air transportation. The theoretical approach to compute incidence is limited, which supports an empirical approach. However, the theory places bounds on the empirical computations of incidence. Under perfect competition, incidence is bounded by zero (i.e., full shifting onto the producer) and one (i.e., full shifting onto the consumer). Further, the incidence of a unit tax and an ad valorem tax are identical. Under imperfect competition and pure monopoly, overshifting is a possibility, so that the incidence can exceed one, and it is also possible for the incidence of the unit tax to be greater than that of the ad valorem tax.

Statutory vs. Economic Incidence

When discussing the burden of taxation, a distinction must be made between statutory and economic incidence. The statutory incidence of ticket taxes defines who is legally obligated to collect the tax and pay it to the treasury. In the U.S., the statutory incidence is clearly on the airline industry (AIR-21, 2000; Aviation and Transportation Security Act, 2001; Internal Revenue Code, 1986). However, statutory incidence is not the same as economic incidence, which determines who ultimately bears the burden of the tax (Fullerton and Rogers, 1993, p. 1). Statutory and economic incidence are independent and the general recommendation is that the statutory burden be structured so as to minimize tax collection costs. This concept of tax incidence equivalence applies to both unit and ad valorem taxes, is independent of the market structure, and is supported by experimental evidence (Ruffle, 2005).

There is often public confusion between statutory and economic incidence. For example, in response to an administration proposal to increase the federal security fee, the Administrator of the Transportation Security Administration, Kip Hawley, stated that “at the end of the day the money has to come from somewhere…our sense is that it’s fair to have that part of it come from the air passenger” (Faler, 2006, March 1, para. 23). This seems to imply a belief that an increase in the security fee would be entirely absorbed by the passengers.

Statutory incidence can affect economic incidence under certain assumptions. One example is imperfect or asymmetric information: Consider the payment of a hypothetical departure tax which must be paid in cash by the passenger at the airport at the time of departure: This tax may be unanticipated by the passenger. In this situation, it is possible that the passenger’s purchasing decision would have been different if the information available to the passenger and the airline had been identical. For the purpose of notation, this study places the statutory incidence on the airlines, which reflects U.S. and EU practices. The possibility of imperfect or asymmetric information between airlines and passengers in regards to ticket taxes and fees is not explored.

General vs. Partial Equilibrium

A simplifying assumption of this study is that the airline industry is treated independently of the rest of the economy: All other markets are ignored. Such a partial equilibrium analysis may lead to incomplete results, especially when the market under consideration is large relative to the overall economy (Rosen, 2005, p. 292). Historically, passenger revenues for U.S. airlines have hovered around 1% of total gross domestic product, although this has dropped to 0.7-0.75% since the events of September 11, 2001 (Hansman, 2005).

There are several drawbacks to considering only a partial equilibrium framework. A tax applied to the airline industry affects not only the price of air travel, but also the price of other goods, as air travelers and airlines adjust their consumption in response to the tax. It should be noted that economists consider the tax burden to be carried exclusively by individuals, not firms (Rosen, 2005, p. 274; Gruber, 2005): Thus, the notion of airlines carrying a portion of the tax burden actually describes the burden carried by individual airline employees and investors. This distinction becomes increasingly important when considering the impact of air transportation taxes on other markets. For the sake of simplicity, the term “airlines” is used throughout this study to refer to the portion of the burden not borne by passengers.

Some industries will benefit from increased taxation on the airline industry, and others will suffer. In turn, this affects the welfare of those who provide labor and capital to industries, which can alter the economic incidence. Consequently, using a broader general equilibrium model can produce outcomes which are not possible under partial equilibrium models (Fullerton and Metcalf, 2002, p. 1790).

Partial equilibrium analyses ignore the spending of the tax revenues collected. This spending matters, as it can have distributional effects on relative prices (Fullerton and Metcalf, 2002, pp. 1791-1792). There is a feedback mechanism involving public spending: When, for example, the FAA acquires a new radar system, it converts private goods such as labor, capital, and materials into a public good. Therefore, its consumption choices are affected by the relative prices of goods in the private markets, which in turn are affected by the raising of taxes (Keller, 1980, pp. 8-10). This can be addressed through a balanced-budget incidence analysis, “which computes the combined effects of levying taxes and government spending financed by those taxes” (Rosen, 2005, p. 276). Partial equilibrium models also do not capture taxes on inputs such as labor and fuel. This has some bearing on the results, especially if changes in ticket taxes are linked to or coincide with changes to these input taxes.

General equilibrium models vary in complexity and analytical power. Relatively simple models, for example those considering two sectors using two inputs, capital and labor, can be solved analytically. They can therefore be used to generate results with considerable explanatory power. However, such models generally require a substantial number of simplifying assumptions that limit their value. For example, such models may only allow for incrementally small tax changes, may require specific assumptions regarding the production function, and may exclude dynamic effects or long term implications of changes in capital (Keller, 1980, pp. 2-6; Fullerton and Metcalf, 2002, pp. 1795-1800).

The alternative approach is to use computational models that allow for much more complex models of the economy, which are then solved numerically. However, such models may not provide the explanatory power required to draw more general conclusions (Keller, 1980, p. 3). In practice, these models also require a large number of assumptions to be made in order to be able to arrive at a computable result. Given these limitations, a partial equilibrium analysis seems a reasonable starting point for analyzing tax incidence in the airline industry. A logical progression for future work would be a study of balanced-budget incidence.

Tax Incidence Under Perfect Competition

Under the assumption of perfect competition with flexible prices, tax incidence can be analytically derived. It can also be shown that the incidence of a unit tax is identical to that of an ad valorem tax, given that the latter is normalized to account for units of measurement and a multiplier effect inherent to ad valorem taxation.

Unit Tax

The derivation shown here generally follows Kotlikoff and Summers (1987). Consider the case of a unit tax, t. If $t = 0$, there is no tax, and output and price are simultaneously determined by market clearing forces at some equilibrium price p^*. After the application of the tax, the passenger faces the tax inclusive price p^D and the supplier receives the tax exclusive price p^S, such that:

$$p^D = p^S + t \qquad (4)$$

Note that in an airline pricing example, p^S is identical to the base fare (BF). It is also known as the net price, whereas p^D represents the total fare or gross price.

This framework assumes that the statutory incidence is placed on the supplier, as is the case in the U.S. airline industry. The results are identical if the tax is collected from the consumer and, effectively, it does not matter whether the tax is modeled as a shift in the demand curve or in the supply curve.

The equilibrium price p^* in the absence of a tax is defined by the demand function $D(p^D)$ and supply function $S(p^S)$, so that $D(p^*) = S(p^*)$. The after tax equilibrium is given by (Kotlikoff and Summers, 1987, p. 4) :

$$D(p^D) = S(p^D - t) \tag{5}$$

Differentiating Equation 5 with respect to t results in:

$$\frac{dD}{dp^D}\frac{dp^D}{dt} = \frac{dS}{dp^S}\left(\frac{dp^D}{dt} - 1\right) \tag{6}$$

Solving for the tax incidence, expressed as the pass-through burden on the consumer, yields:

$$\frac{dp^D}{dt} = \frac{S'}{S' - D'} \tag{7}$$

where $S' = dS / dp^D$ and $D' = dD / dp^S$.

Noting $D(p^D) = S(p^S)$ and $dS / dp^S = dS / dp^D$, the result expressed by Equation 7 can be restated in terms of the price elasticities of supply and demand:

$$\frac{dp^D}{dt} = \frac{\varepsilon^S}{\varepsilon^S - \varepsilon^D} \tag{8}$$

where

$$\varepsilon^S = \frac{dS}{dp^S}\frac{p^S}{S} \tag{9}$$

and

$$\varepsilon^D = \frac{dD}{dp^D}\frac{p^D}{D} \tag{10}$$

Note that for a downward sloping demand curve, $D' < 0$, so that $\varepsilon^D \leq 0$, whereas $\varepsilon^S \geq 0$. This places lower and upper bounds on tax incidence under perfect competition, so that:

$$0 \leq \frac{dp^D}{dt} \leq 1 \tag{11}$$

A value of zero means the tax is completely shifted onto the producer, whereas a value of one means the tax is shifted onto the consumer. One implication of these bounds is that there is no possibility of overshifting of taxes, under the assumption of perfect competition. Whichever party has a more inelastic response to price generally ends up carrying the tax burden. For example, if the demand curve is perfectly inelastic, the tax incidence under perfect competition is given by:

$$\frac{dp^D}{dt} = \frac{\varepsilon^S}{\varepsilon^S - \varepsilon^D} = \frac{\varepsilon^S}{\varepsilon^S} = 1 \tag{12}$$

In this case, the tax burden falls entirely on the consumer.

Ad Valorem Tax

Consider a single ad valorem tax with an effective tax rate τ. After the application of the tax, the passenger faces the tax inclusive price p^D and the supplier receives the tax exclusive price p^S, such that:

$$p^D = p^S(1+\tau) \tag{13}$$

Under this framework, the incidence is obtained by evaluating dp^D / dr, where dr is the change in tax revenue resulting from a change in the ad valorem tax rate:

$$dr = p^S d\tau \tag{14}$$

From Equations 13 and 14, it follows that the tax incidence of an ad valorem tax is given by:

$$\frac{dp^D}{dr} = \frac{1}{p^D}\frac{dp^D}{d\tau}(1+\tau) \tag{15}$$

Two observations are in order: The first is that a factor of $1/p^D$ is required to adjust for measurement units, since incidence is defined as a change in price with respect to a tax level, not a tax rate. The second is that the incidence of an ad valorem tax includes a multiplier effect represented by the factor $1+\tau$. "Ad valorem taxation has a distinctive multiplier effect: since part of any increase in the consumer price goes to the government as tax revenue", whereas a unit tax "has no such effect: the producer price rises one-for-one with the consumer price" (Keen, 1998, p. 5).

The multiplier effect can be illustrated with a simple example. Consider a before tax price of $100 with an ad valorem tax rate of 10%. Assume that the tax rate is increased to 20% and that the consumer bears the full burden. In this case, the after tax price increases from $110 to $120. With $\Delta p^D = \$10$ and $\Delta\tau = 0.1$, the price effect is given by:

$$\frac{\Delta p^D}{\Delta\tau} = \$100 \tag{16}$$

Dividing by $p^D = \$120$ to convert units results in:

$$\frac{1}{p^D}\frac{\Delta p^D}{\Delta\tau} = 0.833 \tag{17}$$

Applying the multiplier effect $1+\tau = 1.2$ provides the desired result:

$$\frac{1}{p^D}\frac{\Delta p^D}{\Delta\tau}(1+\tau) = 1 \tag{18}$$

Full shifting onto the consumer implies that the producer price remains constant as the tax rate increases. The multiplier effect means that an increase in taxes collected from the producer results in an even higher increase in consumer price, since a portion of the increase goes to the government as additional ad valorem tax revenue (Delipalla and O'Donnell, 2001, p. 891). Note that for small τ, Equation 17 is a reasonable approximation of the true incidence, but will always be biased downwards, as it excludes the multiplier effect.

Given a demand function $D(p^D)$ and a supply function $S(p^S)$, the after tax equilibrium is given by:

$$D(p^D) = S\left(\frac{p^D}{1+\tau}\right) \tag{19}$$

Differentiating Equation 19 with respect to τ results in:

$$\frac{dD}{dp^D}\frac{dp^D}{d\tau} = \frac{dS}{dp^S}\left[\frac{\frac{dp^D}{d\tau}(1+\tau) - p^D}{(1+\tau)^2}\right] \tag{20}$$

Solving for $dp^D / d\tau$ results in:

$$\frac{dp^D}{d\tau} = \frac{\dfrac{S' p^D}{(1+\tau)^2}}{\dfrac{S'}{1+\tau} - D'} \tag{21}$$

Normalizing by $1/p^D$ and applying the multiplier effect $1+\tau$ results in the following expression for the tax incidence:

$$\frac{1}{p^D}\frac{dp^D}{d\tau}(1+\tau) = \frac{\dfrac{S'}{1+\tau}}{\dfrac{S'}{1+\tau} - D'} \tag{22}$$

Noting $D(p^D) = S(p^S)$ and $dS / dp^S = (1+\tau) dS / dp^D$, the tax incidence of an ad valorem tax can be expressed in terms of the price elasticities of demand and supply:

$$\frac{1}{p^D}\frac{dp^D}{d\tau}(1+\tau) = \frac{\varepsilon^S}{\varepsilon^S - \varepsilon^D} \tag{23}$$

Comparing this result with Equation 8 demonstrates that under perfect competition, the tax incidence of a unit tax and that of an ad valorem tax are identical, and have the same testable implications. Specifically, the tax incidence of an ad valorem tax under perfect competition has a lower bound of zero and an upper bound of one.

Application of Theory to Air Transportation

Assuming for the moment that perfect competition is an applicable model, several difficulties arise in trying to apply Equations 8 or 23 to estimate tax incidence in the air transportation industry. The first is that price elasticities vary along several dimensions, including type of travel (i.e., leisure vs. business) and trip length (Gillen, Morrison, and Stewart, 2002). Second, short-run price elasticities are likely to differ from those in the long-run. One estimate, although out of date, is that the price elasticity of demand for air travel ranges from −0.1 in the short run to −2.4 in the long run (Gwartney and Stroup, 1997). On the supply side, short run behavior is expected to be inelastic, as airlines' capital investments in aircraft and airport facilities cannot be changed quickly. Third, because the airline industry has undergone structural changes in recent years, including a multi-year demand shock caused by the events of September 11, 2001 (Ito and Lee, 2004), only the latest estimates of price elasticities should be used.

On the demand side, there are large numbers of agents acting as price takers and without consideration of the actions of other consumers, so that the demand curve is relatively clearly defined. On the supply side, the agents form a much smaller group, and are more likely to react to the behavior of competitors. These agents may exhibit various forms of price leadership and the notion of a supply curve may cease to exist. For this reason, there are large numbers of empirical assessments of price elasticity of demand, including several recent meta-studies, but practically no estimates of price elasticity of supply.

A MITRE Corporation study estimates that price elasticity of demand ranges from −0.56 to −1.82, depending on distance (Bhadra, 2002). Two large meta-analyses have similar results: A study for the Canadian Department of Finance resulted in values ranging from −0.70 to −1.52 for domestic travel (Gillen, Morrison, and Stewart, 2002). Another meta-analysis of 204 studies found a mean elasticity of −1.15 with a standard deviation of 0.62 (Brons, Pels, Nijkamp, and Rietvald, 2002). On the supply side, Ito and Lee report an implied price elasticity 0.74 (2004), estimated over a time period of several years. These values can be used to generate hypothetical tax incidence values, as shown in Table 3.1.

Table 3.1: Hypothetical values of tax incidence under perfect competition

	$\varepsilon^D = -0.70$	$\varepsilon^D = -1.15$	$\varepsilon^D = -1.52$
$\varepsilon^S = 0.74$	0.51	0.39	0.33

The value of this analysis is quite limited given the required assumption of perfect competition, as well as the lack of empirical estimates of the price elasticity of supply. Under different assumptions regarding market power, the conclusions would change. This theoretical approach provides, at best, limited indications about incidence, which argues for empirical methods. However, these theoretical results represent are useful for comparison with the empirical results. They emphasize that incidence is bounded by zero and one. The range of values shown in Table 3.1 might be reasonable results of an empirical analysis. Different empirical results could indicate a market structure other than perfect competition.

Tax Incidence With Free Entry and Exit

In the discussion above, the number of firms is assumed to be fixed and exogenous. Under a long-run assumption that allows for free entry and exit of firms, the results change. For example, consider a simple model such as presented by Varian (1992, p. 220), with no entry or exit costs and with firms facing a uniform cost function $c(y)$. If the number of firms is high, the supply curve is flat, and is assumed to be defined by $p^S = p^*$. The equilibrium price p^* is set by the zero-profit condition, which is the level of output where average cost equals marginal cost:

$$\frac{c(y)}{y} = \frac{dc}{dy} \tag{24}$$

In this case, supply is perfectly elastic, so that $\varepsilon^S = \infty$. Since all the assumptions regarding perfect competition still hold, Equation 8 can be used to compute tax incidence, as long as the price elasticity of demand is assumed to be finite:

$$\frac{dp^D}{dt} = \frac{\varepsilon^S}{\varepsilon^S - \varepsilon^D} = 1 \tag{25}$$

Consequently, in this long term scenario, the tax burden falls entirely on the consumer: When a unit tax is increased, the price facing the consumer rises by exactly the amount of the tax.

Tax Incidence Under Pure Monopoly or Imperfect Competition

Unlike perfect competition, pure monopolies and imperfect competition allow for the possibility of overshifting (Anderson, de Palma, and Kreider, 2001, pp. 7-12), since prices are set above marginal cost (Delipalla and O'Donnell, 2001, p. 891). In the overshifting scenario, the total fare paid by the passenger after a tax increase is higher than the sum of the original fare and the tax increase. In some, but not all, cases of overshifting, a tax increase can result in higher profits. As shown above, overshifting cannot occur under perfect competition, but "once imperfectly competitive markets are allowed, overshifting becomes a possibility and can be guaranteed in some model specifications" (Fullerton and Metcalf, 2002, p. 1825).

Additionally, under imperfect competition the economic effects of an ad valorem tax can be different than those of a unit tax. For example, under certain assumptions, an ad valorem tax can lead to firms exiting the market, which reduces the burden on producers and increases the burden on consumers: "While a change in the excise tax does not affect the equilibrium number of firms, a change in the ad valorem tax does… Ad valorem tax incidence can be decomposed into two components: a direct effect and an indirect effect through the change in the equilibrium number of firms" (Fullerton and Metcalf, 2002, p. 1831).

In industries with differentiated products, non-price competition opens up additional pathways in which taxes can manifest their impacts. For example, in addition to direct impacts on fare levels, changes in ticket taxes can affect product quality and variety: "Non-price competition can substantially affect the degree to which output taxes are passed forward to consumers and can lead to counterintuitive results" (Fullerton and Metcalf, 2002, p. 1832). It is therefore possible that the introduction of a new tax is entirely absorbed by the airlines, or even that fares go down after a tax hike, because of strategizing within an oligopoly of airlines.

Pure Monopoly

A pure monopoly scenario allows for a relatively straightforward theoretical analysis of tax incidence. For example, to demonstrate that overshifting can occur in a pure monopoly, consider a monopolist model with constant marginal cost and a downward sloping demand curve (see, for example, Varian, 1992, pp. 236-237). The profit maximization problem is stated as:

$$\max_{y} p(y)y - cy \qquad (26)$$

If the firm now faces a unit tax, the profit maximization problem can be extended to account for the tax:

$$\max_{y} p(y)y - (c+t)y \qquad (27)$$

At the optimal choice of output y^*, the first order condition becomes:

$$\frac{d\pi}{dy} = p(y^*) + y^* p'(y^*) - (c+t) = 0 \qquad (28)$$

Note that the tax enters as a parameter to the optimal output, so that $y^* = y(t)$.

Equation 28 can readily be arranged in terms of the price elasticity of demand:

$$p(y^*)\left(\frac{1+\varepsilon^D}{\varepsilon^D}\right) = c+t \qquad (29)$$

The marginal cost and unit tax are both positive. Therefore, under the standard assumption of a downward sloping demand curve, the condition $\varepsilon^D < -1$ must hold.

The chain rule is the starting point for deriving a theoretical expression for tax incidence in this example:

$$\frac{dp}{dt} = p'(y^*)\frac{dy}{dt} \qquad (30)$$

Recognizing that $d\pi / dy$ is constant at zero from the first order condition (Equation 28), it follows from total differentiation that:

$$\frac{\partial^2 \pi}{\partial y^2}dy + \frac{\partial^2 \pi}{\partial y \partial t}dt = 0 \qquad (31)$$

Rearranging results in:

$$\frac{dy}{dt} = -\frac{\dfrac{\partial^2 \pi}{\partial y \partial t}}{\dfrac{\partial^2 \pi}{\partial y^2}} \qquad (32)$$

Note that the second order condition $\frac{\partial^2 \pi}{\partial y^2} < 0$ is guaranteed by the sufficient conditions for the existence of a maximum.

From the profit function $\pi(y^*) = p(y^*)y^* - (c+t)y^*$ it follows that

$$\frac{dy}{dt} = \frac{1}{2p'(y^*) + y^* p''(y^*)} \qquad (33)$$

Substituting Equation 33 into 30 and rearranging, results in the following expression for tax incidence:

$$\frac{dp}{dt} = \frac{1}{2 + y^* p''(y^*)/\, p'(y^*)} \qquad (34)$$

Since $p'(y) < 0$, it follows that overshifting is guaranteed under the following condition:

$$y^* > -\frac{p'(y^*)}{p''(y^*)} \qquad (35)$$

As an example, consider the demand function $y = ap^{\beta}$, which has a constant price elasticity of demand, so that:

$$\varepsilon^D = \beta \qquad (36)$$

In this case, the first order condition given by Equation 29 can be differentiated to obtain:

$$\frac{dp}{dt} = \frac{\varepsilon^D}{1+\varepsilon^D} = \frac{\beta}{1+\beta} \qquad (37)$$

As noted previously, the first order condition also implies that $\varepsilon^D < -1$, from which it follows that:

$$\frac{dp}{dt} > 1 \qquad (38)$$

Consequently, a constant price elasticity demand function is one of several special cases which guarantee overshifting of taxes in a pure monopoly.

The monopolist charges a price which represents a mark-up over the marginal cost, which can be shown to equal $-P/\varepsilon^D$, whereas in perfect competition, the price equals marginal cost. It is this mark-up that allows for over-shifting. For example, if $\varepsilon^D = -4$, and the price is \$100, the mark-up is 25% and the marginal cost is \$75. If the marginal cost increases by \$15 because of a new tax, the new price will be \$120, which would represent overshifting by one-third of the tax increase.

Note that this does not mean that the monopolist is better off after a tax increase. By the envelope rule, it follows that:

$$\frac{d\pi^*}{dt} = -y \qquad (39)$$

Therefore, in the vicinity of the maximum profit π^*, the monopolist's profit decreases with a tax increase, as long as output is positive.

Oligopoly

Under theoretical constructs such as perfect competition and pure monopoly, analytical derivation of tax incidence is relatively straightforward. Oligopolies, however, include a range of possible strategic behaviors with varying consequences for the incidence question. These behaviors are usually modeled by selecting one of a few archetypical models of oligopolistic behavior. While real world markets are likely to exhibit aspects of several of these theoretical models of oligopolistic competition, the models are useful in deriving results that can be used to approximate actual behavior. These models can be broadly distinguished as non-cooperative or cooperative (i.e., cartel) models. Ruling out cartel behavior, two of the basic models include Cournot and Bertrand behavior. In the Cournot model, firms take as given the output of other firms, and then choose their output so as to maximize profits, whereas in the Bertrand model, the price of other firms is taken as given (Varian, 1992, pp. 285-292). Other non-cooperative models include models with a dominant firm acting either as a price or quantity leader (Varian, 1992, pp. 295-302). Another important distinction is whether or not the oligopoly in question is delivering a homogenous product, or whether there is non-price competition via differentiated products, which may apply to the airline industry.

Tax incidence can be analytically derived for some of these oligopoly models (see, for example, Hamilton, 1999 and Barron, Blanchard, and Umbeck, 2004). However, this requires knowing which model is applicable to the market under consideration. Empirical analysis demonstrates that imperfect competition exists in the airline industry, but that the evidence is inconclusive as to which specific model best applies (Fischer and Kamerschen, 2003, p. 91). There is mixed support in the literature for both the Cournot and Bertrand models (Bilotkach, 2004, pp. 8-10). This makes it difficult to proceed much further with a theoretical incidence discussion under imperfect competition, which strengthens the case for an empirical approach.

Tax Incidence Under the Dual Policy of Ad Valorem and Unit Taxes

While there is considerable literature on the impact of unit taxes, analyses of the simultaneous application of both ad valorem and unit taxes are much less common, especially under imperfect competition. A seminal paper in this regard is that of Delipalla and O'Donnell (2001), which, in turn, is based on the theoretical framework of Delipalla and Keen (1992). The starting point of these papers is the after-tax profit for firm i with output y_i, in an industry consisting of n firms with total output Y. Within this framework, the after-tax profit is given by:

$$\pi_i = \left[(1-\upsilon)p^D(Y) - s\right]y_i - c(y_i) \tag{40}$$

It should be noted that this model has the statutory incidence placed on the consumer, so that the unit tax s and ad valorem rate υ relate to the producer and consumer prices as follows:

$$p^S = (1-\upsilon)p^D - s \tag{41}$$

This differs from the airline industry, where the statutory incidence is placed on the producer. In this case, a joint policy with a unit tax t and an ad valorem rate τ result in a different relationship between the consumer and producer prices:

$$p^D = (1+\tau)p^S + t \tag{42}$$

As noted previously, the economic implications are the same regardless of the framework. However, it is important to recognize that while the ad valorem rates τ and υ are related, they are not identically defined. The same applies to the unit taxes t and s. Specifically, comparing Equations 41 and 42 reveals that:

$$\upsilon = \frac{\tau}{1+\tau} \tag{43}$$

and

$$s = t(1-\upsilon) = \frac{t}{1+\tau} \tag{44}$$

The price effects of each type of tax are related by market power through μ, "the mark-up of gross price over tax-inclusive marginal cost" (Delipalla and O'Donnell, 2001, p. 890), so that:

$$\frac{\frac{dp^D}{dt}}{\frac{1}{p^D}\frac{dp^D}{d\tau}(1+\tau)} = \mu \quad (45)$$

In perfect competition, $\mu = 1$, implying that the price effect of the two types of taxes do not differ. In imperfect competition, however, $\mu > 1$, so that "the price effect of the specific tax exceeds that of the ad valorem by a proportion given by the value of the mark-up" (Delipalla and O'Donnell, 2001, p. 891).

The mark-up is a function of price elasticity of demand and the strategic interaction between firms, so that:

$$\mu = \frac{1}{1 + \frac{1}{\varepsilon^D \sum_{i=1}^{n} \frac{1}{\lambda_i}}} \quad (46)$$

Here, λ_i characterizes the strategic interaction between firms:

$$\lambda_i = \frac{dY}{dy_i} \in [0, n] \quad (47)$$

where $\lambda_i = 0$ corresponds to "'competitive' in the sense that each firm takes industry output to be unaffected by its own input choice" (Delipalla and Keen, 1992, p. 353), $\lambda_i = 1$ corresponds to a Cournot model, and $\lambda_i = n$ to joint profit maximization (i.e., tacit collusion).

CHAPTER IV

EMPIRICAL FRAMEWORK

As a result of the theoretical limitations outlined above, few of the findings regarding tax incidence have been thoroughly tested (Fullerton and Metcalf, 2002, pp. 1822-1823):

> In summary, few of the standard assumptions about tax incidence have been tested and confirmed… Most others have never been reliably tested… Many general equilibrium simulation studies "calculate" the incidence of each tax based on carefully-articulated theories, and many data-intensive studies use these results to "assume" the incidence of each tax. But competing theories are rarely tested, and so econometric estimation remains fertile ground for new research.

To the author's best knowledge, there are no published econometric studies of tax incidence in the airline industry. The econometric method described here is intended to be a starting point for empirical research in this area.

Unfortunately, there is no natural experiment in which a sample of U.S. airline tickets receives a tax policy treatment and a control group does not. Due to the general lack of ticket level data in nations other than the U.S., it is not possible to mimic Delipalla and O'Donnell (2001) by exploiting variations in taxes across different nations. Also, it should be emphasized that Delipalla and O'Donnell study taxes on cigarettes, a relatively homogenous product. For air travel, the most viable approach appears to be to model the change in price due to variations in taxes across time and routes, while controlling for other exogenous factors that impact fares.

Model Specification

There are two basic choices in model specification: Using a structural form or a reduced form. The former requires modeling the demand and supply sides separately. The advantage of the structural form is its explanatory power of the underlying market dynamics. However, the structural form is subject to misspecification and identification problems. The reduced form specification is simpler to implement, provides a direct estimation of the price impact, but has less explanatory power. This study follows the approach of Delipalla and O'Donnell (2001), Alm, Sennoga, and Skidmore (2005), and others, by using a reduced form approach.

The reduced form specification can be generalized as:

$$P = f\left(t, \tau; \vec{V}, \vec{Z}\right) \tag{48}$$

where $\vec{V}$ and $\vec{Z}$ are vectors of exogenous variables affecting supply and demand, respectively. These could include consumer preferences, factor costs, income, and other exogenous controls.

Functional Form

If the only variation is in the unit tax, a simple linear specification is perfectly adequate (or logarithmic, if the focus is on elasticities). Consider the approach adopted by Alm, Sennoga, and Skidmore (2005), which explores the linear demand and supply functions $p^D = a - by$ and $p^S = c + dy$, where the standard assumptions $b > 0$ and $d > 0$ apply.

Under these assumptions, the equilibrium after introducing a unit tax t with statutory incidence on the producer is given by:

$$p^D = a - by = c + dy + t \tag{49}$$

Solving results in:

$$p^D = \frac{ad + bc + bt}{b + d} \tag{50}$$

The tax incidence is then given by:

$$\frac{dp^D}{dt} = \frac{b}{b + d} \tag{51}$$

In this case, the incidence is constant. In a linear specification, the coefficient on the unit tax will be a direct estimate of the tax incidence.

Conversely, if the only variation is in the ad valorem tax, a strong argument exists for using a semilogarithmic specification (log-lin) for estimating the incidence (Besley and Rosen, 1999, pp. 160-161). Consider a specification of the following general form:

$$\ln p^D = \beta\tau + \vec{\gamma}\vec{V} + \vec{\varpi}\vec{Z} + \varepsilon \tag{52}$$

where ε is a stochastic error term and $\vec{V}$ and $\vec{Z}$ are exogenous supply and demand shifters.

Differentiating this specification with respect to the ad valorem tax rate results in:

$$\frac{1}{p^D}\frac{dp^D}{d\tau} = \beta \tag{53}$$

Note that this estimate excludes the multiplier effect $1+\tau$, and is therefore biased downwards. For this reason, estimating the incidence of an ad valorem tax, such as the federal ticket tax, is more challenging than estimating the incidence of a unit tax. For small τ, the multiplier effect is close to unity, in which case β approximates the incidence of the ad valorem tax. A simple, but imperfect, way to adjust for this bias is to multiply the estimated coefficient $\hat{\beta}$ by $1+\bar{\tau}$, where $\bar{\tau}$ is the sample mean of the ad valorem tax rate.

To highlight the complexity of simultaneously modeling unit and ad valorem taxes, the case of perfect competition with linear demand and supply functions is extended to include both types of taxes. This results in the following expression for the consumer price at equilibrium:

$$p^D = a - by = (1+\tau)(c+dy) + t \tag{54}$$

Eliminating y and solving for p^D results in:

$$p^D = \frac{(1+\tau)(ad+bc)+bt}{b+d(1+\tau)} \tag{55}$$

Differentiating Equation 55 with respect to the unit tax and the ad valorem tax rate, respectively, results in:

$$\frac{\partial p^D}{\partial t} = \frac{b}{b+d(1+\tau)} \tag{56}$$

$$\frac{\partial p^D}{\partial \tau} = \frac{b(ad+bc-dt)}{[b+d(1+\tau)]^2} \tag{57}$$

These two expressions represent non-linear functions of τ (and t, in the case of Equation 57).

The existing literature offers several practical options for specifying the empirical model. One approach is to convert the ad valorem tax to a specific tax by multiplying the ad valorem rate and the producer price. This is the method adopted by Chouinard and Perloff (2004) in their study of incidence of federal and state gasoline taxes. This approach potentially introduces endogeneity, as price is entered on both the left-hand and right-hand sides of the model specification. In the case of gasoline taxes, ad valorem taxes are only present in some states, and are small relative to the specific taxes. In the case of U.S. ticket taxes, however, ad valorem taxes constitute approximately half of the total tax burden. Consequently, this approach is rejected for this study.

Delipalla and O'Donnell use a reduced form estimation, and emphasize that their choice is driven by "the specification which best fits the data subject to the statistics properties assumed by the estimator being satisfied" (Delipalla and O'Donnell, 2001, p. 898). They employ a linear specification (lin-lin) for some countries and a logarithmic specification (log-log) for others. In same cases, they also introduce quadratic terms (Delipalla and O'Donnell, 2001, p. 899). While this approach adds flexibility, it creates a level of detachment between their theoretical framework and the empirical estimation. It is also difficult to deduce a specific rationale for any one of their specifications, other than optimizing the fit to the data.

To summarize, there is a trade-off in the choice of specification between a semilog and a linear (or fully logarithmic) form. The semilog specification provides a direct estimate of the tax incidence of the ad valorem tax, but misspecifies the estimation of the incidence of the unit tax. Conversely, the linear specification directly estimates the tax incidence of the unit tax, but misspecifies the estimation of the incidence of the ad valorem tax. In order to estimate the tax incidence of the ad valorem tax under a linear specification, the coefficient from the estimation must be evaluated at the sample means of the price and ad valorem tax rate, through application of Equation 15, which is also part of the method chosen by Delipalla and O'Donnell (2001, pp. 899, 903)

Primary Model

The empirical analysis uses quarterly fare and tax data for all origin-destination airport pairs in the continental United States. To simplify the analysis, Alaska and Hawaii are excluded, since the tax rules treat these markets as hybrids of domestic and international flights (ATA, 2006e). The model is estimated both in the aggregate and for two pools of selected sub-markets, one pool of highly competitive markets and one pool of highly concentrated (i.e., dominated) markets.

The aggregate estimation uses the semilogarithmic specification:

$$\ln p_t^D = \beta_0 + \beta_1 \tau_t + \beta_2 \ln t_t + \beta_3 \ln ATACostIndex_t + \beta_4 LCCShare_t + \beta_5 \theta_t + \vec{\gamma}_t + \varepsilon_t \tag{58}$$

where the subscript t indicates the time period (i.e., quarter), p_t^D is passenger weighted average tax-inclusive fare, τ_t is the ad valorem tax rate applied to the producer price, and t_t is passenger weighted average of the sum of all unit taxes and fees. Two supply-side variables are included: $ATACostIndex_t$ is an airline cost index compiled by the ATA. $LCCShare_t$ is the share of total revenue passenger miles (RPM) generated by low-cost carriers (LCCs). Price response to the entry of LCCs is thought to have significantly altered the airline industry: "Probably the most significant development in the U.S. airline industry during the past decade has been the continued expansion of Southwest and the resurgence of low-fare entry generally" (Transportation Research Board, 1999, p. 49). Due to the severe limit on available degrees of freedom caused by the low number of observations, a single time trend variable θ_t is used in lieu of year fixed effects. Quarter fixed effects are denoted by $\vec{\gamma}_t$ and ε_t is a random error term.

There is no industry standard for which airlines are classified as low-cost carriers. Following the convention of other authors (e.g., Hansman, 2005; Ito and Lee, 2003) the following carriers are included: AirTran, America West, ATA, Frontier, JetBlue, Southwest, and ValuJet (merged with AirTran in 1997).

For the pools of sub-markets, the primary model is the semilogarithmic specification:

$$\ln p_{it}^D = \beta_0 + \beta_1 \tau_t + \beta_2 \ln t_{it} + \beta_3 \ln ATACostIndex_t + \beta_6 u_{it} + \vec{\gamma}_t + \vec{\omega}_t + \vec{\rho}_i + \varepsilon_{it} \tag{59}$$

where the subscript i represents a specific origin-destination route defined at the airport level. Variables not already defined above include the following: u_{it} is a route specific unemployment rate derived from underlying state labor force data, which serves to represent all exogenous demand-side influences attributed to the general state of the economy. Year fixed effects are denoted by $\vec{\omega}_t$ and route fixed effects are denoted by $\vec{\rho}_i$. Year fixed effects are used instead of a single time trend variable, since more degrees of freedom are available and they can potentially identify effects unique to a specific year.

Alternate models using fully logarithmic and linear specifications are used to evaluate robustness to functional form. All variables are defined in more detail in Table 4.1, which also identifies the data sources used. The column labeled "Identifier" shows how the variable in question is named in the statistical programs used for estimation, as well as in the corresponding output tables.

Table 4.1: Definitions of variables

Variable	Identifier	Description and source
p^D	P or TF	Total fare including all taxes. Source: Bureau of Transportation Statistics.
τ	FTTRate	Federal ticket tax rate. Source: Air Transport Association.
t	UnitTax	Sum of all unit taxes (i.e., FST+FSSF+PFC). Source: Air Transport Association (FST and FSSF), Federal Aviation Administration (PFC).
ATACostIndex	ATACostIndex	U.S. airline cost index. Source: Air Transport Association.
LCCShare	LCCShare	Low-cost carrier market share of revenue passenger miles. Source: Bureau of Transportation Statistics.
U	Unempr	Route specific unemployment rate, derived from underlying seasonally adjusted state employment data. Source: Bureau of Labor Statistics.
$\vec{\gamma}$	Q*n*	Quarter fixed effects (*n* represents the quarter in question, for example *n* = 2 for the second quarter [Q2]).
θ	Time	Time trend variable used in aggregate estimation (integer set to 1 through *n*, where *n* is the number of quarterly observations)
$\vec{\omega}$	Y*nnnn*	Year fixed effects used in estimation of sub-markets (*nnnn* represents the year in question, for example *nnnn* = 2005 for the year 2005 [Y2005]).
$\vec{\rho}$	*XXXZZZ*	Route fixed effects (*XXX* and *YYY* represent the three-letter airport identifiers for the airports which form the route, for example ATL for Atlanta and BOS for Boston [ATLBOS]).

Data

The main data source used for ticket specific information is a database prepared by the Bureau of Transportation Statistics (BTS) of the U.S. Department of Transportation (USDOT). This *Origin and Destination Survey* (DB1B) is related to the DB1A database referred to in Chapter III. DB1B contains "the full itinerary and the dollar amounts paid by each passenger…

summarized by routing and fare" for a "continuous 10% sample of airline tickets" (BTS, n.d., para. 7). Because DB1B aggregates sampled tickets with identical routings and fares, each record can correspond to more than one passenger. A data field in each record indicates the number of passengers for which the record applies.

DB1BMarket

DB1B consists of three sub-tables: DB1BCoupon, DB1BMarket, and DB1BTicket (BTS, 2006b). For this study, DB1BMarket is used, which "contains directional market characteristics of each domestic itinerary of the Origin and Destination Survey, such as the reporting carrier, origin and destination airport, prorated market fare, number of market coupons, market miles flown, and carrier change indicators" (BTS, 2006b).

Airlines report total fares for each sample ticket to the USDOT, whether one-way or round-trip. BTS then constructs DB1BMarket to consist of directional data, with round trip tickets represented by two records – one for each direction. As a result, all fare information in this study is presented on a "one-way" basis and there is no means of distinguishing between data from round-trip vs. one-way tickets. Approximate round-trip prices can be obtained by doubling listed fare values. Also, for the purpose of this study, both directions of any one market have been combined. For example, data for flights from Atlanta to Boston have been combined with flights from Boston to Atlanta. Market identifiers (e.g., "ATLBOS") are created by concatenating the three-letter airport identifiers for the two airports forming the market (in alphabetical order).

The DB1B database does not indicate the amount of ticket taxes and fees collected from passengers. These have to be retroactively computed based on the itinerary and total fare. This is done through a simple process. The individual steps are shown below, using tax rates and levels for 2006 as an example:

1. $FST = \$3.30\,n$, where n is the number of segments (i.e., $n = 1$ indicates a non-stop flight)
2. $FSSF = \$2.50\min(n, 2)$ (Note: the federal security fee is only collected for the first two segments in each direction of travel)

3. Look up PFC_1, the passenger facility charge for the origin airport (if a PFC is collected at that airport)

4. Look up PFC_2, the passenger facility charge for the first connecting airport (if a connection exists and a PFC is collected at that airport)

5. $PFC = PFC_1 + PFC_2$ (Note: PFCs are only collected for the first two airports in each direction of travel)

6. $UnitTax = FST + PFC + FSSF$

7. $FTT = FTTRate\left(\frac{TF - UnitTax}{1 + FTTRate}\right)$, where $FTTRate = 0.075$

The base fare is also computed, by subtracting the total taxes and fees from the total fare. Route and national averages are weighted by the number of passengers. Additional statistics are also derived, such as the average track distance and number of connections, although this data is not entered into the empirical estimation.

This method of retroactively computing individual taxes and fees has been validated against 60 sample tickets representing typical business and recreational itineraries retrieved from two major online travel providers (Karlsson, Odoni, and Yamanaka, 2004, p. 288). Online travel providers were used, as they identify base fare, taxes, fees, and total fare for any requested itinerary.

While DB1B is quarterly database, changes in tax rates and levels often do not coincide with the beginning or end of a quarter. In these cases, the tax variable for that time period is prorated. For example, if an airport collects a PFC of $3 for the first third of a quarter, and $4.50 for the last two-thirds, a PFC value of $4 is used. Similarly, if the ad valorem rate drops from 10% to 0% in the middle of a quarter, a value of 5% is used for the entire quarter. One benefit of using quarterly averages is that this attenuates any discrepancies between the amount of tax collected on the day of sale and that in effect on the day of travel, which can occur several months later.

PFC collection levels and their start and end dates are published by the FAA (2006) on a monthly basis. Changes in PFC collections can be relatively frequent. As an extreme example, Reno-Tahoe International Airport had seven changes in PFC collection during the 1994-2005 period. As part of this study, a PFC lookup tool was developed based on the FAA data, which allows the PFC for any airport to be determined for any quarter in the period 1992Q1-2006Q4.

One weakness of the DB1B data is that the intermediate airport on one-stop continuing itineraries is not recorded. A one-stop continuing itinerary occurs when a passenger lands at an intermediate airport and subsequently departs on the same aircraft, usually with the same flight number. This differs from a connecting flight, where the passenger changes aircraft and flight numbers usually change. For example, if a passenger travels from Boston to Los Angeles via Chicago without changing aircraft, the Chicago stopover does not show up in DB1B. Thus, one-stop continuing flights look identical to nonstop flights in the data set. Neither a federal security service fee, nor a passenger facility charge is collected at the intermediate airport, since the passenger is not considered to constitute an enplanement. The segment tax, however, is collected for all segments of the flight, This is not captured by the tax computation process used for this study. Any discrepancies resulting from this flaw in the data should be quite small, in most cases just the amount of the segment tax (approximately $3).

This study also does not attempt to identify rural airports which are excluded from the collection of federal segment taxes. Flights to and from rural airports account for only 0.17% of all passengers (Karlsson, Odoni, and Yamanaka, 2004, p. 288).

In the precursor research to this study, a series of fare rules were applied to filter out records which were thought to have excessively low or high fares (Karlsson, Odoni, and Yamanaka, 2004, p. 289). The fare rules were a slightly modified version of rules developed by the USDOT Office of the Assistant Secretary for Aviation and International Affairs. This office is a major user of the DB1A and DB1B origin-destination surveys. A post-estimation sensitivity analysis revealed that these fare rules had very little impact on the results. For example, depending on the set of filters applied, the average ETR for 2002Q2 varied by only −0.1 to 0.8 percentage points from the result with all filters applied (Karlsson, Odoni, and Yamanaka, 2004, p. 291).

Given the lack of sensitivity of the ETR calculations to the application of fare filters, this study uses a simplified set of filters, as they are computationally intensive,. The filters applied in this study remove the following records:

1. Records with travel outside the continental U.S.
2. Records with zero passengers
3. Records with zero total fare (e.g., frequent flyer awards)
4. Records marked as “bulk fare”
5. Records with non-positive base fare
6. Records with base fares greater than or equal to $2,500

After taxes are subtracted from the total fare, it is possible for base fares to be negative. It is assumed that these are data errors, and these records are rejected. These filters assume an upper threshold for base fares set at $2,500. This is consistent with the upper limit used in earlier work on ticket taxes (Karlsson, Odoni, and Yamanaka, 2004, p. 289).

Even after application of the filters, the data sets are very large. The number of records, before and after filtering, is shown in Tables 4.2 and 4.3. The designation “Filter 1” refers to steps 1 through 4 from the above list, whereas “Filter 2” refers to the last two steps. The majority of rejected records are result of the first collection of filters, although this balance shifted somewhat towards the end of the time series. As can be seen, the number of records in the database has increased over time, commensurate with increased demand for air travel. Overall, 148.6 million records were processed, with 130.7 million remaining after filtering.

Not all time periods shown in Tables 4.2 and 4.3 are used for the regression analysis. In particular, no data from 2001 is used, in order to avoid the volatile period following the events of September 11, 2001. Also, the last quarter in 2005 is excluded, since the ATA cost index and the data used to compute the LCC market share had not been released for that time period when the analysis was conducted.

This analysis resulted in the creation of an extensive time series of passenger weighted averages for total fare, base fare, ticket taxes and fees, effective tax rate, track distance, and number of segments per ticket. No data set of this nature has been developed previously and it is likely to have applications beyond this study. Summaries of this data are presented in Tables 4.4 and 4.5, expressed on an annual basis for the periods 1994-1997 and 2001-2005, respectively.

Table 4.2: Filter statistics (1994Q1-1997Q4)

	Number of Records				
Quarter	Before filtering	After Filter 1	Ratio	After Filter 2	Ratio
1994Q1	2,876,398	2,516,047	87.5%	2,505,275	87.1%
1994Q2	3,133,457	2,756,584	88.0%	2,743,500	87.6%
1994Q3	3,214,432	2,820,564	87.7%	2,799,671	87.1%
1994Q4	3,321,120	2,942,321	88.6%	2,929,694	88.2%
1995Q1	3,143,892	2,791,847	88.8%	2,781,358	88.5%
1995Q2	3,405,076	3,009,020	88.4%	2,999,807	88.1%
1995Q3	3,411,652	2,985,809	87.5%	2,972,944	87.1%
1995Q4	3,638,244	3,189,154	87.7%	3,173,603	87.2%
1996Q1	3,656,776	3,249,352	88.9%	3,236,266	88.5%
1996Q2	3,660,591	3,193,258	87.2%	3,180,661	86.9%
1996Q3	3,581,307	3,131,776	87.4%	3,122,364	87.2%
1996Q4	3,726,559	3,307,457	88.8%	3,297,690	88.5%
1997Q1	3,466,382	3,077,375	88.8%	3,068,521	88.5%
1997Q2	3,876,904	3,467,389	89.4%	3,454,739	89.1%
1997Q3	3,871,629	3,448,596	89.1%	3,436,464	88.8%
1997Q4	3,809,567	3,414,692	89.6%	3,399,344	89.2%
Total	55,793,986	49,301,241	88.4%	49,101,901	88.0%

Table 4.3: Filter statistics (2001Q1-2005Q4)

	Number of Records				
Quarter	Before filtering	After Filter 1	Ratio	After Filter 2	Ratio
2001Q1	4,225,419	3,762,903	89.1%	3,749,960	88.7%
2001Q2	4,864,353	4,325,967	88.9%	4,310,419	88.6%
2001Q3	4,386,059	3,878,601	88.4%	3,865,421	88.1%
2001Q4	4,299,606	3,836,241	89.2%	3,824,962	89.0%
2002Q1	4,257,426	3,836,055	90.1%	3,752,368	88.1%
2002Q2	4,670,648	4,270,203	91.4%	4,069,497	87.1%
2002Q3	4,521,610	4,143,192	91.6%	3,940,904	87.2%
2002Q4	4,457,483	4,114,750	92.3%	3,932,895	88.2%
2003Q1	3,968,611	3,635,534	91.6%	3,480,872	87.7%
2003Q2	4,690,418	4,262,522	90.9%	4,090,994	87.2%
2003Q3	4,403,147	3,863,451	87.7%	3,804,442	86.4%
2003Q4	4,800,205	4,390,597	91.5%	4,231,072	88.1%
2004Q1	4,243,960	3,895,564	91.8%	3,722,115	87.7%
2004Q2	4,950,846	4,544,769	91.8%	4,337,792	87.6%
2004Q3	4,667,842	4,270,082	91.5%	4,048,262	86.7%
2004Q4	5,032,710	4,664,109	92.7%	4,449,083	88.4%
2005Q1	4,664,067	4,304,220	92.3%	4,122,703	88.4%
2005Q2	5,330,050	4,922,769	92.4%	4,706,419	88.3%
2005Q3	5,198,582	4,790,959	92.2%	4,567,381	87.9%
2005Q4	5,131,322	4,759,190	92.7%	4,554,981	88.8%
Total	92,764,364	84,471,678	91.1%	81,562,542	87.9%

Table 4.4: Annual summary of ticket records

Year	Records	Passengers per record	Passengers	Track miles	Coupons
1994	10,978,140	2.6	28,129,335	956	1.40
1995	11,927,712	2.4	28,883,862	960	1.39
1996	12,836,981	2.4	31,443,270	972	1.38
1997	13,359,068	2.5	33,485,858	987	1.38
2001	15,750,762	2.2	35,186,269	1,038	1.38
2002	15,695,664	2.1	33,460,132	1,062	1.39
2003	15,607,380	2.2	34,164,984	1,081	1.39
2004	16,557,252	2.3	37,348,201	1,094	1.36
2005	17,951,484	2.2	39,707,597	1,086	1.35

Table 4.5: Annual averages of fares and taxes

Year	BF	FTT	PFC	FSSF	FST	TTF	TF	ETR
1994	$145.87	$14.59	$2.54	$0.00	$0.00	$17.12	$163.00	11.7%
1995	$149.30	$14.93	$2.86	$0.00	$0.00	$17.79	$167.08	11.9%
1996	$151.09	$5.16	$2.79	$0.00	$0.00	$7.95	$159.04	5.3%
1997	$152.76	$12.30	$3.11	$0.00	$0.35	$15.76	$168.52	10.3%
2001	$153.11	$11.48	$3.90	$0.00	$3.80	$19.18	$172.30	12.5%
2002	$144.90	$10.87	$4.60	$3.15	$4.17	$22.79	$167.69	15.7%
2003	$147.07	$11.03	$4.87	$2.24	$4.16	$22.30	$169.37	15.2%
2004	$141.04	$10.58	$4.97	$3.35	$4.23	$23.12	$164.17	16.4%
2005	$143.56	$10.77	$5.10	$3.32	$4.32	$23.51	$167.07	16.4%

The data indicates steady growth in the total number of passenger in the sample. The annualized growth rate from 1994 to 2005 levels is 3.2%. This growth primarily reflects increasing air travel, but some of it may be due to changes in data reporting requirements or improvements in data quality. There has also been a very gradual growth in track miles per ticket (i.e., the actual distance flown over the surface of the Earth). This may reflect a reduction in short-haul flights since September 11, 2001. Finally, the average number of coupons has declined slightly, indicating that there has been a minor reduction in the share of passengers who connect.

A striking result of this analysis is that base fares have remained relatively constant, even as flight distances have grown. In real terms, base fares have declined approximately 25%. Taxes have increased in nominal terms, but have remained virtually constant when adjusted for inflation (Yamanaka, Karlsson, and Odoni, 2005, p. 5). Consequently, the effective tax rate has increased by almost five percentage points in the time period covered here.

The ETR values reported in Table 4.5 are comparable to those derived in earlier work (see Table 2.1). For example, Table 4.5 shows that the yearly ETR for 1994 is 11.7%, compared to the 1993Q2 value of 10.9% shown in Table 2.1. The yearly ETR for 2004 shown in Table 4.5 is estimated at 16.4%, compared to the 20004Q2 value of 16.5% in Table 2.1. This provides evidence that the methodology used here produces results comparable to previously published data, even though the underlying databases and techniques vary slightly.

The approach used here represents an improvement over earlier methods in several ways. The previous analyses are limited to flights with no more than one connection in any direction and exclude open jaw itineraries, as well as any market with fewer than ten passengers. Also, the DB1B data used here is publicly available in an electronic, online format, unlike the DB1A database used in the earlier research.

Other Data Sources

Historical federal ticket tax rates and levels of the segment tax and federal security fee are obtained from ATA (2005, 2006e). PFC values are obtained from the FAA (2006). The Airline Cost Index is prepared by the ATA (2006d). The cost index reflects major airline cost categories, notably labor and fuel. It excludes taxes, as these are handled off-budget, but does include landing fees and other payments to government entities, such as leases for terminal space. The largest cost categories are summarized in Table 4.6.

Table 4.6: Major categories of ATA cost index

Category	Share
Labor	24.7%
Fuel	24.1%
Aircraft ownership costs	7.7%
Non-aircraft ownership costs	4.4%
Professional services	8.0%
Subtotal	68.9%
All other categories	31.1%

Note: Based on 2005Q3 data

The index is based on nominal costs and normalized to a value of 100 for the year 1982. In 1992 the index value was 155.8, increasing to 183.5 by 2004 (ATA, 2006d).

The LCC market share is computed using carrier specific revenue passenger mile data. The market share is derived using so-called Schedule T2 data collected from USDOT Form 41 carrier filings. While the Form 41 data is monthly, T2 consists of quarterly summaries of some of the Form 41 elements, including total revenue passenger miles for all service classes (BTS, 2006a). The use of LCC share of revenue passenger miles as a measure of market share is consistent with work by other authors (e.g., Ito and Lee, 2004, p. 17).

Seasonally adjusted state unemployment data is used as an overall control for exogenous factors related to overall economic conditions. A market unemployment rate is computed for each market, based on state data corresponding to the geographic location of the two airports that define the market (denoted here by the subscripts 1 and 2):

$$u_{12} = \frac{U_1 + U_2}{L_1 + L_2} \qquad (60)$$

where U is total unemployment and L is the size of the labor force. This method of computing a market based unemployment places more weight on larger population areas. This provides some control for the relative size of economic activity at the market start and end locations, but only at the state level. Publicly available data from the Bureau Labor of Statistics is used for the computations (BLS, 2006).

The use of state level employment data is a somewhat coarse tool. It does not adequately handle airports which are located near state borders, and which have large impacts on neighboring states (e.g., Newark International Airport). Ideally, the geographic unit should be the airport’s market catchment area, roughly defined as a driving distance of one to two hours from the airport. However, while state level data is imperfect, it is readily available and computationally efficient. An alternate approach would be to use locally defined data, such as unemployment information for Metropolitan Statistical Areas. This might more closely capture the economic conditions within the market capture area of each airport.

Measuring Market Concentration

In order to study the price impact of route specific competition, a market concentration variable such as the Herfindahl-Hirschman Index (HHI) should ideally be used. HHI is defined as:

$$HHI_i = \sum_{j=1}^{n} \sigma_{ij}^2 \qquad (61)$$

where σ_{ij} is the individual share of carrier j in market i, which is served by n carriers. For a market dominated by a single carrier, $HHI_i = 1$, which is the upper bound on the index. An intuitive interpretation of HHI_i is that its inverse is a measure of the effective number of competitors in the market (Morrison and Winston, 1995, p. 8).

The drawback of using HHI in this study is that it is very computationally intensive given the large number of observations. Unfortunately, market specific HHI data is not available through other sources for the time periods in question. Consequently, the approach taken here is to pool the data into two subsets of twenty markets. One pool consists of highly competitive markets (i.e., markets with many carriers with significant market shares), whereas the other pool consists of highly concentrated markets (i.e., markets dominated by a single carrier).

Markets are assigned to the pools using an approximate measure of concentration. This measure is based on statistics available in the quarterly *Consumer Air Fare Report*, published by the USDOT Office of the Assistant Secretary for Aviation and International Affairs (2006). This report includes average fares for each market, as well as the average fare and market share for the carriers with the largest market share and lowest fare, respectively.

Using the limited market share data available, upper and lower bounds for HHI_i are computed using the following expressions (the route subscript is dropped for clarity):

$$HHI_{\max} = \sigma_L^2 + \sigma_{LF}^2 + \max(0, \tilde{n} - 3)\tilde{\sigma}_3^2 + \sigma_{\tilde{n}}^2 \qquad (62)$$

$$HHI_{\min} = \sigma_L^2 + \sigma_{LF}^2 \qquad (63)$$

where σ_L is the market share of the largest carrier and σ_{LF} is the market share of the low fare carrier. If the dominant and low fare carriers are one and the same, then σ_{LF} is set to zero.

The term $\tilde{\sigma}_3$ is an approximation of market shares number 3 through $\tilde{n}-1$. The computation of $\tilde{\sigma}_3$ makes use of the knowledge that σ_L is an upper bound for the market share of any other carrier:

$$\tilde{\sigma}_3 = \min(\sigma_L, 1-\sigma_L-\sigma_{LF}) \quad (64)$$

Finally, the remaining market share σ_n is computed as:

$$\sigma_n = \min(\tilde{\sigma}_3, 1-\sigma_L-\sigma_{LF}-\tilde{\sigma}_3 \max(0,\tilde{n}-3)) \quad (65)$$

The true number of carriers in the market is not known. The parameter $\tilde{n}$ is a counter which indicates the number of market shares tracked by this algorithm. Note that two of these market shares may have a zero value, namely σ_{LF} and σ_n. The counter $\tilde{n}$ is given by:

$$\tilde{n} = 3 + \left\lfloor \frac{1-\sigma_L-\sigma_{LF}}{\tilde{\sigma}_3} \right\rfloor \quad (66)$$

where $\lfloor\ \rfloor$ represents the floor operator. Note that if $\tilde{\sigma}_3 = 0$, $\tilde{n}$ is set to three.

The algorithm for estimating $HHI_{\max}$ is best illustrated by an example. Consider the market Columbus-San Francisco in 1997Q2. The dominant carrier was Delta, with a market share of 20.1%. The low fare carrier was Northwest, with a market share of 17.9%. The combined market share of these two carriers is given by $\sigma_L + \sigma_{LF} = 38\%$. The remainder of the market allocated to other carriers is given by $1-\sigma_L-\sigma_{LF} = 62\%$.

The next market shares are represented by $\tilde{\sigma}_3$. By definition, these can be no more than Delta's market share of 20.1%. Another limitation, stated by Equation 64, is that $\tilde{\sigma}_3$ can be no more than the balance of the market share after the dominant and low fare carriers have been accounted for. Since Delta's market share of 20.1% is less than the balance of 62%, it follows from Equation 64 that $\tilde{\sigma}_3 = 20.1\%$. Next, $\tilde{n}$ is determined by Equation 66. Dividing $\tilde{\sigma}_3$ into 62% and rounding down to the nearest integer, reveals that the balance of 62% allows for three additional carrier shares at the 20.1% level. The total number of market shares tracked by this algorithm is given by $\tilde{n} = 6$ (i.e., the market share of the dominant carrier, the market share of the low fare carrier, three market shares at $\tilde{\sigma}_3 = 20.1\%$, and σ_n). The final market share, σ_n is computed according to Equation 65 as $\sigma_n = 62\% - 3 \times 20.1\% = 1.7\%$. As a check, the total market share can be derived by simple addition: $20.1\% + 17.9\% + 3 \times 20.1\% + 1.7\% = 100\%$. The upper bound in this example is $HHI_{\max} = 0.201^2 + 0.179^2 + 3 \times 0.201^2 + 0.017^2 = 0.194$. In comparison, the lower bound is $HHI_{\min} = 0.201^2 + 0.179^2 = 0.072$. Consequently, this market would be classified as competitive for the purpose of this study.

The 1997Q2 *Consumer Air Fare Report* contains the earliest available data on the market share of the largest and the low fare carrier, respectively. It is used to define the pools of markets studied for the 1994-1997 time period. The 2003Q3 report is used to define the pools of markets studied for the 2002-2005 period. An underlying assumption is that market concentration does not change dramatically over the course of these four-year periods. The competitive and concentrated pools are selected from markets with at least 250 daily passengers (755 airport pairs met this threshold in the 1997Q2 report, and 789 in the 2003Q3 report). For the 1994-1997 period, the average lower and upper bounds of the HHI estimates are 0.442 and 0.523, respectively, with an average spread of 0.081. For the 2002-2005 period, the average lower and upper bounds are 0.420 and 0.511, respectively, and the average spread between the bounds is 0.091.

The competitive pool of markets is selected by taking 20 random markets from the subset of all markets with $HHI_{\max} \leq 0.3$. This threshold is met in 53 markets in the 1997Q2 report and 81 in the 2003Q3 report. The concentrated pool of markets is selected using $HHI_{\min} \geq 0.8$. This threshold is met in 58 markets in the 1997Q2 report and 86 in the 2003Q3 report. Markets containing airports with close substitutes are removed from the candidate list of concentrated markets. For example, the Oakland-Reno market appears as a market dominated by a single carrier, with $HHI_{\min} = 1$, but is in fact a competitor to the San Francisco-Reno and San Jose-

Reno markets. No algorithm was readily available to review the markets for close substitutes. This was completed by inspection, using maps and FAA airport master records.

Table 4.7 shows the resulting pools of competitive and concentrated markets selected from the 1997Q2 *Consumer Air Fare Report* using the method described above. Table 4.8 shows the competitive and concentrated pools selected from the 2003Q3 report. The make-up of the pools are airport specific. For example, New York may be represented either by LaGuardia Airport (LGA), John F. Kennedy International Airport (JFK), or Newark Liberty International Airport (EWR), depending on the concentration measures for each airport market.

Table 4.7: Markets selected from the 1997Q2 *Consumer Air Fare Report*

ID	Competitive markets	ID	Concentrated markets
ABQSEA	Albuquerque-Seattle	ATLBNA	Atlanta-Nashville
BDLSFO	Hartford-San Francisco	ATLCVG	Atlanta-Cincinnati
BOSMSY	Boston-New Orleans	ATLDAY	Atlanta-Dayton
BOSSAN	Boston-San Diego	ATLRIC	Atlanta-Richmond
BWISAN	Baltimore-San Diego	AUSELP	Austin-El Paso
CLEORD	Cleveland-Chicago	AUSLBB	Austin-Lubbock
CMHTPA	Columbus-Tampa	BDLPHL	Hartford-Philadelphia
COSIAD	Colorado Springs-Washington, DC	BHMMSY	Birmingham-New Orleans
EWRSEA	New York-Seattle	BOSPHL	Boston-Philadelphia
FLLLAX	Ft. Lauderdale-Los Angeles	BOSPIT	Boston-Pittsburgh
FLLLGA	Ft. Lauderdale-New York	BOSROC	Boston-Rochester
LASORD	Las Vegas-Chicago	CLTPHL	Charlotte-Philadelphia
LAXMCI	Los Angeles-Kansas City	DCAPVD	Washington, DC-Providence
LAXMKE	Los Angeles-Milwaukee	DTWMKE	Detroit-Milwaukee
LAXMSY	Los Angeles-New Orleans	DTWMSP	Detroit-Minneapolis/St. Paul
LGAPBI	New York-West Palm Beach	INDPHL	Indianapolis-Philadelphia
MCOSEA	Orlando-Seattle	MCIOKC	Kansas City-Oklahoma City
MCOSFO	Orlando-San Francisco	MKEMSP	Milwaukee-Minneapolis/St. Paul
ORDPHX	Chicago-Phoenix	PHLPIT	Philadelphia-Pittsburgh
PHXSEA	Phoenix-Seattle	SANSMF	San Diego-Sacramento

Competitive markets generally consist of long distance markets, with an average distance of approximately 1,600 miles. The concentrated markets are mostly short haul markets, with an average distance of approximately 400 miles. The concentrated markets also include a relatively high number of intra-state routes, such as Austin-El Paso and Philadelphia-Pittsburgh. Several cities appear multiple times in each pool, such as Ft. Lauderdale, Los Angeles, and New York in the competitive markets, and Atlanta, Austin, and El Paso in the concentrated markets. A bit more unusual is that some cities, such as Boston and San Diego appear repeatedly in both pools. This emphasizes that to a large extent, the level of concentration is route specific, and not predicated by a specific airport, at least in the case of large airports.

Table 4.8: Markets selected from the 2003Q3 *Consumer Air Fare Report*

ID	Competitive markets	ID	Concentrated markets
BDLLAS	Hartford-Las Vegas	ABQLAS	Albuquerque-Las Vegas
BOSLAX	Boston-Los Angeles	ATLCVG	Atlanta-Cincinnati
BOSPHX	Boston-Phoenix	ATLRIC	Atlanta-Richmond
DENMCO	Denver-Orlando	BHMMSY	Birmingham-New Orleans
DFWSLC	Dallas/Ft. Worth-Salt Lake City	BNAMSY	Nashville-New Orleans
EWRLAX	New York-Los Angeles	BNARDU	Nashville-Raleigh/Durham
EWRORD	New York-Chicago	BOSPIT	Boston-Pittsburgh
FLLMCI	Ft. Lauderdale-Kansas City	BOSRSW	Boston-Ft. Myers
INDSEA	Indianapolis-Seattle	DFWSTL	Dallas/Ft. Worth-St. Louis
JAXMDW	Jacksonville-Chicago	ELPPHX	El Paso-Phoenix
JFKTPA	New York-Tampa	ELPSAT	El Paso-San Antonio
LAXMCO	Los Angeles-Orlando	LASRNO	Las Vegas-Reno
LAXPVD	Los Angeles-Providence	MCIMSP	Kansas City-Minneapolis/St. Paul
LGAMSY	New Orleans-New York	MCIOKC	Kansas City-Oklahoma City
LGARDU	New York-Raleigh/Durham	MSYTPA	New Orleans-Tampa
MCIPDX	Kansas City-Portland, OR	PDXRNO	Portland, OR-Reno
MCISEA	Kansas City-Seattle	PDXSEA	Portland, OR-Seattle
MKESFO	Milwaukee-San Francisco	PHLPIT	Philadelphia-Pittsburgh
ORDTPA	Chicago-Tampa	SANSMF	San Diego-Sacramento
PVDSAN	Providence-San Diego	SANTUS	San Diego-Tucson

Data Quality

In 1998, the USDOT Office of the Inspector General (OIG) issued an audit report for the passenger origin-destination survey which is the main source of data for this study. The audit found that over two-thirds of markets did not meet the 95% accuracy criterion set by USDOT officials (OIG, 1998, p. iii). In terms of passengers, the results are better, in that “only” 38% of all passengers failed to meet the accuracy standard. This seems to suggest that high density markets have more accurate reporting. The audit also concluded that there were systematic differences in reporting quality across carriers. However, the carriers were not individually identified by the OIG. There also seemed to be systematic errors for specific airports. For example, Dulles was cited as being particularly inaccurate (OIG, 1998, p. 9).

The identified causes for these problems were numerous, including inability to accurately report code sharing (this seems to have been rectified with a subsequent rule change that requires reporting both the "ticketing carrier" and "operating carrier"), invalid airport codes (e.g., "NEW" for "Newark"), incorrect reporting of bulk air fares (four carriers were found to have used 999 instead of 99999, which led to a fare entry of $999 instead of marking the fare as a bulk fare), improper data processing (two carriers simply deleted data when a problem was found, such as an invalid airport code), outdated fare caps, outdated data collection procedures, and general non-compliance with BTS regulations. Of particular interest to this study, the audit reported that some air carriers “incorrectly submitted fares net of taxes” (OIG, 1998, p. vi). The report also found that as an oversight agency, the BTS was not effective in monitoring the quality of the data.

There is evidence that the data quality has improved since the OIG audit. After contacting the BTS to try to assess the current quality of the data, the Assistant Director of the Office of Airline Information made the following statement: “I believe the data quality of the Passenger O-D Survey is good, based upon a recent evaluation from our Office of Statistical Quality” (D. Bright, personal communication, 2003, October 2). Consequently, it is likely that data problems are more of a concern for the 1994-1997 analysis than for the one covering 2002-2005.

Despite these concerns, there is little choice than to rely on the passenger origin-destination survey for this study. There simply is no equivalent data set and it clearly has become the industry standard for ticket level studies. Many of the data errors are likely to be random, and should not significantly alter the results. However, some of the data quality problems introduce systematic biases which cannot be detected. At a minimum, some caution must be exercised in interpreting the results of any study relying on the DB1B data set.

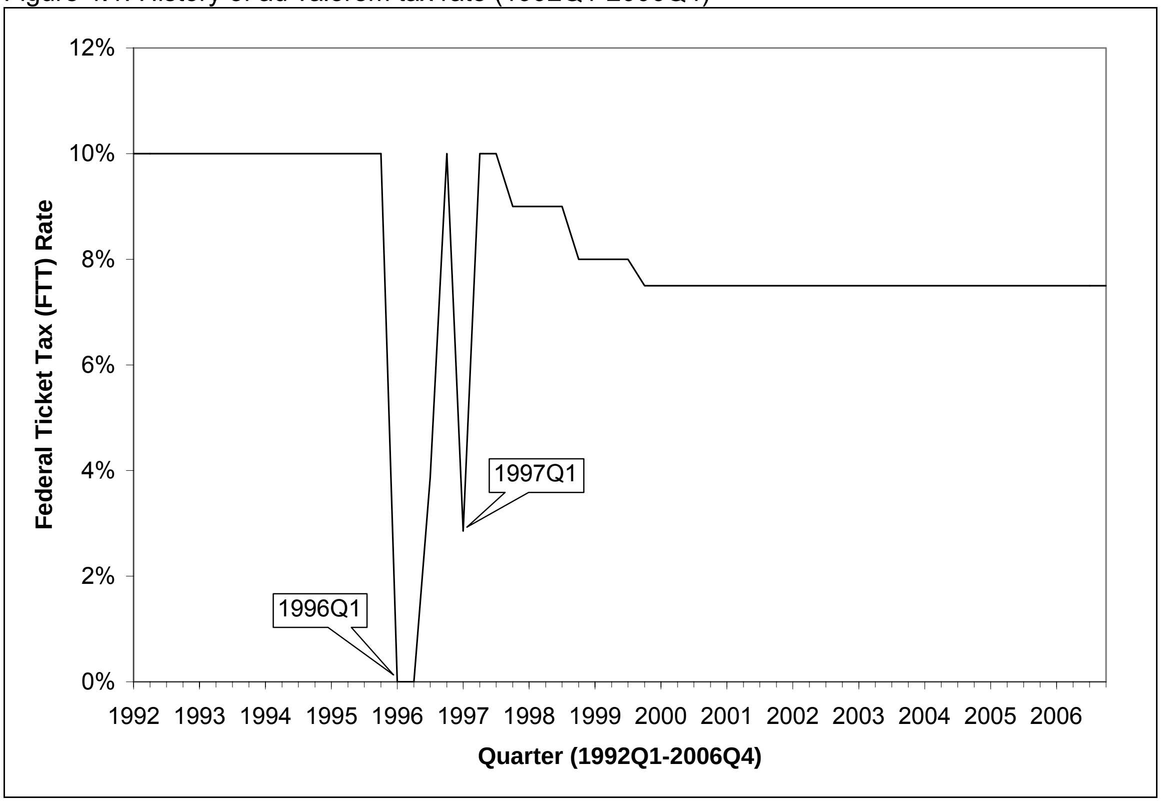
Variation in Taxes

In the absence of a natural experiment, this study relies on variations in tax rates and levels over time. As shown in Table 1.1, there has been a gradual reduction in the ad valorem rate since 1992. Also, PFC levels have gradually been increasing over time. The same is true for the segment tax, which is inflation adjusted annually to the nearest $0.10. However, these variations are relatively small in amplitude and heavily time trended.

There are two episodes since the 1990s which have produced shock-like variations. The first episode consists of two periods during 1996-1997 when the federal authority to collect ticket taxes lapsed. The specific dates for the periods in question are January 1-August 26, 1996 and

January 1-March 6, 1997 (ATA, 2006a). This lapse in tax collection authority explains the sharp drop in ETR from 11.9% in 1995 to 5.3% in 1996, which is shown in Table 4.5. Figure 4.1 graphically represents the history of the federal ticket tax, and clearly shows this lapse of tax collection authority. The second episode occurred during the period June 1-September 30, 2003, when Congress suspended the federal security service fee. The goal of this tax holiday was to provide financial relief to the airline industry during the war with Iraq (Emergency Wartime Supplemental Appropriations Act, 2003). This episode is shown graphically in Figure 4.2.

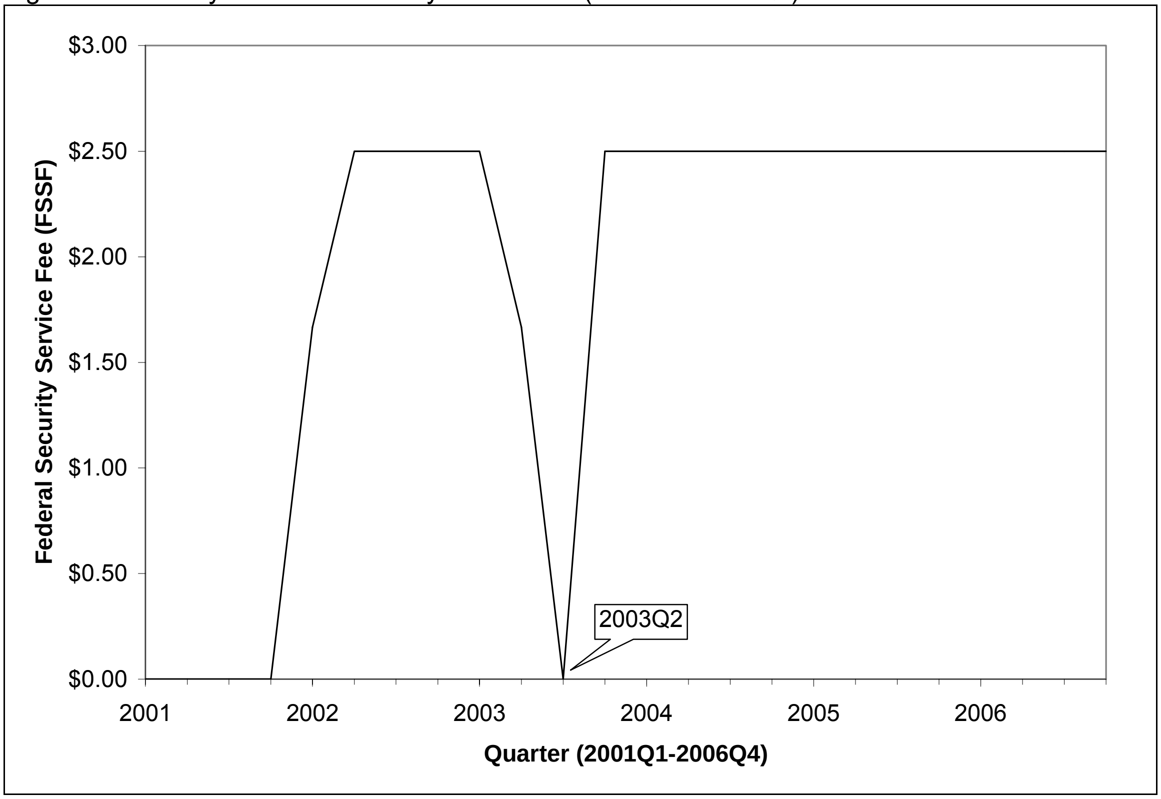
Figure 4.1: History of ad valorem tax rate (1992Q1-2006Q4)



Note: Tax rate prorated when changes do not coincide with beginning or end of quarter

The timing of these episodes determined the time periods selected for analysis in this study. The intent is to include two years of observations prior to the tax shock, followed by one year after the shock. For the first episode, which began in 1996Q1 and ended approximately midway through 1996Q3, the period 1994Q1-1997Q4 is selected, for a total of 16 quarters. However, it should be noted that a second expiration of tax collection authority took place in 1997Q1.

Figure 4.2: History of federal security service fee (2001Q1-2006Q4)



Note: Tax level prorated when changes do not coincide with beginning or end of quarter

The second episode began partway through 2003Q2 and ended at the close of 2003Q3. Using similar reasoning as applied to the first episode, the preferred period selected for analysis would be 2001Q1 through 2004Q4. However, in order to avoid the shock to the industry caused by the events of September 11, 2001, the period 2002Q1 through 2005Q3 is selected instead, for a total of 15 quarters (some 2005Q4 data was not available at the time of analysis).

It is of some importance to try to determine the degree to which these shocks were anticipated, and also whether they were thought to be temporary or not. Anticipated and/or permanent lapses of taxes are likely to affect the economic decisions of airlines and passengers in ways different than unanticipated, temporary lapses. One example would be that some travelers might postpone travel to wait for the start of an anticipated tax holiday.

The first shock appears to have taken the industry by surprise: The lapse in federal tax collection authority was caused by protracted congressional negotiations over the future shape of the federal ticket tax structure. While it should have been clear to all parties that negotiations were in progress, there is no evidence showing widespread belief that Congress would let the authority to collect taxes expire. One indication of this is that the General Accounting Office (GAO; since July 7, 2004 called the Government Accountability Office) seems to have been operating in a reactive mode: Its first report addressing the impact of the lapse was released in April of 1996, near the middle of the episode (GAO, 1996a). The temporary nature of this episode should have been evident, due to the importance of the federal taxes in funding the FAA and the U.S. air transportation infrastructure. This is emphasized by the two GAO reports on the topic (1996a, 1996b).

The 2003 security tax holiday was to some extent anticipated, as it was a planned relief effort for the airline industry (Emergency Wartime Supplemental Appropriations Act, 2003). It is likely to at least in part have come about due to lobbying by the industry. It is possible that the advance knowledge of this tax holiday led to a more gradual price response, which may result in a time-shifted response in tax incidence. However, any plans to institute price changes prior to the effective date of the holiday may have been tempered by federal antitrust oversight. On the demand side, it is less likely that the typical airline passenger would have been aware of the tax holiday. The 2003 episode was crafted from the beginning as temporary tax holiday and should not have been anticipated by any party to have been permanent.

The temporary nature of both episodes may have impacts on the price response. This could limit the ability to translate the empirical estimates developed here into more generalized conclusions. It is difficult to determine the direction of any possible bias, however. On one hand airlines could have attempted to recoup the tax savings in the form of increased revenue. Conversely, the tax breaks could have resulted in increased price competition in some markets. The transaction costs of republishing fares may also have been a factor. The temporary nature of the tax shocks also raises political or strategic considerations not captured in the models used here. For example, congressional scrutiny may encourage airlines to pass along any tax savings to consumers. Conversely, airlines may retain the entire tax savings to signal their precarious financial situation. Fare wars triggered by tax changes is another possible outcome.

The 2003 security tax holiday differs from the 1996 and 1997 lapses in tax collection authority in that the former features no variation in the ad valorem tax rate. Consequently, τ is excluded from the model specifications for the period 2002Q1-2005Q3, in order to avoid perfect multicollinearity. A linear specification is used as the primary specification, as this provides a direct estimation of the tax incidence of the unit tax. In the aggregate case, the following linear specification is used instead of Equation 58:

$$p_t^D = \beta_0 + \beta_2 t_t + \beta_3 ATACostIndex_t + \beta_4 LCCShare_t + \beta_5 \theta_t + \vec{\gamma}_t + \varepsilon_t \tag{67}$$

For the competitive and concentrated pools, a linear specification replaces Equation 59:

$$p_{it}^D = \beta_0 + \beta_2 t_{it} + \beta_3 ATACostIndex_t + \beta_6 u_{it} + \vec{\gamma}_t + \vec{\omega}_t + \vec{\rho}_i + \varepsilon_{it} \tag{68}$$

In the linear specifications without the ad valorem tax, β_2 is straightforwardly interpreted as the incidence of the total unit tax. An alternate logarithmic (log-log) specification is used to test for robustness to functional form. In a fully logarithmic specification, the coefficient represents the price elasticity with respect to the unit tax. In order to generate an estimate of the tax incidence of the unit tax, the point elasticity must be evaluated at the sample means of the tax inclusive price and the total unit tax.

Hypotheses

While there does not appear to be any previously published econometric analysis of ticket tax incidence, a GAO report summarizing the impact of commercial aviation taxes and fees briefly addressed the issue. The report found that (GAO, 2004, p. 4):

> During the 1996 ticket tax lapse and 2003 security fee holiday, carriers generally raised “base” airfares (i.e., airfares net of taxes and fees) compared with what they were in periods before the absence of the tax or fee. The effect of this to consumers was to maintain or increase gross fares. These fare increases were more moderate in markets where a low-cost carrier (e.g., Southwest) was operating and among leisure travelers.

Ignoring the possibility of negative incidence (i.e., an increase in gross fares resulting from a declining tax), this implies zero incidence when the tax initially lapsed. For the 1996 episode, the

GAO studied thirteen markets, but published results for only four, some competitive and some concentrated. For example, Las Vegas-Los Angeles was used as a competitive market. This market was described as one “in which a low-cost carrier competed against two network airlines” and in which “all carriers raised their average base fares at some point during the tax lapse, but no one raised them over 15 percent” (GAO, 2004, p. 8).

Conversely, for the Northwest Airlines dominated Billings-Minneapolis/St. Paul market, the GAO report found that “carriers raised their average base fares by as much as 52 percent” (GAO, 2004, p. 9). The report also found that “after the tax was reinstated, most carriers increased these average base fares in these four markets (compared with the average base fares in effect during the fourth quarter of 1995), but not to the same extent as when the tax initially lapsed” (GAO, 2005, p. 9). This increase in base fare was found to be more pronounced for business travelers.

For the 2003 episode, the GAO contracted Harrell Associates to study “week-over-week changes by seven carriers in each of their 20 largest passenger markets” (GAO, 2004, p. 9). Here, the GAO found that base business fares were raised in over 80% of markets, but leisure base fares were not raised to the same degree (GAO, 2004, p. 9). The GAO attributes this difference in incidence to “greater competition for leisure passengers” (GAO, 2004, p. 9). Again, the GAO also found evidence for an asymmetric response to the direction of the tax change: “After the security fee was reimposed beginning in October 2003, carriers generally did not restore those base fares to their prior lower levels” (GAO, 2004, p. 9). If the GAO’s analysis is correct, it would indicate that the tax burden is carried by the producer prior to the tax holiday, and by the consumer afterwards.

Note that the GAO report does not address variations in the unit tax during the 1996 episode (which, admittedly, are relatively small). Also, since the ad valorem rate has remained constant at 7.5% since 1999, the GAO’s analysis of the 2003 security tax holiday only addresses variation in unit taxes. In order to draw any conclusions from the GAO study about the relationship between tax shifting caused by ad valorem taxes and that caused by unit taxes, one would need to compare the ad valorem incidence from the earlier episode with unit tax incidence of the later episode. This is difficult for a number of reasons: It might potentially ignore structural changes in the industry in the intervening years; the GAO only provides a qualitative analysis and does not report any numerical estimates of incidence; and the markets analyzed and the methodologies applied varied significantly between the two episodes.

Formulating testable hypotheses based on the GAO study is a speculative exercise at best. The GAO itself admits that that there are many factors which affect fares, but which are not controlled for in its analysis (GAO, 2004, p. 8):

> Carriers alter their fares in response to many factors, and more rigorous analysis would be needed to isolate the effect of each factor. Therefore, we cannot exclude other exogenous factors from accounting for these changes in base fares. That is, it is possible that the fare changes that occurred in these two instances may have been the result of factors other than the absence of a tax or fee and the presence or absence of low-cost carriers, such as changing economic and competitive conditions in those markets.

Consequently, the fare changes observed by the GAO may have been due to factors other than variations in taxes.

Generally, models of competitive markets predict a symmetric price response to changes in taxes. Consequently, the notion that tax incidence may be a function of the direction of the tax change is excluded by the theoretical framework presented in Chapter III. It may be possible under some forms of imperfect competition not specifically analyzed in Chapter III. Ultimately, it may be difficult to construct a theoretical model which captures the institutional and political intricacies which could explain this outcome.

An asymmetric price effect to tax changes may also be difficult to observe using quarterly data. This effect was most pronounced in the work completed by Harrell Associates on behalf of the GAO. This analysis used week-over-week changes for the two weeks straddling the beginning of the episode and the two weeks straddling the end. Hence, the GAO's findings may reflect a short term effect. This study uses quarterly data points, which may only reveal longer term effects. While a quarter may seem to be a relatively short time period, air travel features a high frequency of price changes compared to other goods and services. Air fares lagged behind only tomatoes and gasoline in terms of frequency of price changes, according to a study of over 350 categories of goods (Bils and Klenow, 2004, pp. 974-983).

The airline industry has issued its own qualitative assessments of tax incidence. ATA has presented a consistent message that the airlines have lost pricing power and are unable to pass along any increases in taxes to consumers. According to Lori Sharpe Day, ATA's Vice President of Government Affairs, the 2003 tax holiday demonstrated that producer prices marched in lock step with changes in the security fee (ATA, 2004):

> While airlines collect these taxes from their customers, the dispute really focuses on who ends up paying.
>
> People who understand the industry know that U.S. airlines absorb these costs themselves. The average fare has declined sharply since 9/11 and U.S. airlines have no pricing power to pass along these costs due to competitive pressures and a substantial decline in travelers' willingness to pay. It's worth pointing out that when Congress suspended the passenger security fees in the summer of 2003, airline yields improved, only to decline a short time later when the passenger security fees were reimposed in the fall of 2003.
>
> In the end, U.S. airlines end up eating these security costs, adversely impacting their revenues. It seems obvious to me that if we could pass along all these costs we would. Then we all would be making money.

Formulating a hypothesis which matches this description is straightforward: This statement implies that the incidence of unit taxes is zero (i.e., $\beta_2 = 0$). However, ATA has not published any specific data to support this statement. Given ATA's role as a special interest group, some caution must be applied in using this statement to form a scientific hypothesis. However, it is certainly possible to test the hypothesis, regardless of whether one finds it credible or not.

The hypotheses $\beta_1 = 0$ and $\beta_2 = 0$ are also equivalent to the GAO's finding that the producer carries the full burden during the beginning of a lapse in taxation, i.e. when the tax first is reduced. Thus, the ATA and GAO statements about tax incidence are consistent when describing the decline of a tax. When describing the reinstatement of the tax, however, the statements contradict each other: The ATA claims that the tax increase is fully shifted onto the producer, so that the incidence remains zero. The GAO on the other hand, states that the burden shifts to the consumer, so that the incidence changes to unity (especially for business travel). Another hypothesis that follows from the GAO report is the possibility that the incidence is unity (i.e., $\beta_1 = 1$) for small τ. Using the linear specification given by Equations 67 and 68, the equivalent test for unit taxes is $\beta_2 = 1$.

Apart from these somewhat anecdotal hypotheses, the theory of tax incidence allows for a broad range of possible outcomes. In the long run, with perfect competition and constant costs, tax incidence should be equal to one: By assumption firms are operating at the minimum of their long-run average cost curves. However, this does not mean that an empirical result of one constitutes a long-run perfect competition condition, as this finding is also possible under other assumptions. A specific testable assumption is whether the tax incidence of the ad valorem tax is identical to that of the unit tax. In the semilogarithmic specification given by Equations 58 and 59 this is tested by:

$$(1+\bar{\tau})\beta_1 = \frac{\bar{p}^D}{\bar{t}}\beta_2 \tag{69}$$

where $\bar{\tau}$, $\bar{t}$, and $\bar{p}^D$ represent the sample means of the ad valorem rate, unit tax, and total fare.

The null hypotheses used for post-regression inference testing of the primary model specifications analyzed in this study are summarized in Table 4.9. The results from the inferential testing are shown in Chapter V, which also includes descriptive statistics. These include the means and standard deviations of the observations, as well as coefficient estimates and standard errors from the regression analysis. Also, point estimates of tax incidence are provided, using sample means for p^D, τ, and t to convert elasticities to derivatives, as necessary, and to calculate the multiplier effect $1+\tau$.

Table 4.9: Summary of hypothesis testing

Episode	Model	H_0	H_1	Motivation
1992Q1 to 1997Q4	semilog	$\beta_1 = 0$	$\beta_1 \neq 0$	GAO/ATA statements; incidence borne by airlines
		$\beta_2 = 0$	$\beta_2 \neq 0$	GAO/ATA statements; incidence borne by passengers
		$\beta_1 = 1$	$\beta_1 \neq 1$	GAO statement; long run perfect comp.
		$(1+\bar{\tau})\beta_1 = \frac{\bar{p}^D}{\bar{t}}\beta_2$	$(1+\bar{\tau})\beta_1 \neq \frac{\bar{p}^D}{\bar{t}}\beta_2$	Market power

Episode	Model	H_0	H_1	Motivation
2002Q1 to 2005Q3	lin-lin	$\beta_2 = 0$	$\beta_2 \neq 0$	GAO/ATA statements
		$\beta_2 = 1$	$\beta_2 \neq 1$	GAO statement; long run perfect comp.

Additionally, it is possible that the price response to tax changes is different in the competitive pool of markets than in the concentrated pool. The theoretical framework does not provide a clear hypothesis for this comparison, but if one assumes that competitive markets behave closer to the predictions for perfect competition and concentrated markets closer to the predictions for imperfect competition, then different price responses might be expected. As an exploratory measure, the hypotheses $H_0 : \beta_{1,comp} = \beta_{1,conc}$ and $H_0 : \beta_{2,comp} = \beta_{2,conc}$ are included in the inferential testing.

Historical Background and Extraordinary Events

This study incorporates a historical review of exogenous factors with the potential to affect tax incidence results. Table 4.10 summarizes the general financial performance of U.S. airlines from 1980 through 2005 (ATA, 2006d). The periods analyzed for this study are highlighted. As shown, the 1994-1997 period exhibited strong financial results. This was partly due to increased productivity, the maturing of revenue management systems, and the introduction of cost saving measures such as cutting travel agent commissions.

One trend is that the number of “effective competitors” dropped sharply from approximately twelve to eight in the 1985-1987 period, but had stabilized by the mid-1990s (Morrison and Winston, 1995, pp. 8-9). In this context, “effective competitors” is defined as the inverse of HHI (recall that HHI decreases with increased competition).

The year 1996 featured two high profile airline accidents, with no survivors in either event: On May 11, a Valujet Airlines aircraft crashed in the Everglades after an onboard fire and on July 17, flight TWA 800 was destroyed by a fuel tank explosion after taking off from JFK International Airport (National Transportation Safety Board, 2002). The impact of these accidents on prices is ambiguous, however: Valujet’s safety record may have allowed legacy carriers to lessen price competition with LCCs, but a general public perception of reduced safety possibly produced an overall downward pressure on fares.

Table 4.10: Airline financial performance (1994-1997)

Year	Operating revenue	Total cost	Operating profit (loss)	
1980	$32,621	$32,814	($192)	-0.6%
1981	$35,103	$35,480	($377)	-1.1%
1982	$34,913	$35,608	($695)	-2.0%
1983	$37,170	$36,827	$343	0.9%
1984	$41,815	$39,767	$2,048	5.1%
1985	$44,413	$43,061	$1,353	3.1%
1986	$45,141	$44,298	$843	1.9%
1987	$51,003	$49,064	$1,939	4.0%
1988	$56,801	$53,953	$2,847	5.3%
1989	$60,906	$59,611	$1,295	2.2%
1990	$66,471	$68,876	($2,405)	-3.5%
1991	$65,243	$67,440	($2,198)	-3.3%
1992	$68,167	$70,917	($2,750)	-3.9%
1993	$72,865	$71,914	$951	1.3%
1994	$74,805	$72,803	$2,002	2.8%
1995	$79,278	$74,093	$5,184	7.0%
1996	$84,963	$79,518	$5,445	6.8%
1997	$90,347	$82,671	$7,675	9.3%
1998	$92,599	$84,505	$8,094	9.6%
1999	$96,583	$89,634	$6,949	7.8%
2000	$105,859	$100,111	$5,748	5.7%
2001	$92,562	$102,913	($10,351)	-10.1%
2002	$84,623	$94,131	($9,508)	-10.1%
2003	$92,498	$95,565	($3,067)	-3.2%
2004	$108,944	$112,183	($3,238)	-2.9%
2005	$117,691	$119,833	($2,141)	-1.8%

Note: Millions of dollars (nominal)

In contrast to the 1994-1997 period, financial performance of the industry in the 2002-2005 period was quite poor. The title of an industry annual report for 2003 captures the general mood: *Airlines in crisis: The perfect economic storm* (ATA, 2003). The report concluded that without government intervention, the airlines could lose $13 billion and 98,000 jobs. The year 2002, in particular, resulted in the worst profit margin ever recorded for the airline industry since at least 1971.

The U.S. airline industry was already struggling in 2001, when it suffered a severe shock caused by the temporary shutdown of all U.S. air traffic and suppressed demand in the aftermath of September 11. There is evidence that the events of September 11, 2001 caused both a transitory and ongoing negative demand shift (Ito and Lee, 2004). In terms of share of GDP, the industry has not recovered (Hansman, 2005), although passenger demand is high, due to low fares (ATA, 2006d). Frequently cited factors contributing to the poor health of the airline industry include rapidly rising fuel costs (ATA, 2006d), the war with Iraq, the Severe Acute Respiratory Syndrome (SARS) epidemic, and heavy taxation. However, in its analysis of the impact of September 11, 2001, Ito and Lee found that of these factors, only fuel cost had a statistically significant impact. To the extent that the Iraq War and SARS affected airline travel, the impact was mostly likely focused on international markets, which mostly would not affect this study.

One aspect of the health of the airline industry which may affect the analysis of the 2003 tax holiday is the large number of carriers that have entered bankruptcy protection. During the 1994-1997 period, no major carriers were in bankruptcy. During 2002-2005, however, a number of carriers operated under bankruptcy protection for at least part of the time. These include, among others, Aloha, ATA, Delta, Northwest, United, and US Airways (ATA, 2006c).

Table 4.11 summarizes all cases of a bankruptcy involving a carrier with the largest market share on any route in the competitive and concentrated pools. Bankrupt carriers are of particular interest to the tax incidence question, as these airlines may enjoy greater flexibility to compete aggressively on price as a result of entering bankruptcy protection. It is possible, for example, that bankrupt carriers are better able to absorb tax increases than other carriers, in which case they may exhibit a tax incidence that is lower than the industry average. This hypothesis is explored briefly in the empirical analysis, by examining descriptive statistics for routes dominated by bankrupt carriers.

Table 4.11: Airlines in bankruptcy (2002-2005)

Code	Carrier name	Start	End
DL	Delta Air Lines Inc.	9/14/2005	
NW	Northwest Airlines Inc.	9/14/2005	
TZ	ATA Airlines d/b/a ATA	10/26/2004	2/28/2006
UA	United Air Lines Inc.	12/9/2002	2/1/2006
US	US Airways Inc.	8/11/2002	3/31/2003
US	US Airways Inc.	9/12/2004	9/27/2005

Note: Only includes bankruptcies involving the largest carrier on each route analyzed

CHAPTER V

ESTIMATION RESULTS

The results from the regression analysis are presented below. Unless otherwise specified, a Type I error rate of $\alpha = 0.10$ is used for all hypothesis testing. If a specific null hypothesis is not shown, listed P-values are based on a t-test of the null hypothesis $H_0 : \beta_i = 0$. The number of observations is denoted by n. The number of independent variables, including the intercept, is denoted by k.

Before continuing, it is worth reviewing what the theoretical framework predicts about the empirical results. Under perfect competition, the incidence should fall between zero and one and should be identical for both the unit and ad valorem taxes. Under imperfect competition, however, the results include the possibility of overshifting. In other words, the incidence of either the unit and ad valorem tax can fall in the zero to one range, but can also exceed one. Additionally, imperfect competition also allows for the two types of incidence to be different. Specifically, the incidence of the unit tax can be expected to exceed that of the ad valorem tax and the ratio between the two is an indicator of market power.

Aggregate Estimation

Aggregating at the national levels has several drawbacks. It reduces an extremely rich data set to very few observations (for example, 49 million records are reduced to 16 observations for the 1994Q1-1997Q4 episode). This low number of observations is in and of itself a problem. It provides sufficient degrees of freedom for only a few control variables and can potentially result in misleadingly good measures of fit.

Aggregate estimations for all tickets in the continental U.S. samples were carried out using generalized least squares (GLS) weighted by passengers. The sample means and standard deviations for both episodes are shown in Table 5.1. The variable names TF and P are used interchangeably – they both refer to the tax inclusive fare. Note that there is no variation in the ad valorem rate in the second episode, as shown by the zero standard deviation. Quarterly fixed effects are defined by setting a dummy variable equal to one for each quarter except the first one (i.e., Q1).

Table 5.1: Descriptive statistics: Aggregate estimation

1994Q1-1997Q4 (n=16)			2002Q1-2005Q3 (n=15)		
Variable	Mean	Std Dev	Variable	Mean	Std Dev
TF	164.5219	6.3258	TF	166.8639	4.2321
lnP	5.1024	0.0385	lnP	5.1169	0.0255
FTTRate	0.0786	0.0380	FTTRate	0.0750	0.0000
UnitTax	2.9056	0.5086	UnitTax	12.0784	0.9677
lnUnitTax	1.0549	0.1508	lnUnitTax	2.4880	0.0880
ATACostIndex	162.0897	4.5056	ATACostIndex	186.0657	4.5049
lnATACostIndex	5.0878	0.0277	lnATACostIndex	5.2258	0.0240
LCCShare	0.0870	0.0069	LCCShare	0.1564	0.0092

Table 5.2 shows passenger weighted averages of key variables before, during, and after the tax shocks. The table also includes total taxes and fees (TTF), i.e., the sum of the ad valorem and unit taxes. The definitions of the breaks between the periods are not perfect, because the dates of the tax shocks do not always coincide with quarter boundaries. Also, the 1996-1997 episode consisted of two separate shocks, as discussed in Chapter IV (see Figure 4.1).

For the earlier episode, the total fare clearly decreases as tax collections decline. This is followed by an increase once the tax is reinstated. The change in total fare is less than the change in total taxes and fees, which indicates, all else being equal, that the tax burden is shared. The price after the tax is reinstated is higher than that before the tax lapse. This may in part be explained by an increase in the unit tax over time, especially if the unit tax is overshifted, and in part by other factors, such as increasing costs.

For the later episode, the results are not as clear. This is not entirely unexpected since the variation in taxes is much smaller: The total taxes and fees only change by approximately $2. There is practically no observed price change when the tax holiday begins. After the tax shock, the price decreases by $3 when the tax is reinstated – a counterintuitive result. It may mean that other exogenous variables must be taken into account in order to estimate the tax incidence during the security tax holiday. For example, the drop in total fare after the tax shock may be explained by the decline in the ATA cost index. This suggests that estimating the incidence of the 2003 security tax holiday is more difficult than estimating that of the 1996-1997 tax collection lapse.

Table 5.2: Weighted averages: Before, during, and after tax shock

Variable	Before shock	
	1994Q1-1995Q4	2002Q1-2003Q1
TF	165.0669	168.5651
FTTRate	0.1000	0.0750
UnitTax	2.6988	11.9887
TTF	17.5595	22.9876
ATACostIndex	159.6015	187.1328
LCCShare	0.0823	0.1450
	During shock	
	1996Q1-1997Q1	2003Q2-2003Q3
TF	160.0198	168.4137
FTTRate	0.0343	0.0750
UnitTax	2.8038	10.2075
TTF	7.8603	21.3202
ATACostIndex	162.4135	191.4008
LCCShare	0.0920	0.1610
	After shock	
	1997Q2-1997Q4	2003Q4-2005Q3
TF	169.8785	165.2418
FTTRate	0.0967	0.0750
UnitTax	3.6435	12.6180
TTF	18.3919	23.3412
ATACostIndex	167.8156	184.2167
LCCShare	0.0915	0.1624

The regression results for the first episode are shown in Table 5.3. The primary model for this episode is the semilogarithmic specification given by Equation 58. The unit of analysis is the quarterly passenger weighted average of the total fare. An alternative fully linear specification is also shown, which, as described in Chapter IV, may be a better choice for estimating the tax incidence of the unit tax.

In the primary specification, the coefficients on the ad valorem rate and the unit tax are both of the expected sign. Only the former is strictly statistically different from zero, but the coefficient on the unit tax is marginally so. The magnitude of the coefficients indicate that the ad valorem tax is shared by both airlines and passengers, with the point estimate tending closer to one than to zero (especially once the multiplier effect is taken into account). The magnitude of the unit tax indicates the possibility that the tax is overshifted – a possibility which is evaluated more carefully later. There are few differences in results between the two functional forms. The linear specification has lower standard errors relative to the magnitude of the two coefficients of interest, so that both are statistically significant.

Table 5.3: Results: Aggregate estimation (1994Q1-1997Q4)

	Dependent variable: lnP Primary specification: semilog				Dependent variable: TF Alternate specification: lin-lin		
	n	16			n	16	
	k	9			k	9	
	R^2	0.707			R^2	0.737	
	Adj. R^2	0.371			Adj. R^2	0.436	
Coefficient	Estimate	S.E.	P-value	Coefficient	Estimate	S.E.	P-value
Intercept	4.807	2.463	0.0920	Intercept	133.697	81.821	0.1463
FTTRate	0.720	0.276	0.0347	FTTRate	119.508	42.653	0.0265
lnUnitTax	0.133	0.085	0.1612	UnitTax	6.967	3.655	0.0983
lnATACostIndex	0.027	0.484	0.9573	ATACostIndex	0.013	0.461	0.9791
LCCShare	-0.055	2.578	0.9834	LCCShare	59.600	407.187	0.8878
Q2	-0.020	0.027	0.4809	Q2	-3.126	4.239	0.4849
Q3	-0.049	0.032	0.1632	Q3	-7.720	4.891	0.1585
Q4	-0.082	0.030	0.0282	Q4	-13.636	4.613	0.0212
Time	0.001	0.005	0.9096	Time	0.005	0.732	0.9948

The cost index and LCC market share have surprisingly little explanatory power. This may in part be due to lack of variation: The ATA cost index varies by just over 10% between 1994Q1and 2005Q3. The LCC market share more than doubles over the same time period, but the trend is very gradual. Quarterly dummies are all negative, but only the fourth quarter is statistically significant, possibly indicating depressed prices during the low travel months of October through December (Thanksgiving and Christmas notwithstanding). The time trend variable is not statistically different from zero.

Table 5.4 shows the results of hypothesis testing. The inferential statistics are derived using the primary specification, except for $H_0 : \beta_2 = 1$. This hypothesis is evaluated using the alternate specification, which provides a direct estimate of the tax incidence of the unit tax. The tests support the hypothesis that the ad valorem tax incidence is positive and close to one. The difference between the incidence on the ad valorem tax and unit tax is not statistically significant. The inferential testing is degraded by the large standard errors in the estimates of the unit tax coefficients. While the point estimate indicates overshifting, the confidence interval is quite broad, as will be shown further below.

Table 5.4: Hypothesis testing: Aggregate estimation (1994Q1-1997Q4)

Coeff. value	H_0	H_1	P-value	Outcome
$\beta_1 = 0.720$	$\beta_1 = 0$	$\beta_1 \neq 0$	0.0347	Reject H_0
$\beta_2 = 0.133$	$\beta_2 = 0$	$\beta_2 \neq 0$	0.1612	Do not reject H_0
$\beta_1 = 0.720$	$\beta_1 = 1$	$\beta_1 \neq 1$	0.3441	Do not reject H_0
$\beta_2 = 6.967$	$\beta_2 = 1$	$\beta_2 \neq 1$	0.1466	Do not reject H_0
	$(1+\tau)\beta_1 = \frac{p^D}{t}\beta_2$	$(1+\tau)\beta_1 \neq \frac{p^D}{t}\beta_2$	0.2012	Do not reject H_0

Table 5.5 lists the regression results for the 2003 security tax holiday. The primary model for this episode is the linear specification given by Equation 67. An alternate logarithmic specification is used to test for robustness. The coefficient on the unit tax is negative, which is unexpected and counter to theory, but it is not statistically different from zero. In fact, with the exception of the intercept, no coefficients have P-values close to the Type I error rate of 0.10. The fit is poor and the explanatory power of the aggregate model for 2003 security tax holiday is weak. These findings vary little in the alternate specification. Compared to the earlier estimation, these results are too noisy to be of much value, which emphasizes the need to disaggregate the data. At best, these results may suggest that the industry experienced some type of structural change since the 1990s.

Table 5.5: Results: Aggregate estimation (2002Q1-2005Q3)

	Dependent variable: TF Primary specification: lin-lin				Dependent variable: lnP Alternate specification: log-log		
	n	15			n	15	
	k	8			k	8	
	R^2	0.543			R^2	0.541	
	Adj. R^2	0.086			Adj. R^2	0.082	
Coefficient	Estimate	S.E.	P-value	Coefficient	Estimate	S.E.	P-value
Intercept	206.323	77.976	0.0331	Intercept	6.619	1.836	0.0087
UnitTax	-0.802	1.548	0.6203	lnUnitTax	-0.055	0.101	0.5992
ATACostIndex	-0.245	0.294	0.4322	lnATACostIndex	-0.279	0.333	0.4311
LCCShare	145.971	296.574	0.6376	LCCShare	0.849	1.777	0.6473
Q2	-0.467	3.411	0.8950	Q2	-0.002	0.021	0.9177
Q3	-4.069	3.153	0.2379	Q3	-0.025	0.019	0.2398
Q4	-3.948	3.330	0.2745	Q4	-0.024	0.020	0.2791
Time	-0.628	0.678	0.3854	Time	-0.004	0.004	0.3822

Table 5.6 shows results from hypothesis testing for the second episode, confirming that there is little to be learned from the aggregate estimation of the security tax holiday. The difference between the incidence of the unit tax and either zero or one is not statistically significant, although it is close to being so in the latter case. This is expected, given that the point estimate of the coefficient is negative.

Table 5.6: Hypothesis testing: Aggregate estimation (2002Q1-2005Q3)

Coeff. value	H_0	H_1	P-value	Outcome
$\beta_2 = -0.802$	$\beta_2 = 0$	$\beta_2 \neq 0$	0.6203	Do not reject H_0
$\beta_2 = -0.802$	$\beta_2 = 1$	$\beta_2 \neq 1$	0.1412	Do not reject H_0

Table 5.7 shows estimates of tax incidence from the aggregate analysis. The table also shows the estimated value of μ , the ratio of the incidence of the unit tax to that of the ad valorem tax. Table 5.8 shows the same results expressed as 90% confidence intervals. The estimate of incidence are computed using the regression coefficients from the primary specification, evaluated at the passenger weighted averages of price, ad valorem rate, and unit taxes from the entire ticket sample. As noted earlier, the tax incidence on the unit tax appears higher than that of the ad valorem tax in the earlier episode, which could be an indication of imperfect competition. However, the large confidence intervals preclude any statistically significant conclusions along those lines and, in fact, incorporate negative values. The incidence of the ad valorem tax is much

more precisely estimated, however. It is positive and close to one. This is likely the most valuable result from the aggregate estimation.

Table 5.7: Estimates of tax incidence: Aggregate estimation

Period	Incidence of ad valorem tax	S.E.	Incidence of unit tax	S.E.	μ
1994Q1-1997Q4	0.776	0.2969	7.441	4.7499	9.587
2002Q1-2005Q3			-0.802	1.5480	

Table 5.8: 90% confidence interval of tax incidence: Aggregate estimation

Period	90% confidence interval of ad valorem tax	90% confidence interval of unit tax
1994Q1-1997Q4	0.214 to 1.339	-4.251 to 13.751
2002Q1-2005Q3		-7.453 to 10.549

The point estimate of μ reported in Table 5.7 indicates the presence of imperfect competition. However, recall from the inferential statistics presented in Table 5.4 that the difference between two types of tax incidence is not statistically significant, so that it is also possible that $\mu = 1$. As a comparison, values of μ in the European cigarette industry range from 0.8 to 21.4 for individual country regressions (Delipalla and O'Donnell, 2001, p. 899).

A Breusch-Pagan test on the estimation results failed to detect heteroskedasticity. Durbin-Watson tests for autocorrelation resulted in inconclusive findings for both episodes. A Breusch-Godfrey test revealed weak evidence for autocorrelation of order one for the 1994-1997 episode. Stepwise autoregression failed to detect autocorrelation for either episode. Estimation with feasible generalized least squares to correct for autocorrelation resulted in only minor changes over the GLS results.

As noted earlier, aggregating the data results in a very small number of observations. Aggregation also hides certain tax avoidance strategies, such as changes in routings (since the specific itinerary affects the unit taxes). It also ignores the possibility that tax incidence is a function of market competition, purpose of travel (i.e., business vs. leisure), the bankruptcy status of a carrier, and other characteristics. The possibility of varying behavior for different subgroups of the observations possibly explains the relatively weak results from the aggregate analysis, especially in the second episode.

The descriptive statistics presented here depict interesting trends. In part they are consistent with the GAO's findings and in part they differ. The regression results are imprecise, but improve on the GAO's analysis in that the underlying data set is much broader and the analysis more sophisticated. There is evidence that the incidence is considerably higher than zero. In one case, the incidence is significantly different from zero, and in other cases this is nearly so. While the analysis of aggregates serves primarily as an opening to restate fundamental theoretical questions within an empirical framework, the results provide some insights not previously available. However, the aggregate analysis is clearly limited, and serves largely as motivation for increasing the sample size and exploring ways to disaggregate the data to more meaningfully answer the research questions at hand. This is the rationale for conducting separate estimations of competitive and concentrated markets.

Separate Estimations of Competitive and Concentrated Markets

Estimations for the pools of competitive and concentrated markets are carried out using GLS. The observations represent route specific averages, so the regression is weighted by the number of passengers in each market. Post regression analysis of the GLS estimation using a Breusch-Pagan test fails to detect any remaining heteroskedasticity. Additionally the regression is clustered by market to produce White standard errors robust to intragroup correlation.

Sample means and standard deviations for both pools are shown in Table 5.9 for the 1994Q1-1997Q4 episode and in Table 5.10 for the 2002Q1-2005Q3 episode. Dummy variables to control for quarterly, yearly, and route fixed effects are not shown. Quarterly fixed effects are defined by setting a dummy variable equal to one for each quarter except the first one (i.e., Q1). Similarly, year fixed effects are defined by setting a dummy variable equal to one for each year in the period, except the first. Route fixed effects are defined by setting a dummy variable to one for each route in the pool, except the first route by alphabetical order.

Total fares are lower for the concentrated markets than the competitive markets. This may seem counterintuitive, but is a function of market distance as the concentrated markets are generally short-haul markets. There is little difference in ETR between the pools in the 1994-1997 period: 9.9% for the concentrated pool vs. 9.5% for the competitive pool. This is due to the dominance of ad valorem taxes. For the 2002-2005 period, there is a more substantial difference. The ETR is 16.9% for the concentrated pool and 14.8% for the competitive pool. Unit taxes average $3.60 for the competitive pool and $2.29 for the concentrated pool during 1994-1997, compared to $13.45 and $9.68, respectively, for 2002-2005.

Table 5.9: Descriptive statistics: Competitive and concentrated pools (1994Q1-1997Q4)

	Competitive (n=320)		Concentrated (n=320)	
Variable	Mean	Std Dev	Mean	Std Dev
TF	192.8108	66.9904	161.7734	67.4855
lnP	5.1972	0.3703	4.9773	0.4985
FTTRate	0.0786	0.0368	0.0786	0.0368
UnitTax	3.5968	1.1452	2.2867	0.9962
lnUnitTax	1.2291	0.3242	0.6379	0.8510
ATACostIndex	162.0897	4.3694	162.0897	4.3694
lnATACostIndex	5.0878	0.0268	5.0878	0.0268
Unempr	0.0619	0.0110	0.0527	0.0093

Table 5.10: Descriptive statistics: Competitive and concentrated pools (2002Q1-2005Q3)

	Competitive (n=300)		Concentrated (n=300)	
Variable	Mean	Std Dev	Mean	Std Dev
TF	176.4699	42.7202	133.2729	65.0742
lnP	5.1450	0.2375	4.7879	0.4437
FTTRate	0.0750	0.0000	0.0750	0.0000
UnitTax	13.4534	3.1110	9.6832	1.1937
lnUnitTax	2.5709	0.2431	2.2624	0.1289
ATACostIndex	186.0657	4.3594	186.0657	4.3594
lnATACostIndex	5.2258	0.0232	5.2258	0.0232
Unempr	0.0582	0.0065	0.0564	0.0075

Table 5.11 shows the 1994Q1-1997Q4 passenger weighted averages for both the competitive and concentrated markets before, during, and after the tax shocks. Table 5.12 shows the same for 2002Q1-2005Q3. For the earlier episode it can be seen that prices go down during the tax shock and climb back up afterwards. This is similar to the descriptive statistics generated for the aggregate data (see Table 5.2). However, in this case the change in total fare appears to exceed the change in total taxes and fees (TTF) in both directions. This could indicate overshifting or be explained by other exogenous factors particular to the competitive markets.

Table 5.11: Weighted averages: Before, during, and after tax shock (1994Q1-1997Q4)

Variable	Competitive	Concentrated
	Before tax shock: 1994Q1-1995Q4	
TF	174.3781	135.4488
FTTRate	0.1000	0.1000
UnitTax	2.9448	2.0369
TTF	18.5297	14.1653
ATACostIndex	159.6645	159.6412
Unempr	0.0638	0.0596
	During tax shock: 1996Q1-1997Q1	
TF	151.3463	149.0236
FTTRate	0.0353	0.0341
UnitTax	3.2192	2.4185
TTF	8.0691	7.1009
ATACostIndex	162.6028	162.3690
Unempr	0.0577	0.0530
	After tax shock: 1997Q2-1997Q4	
TF	167.2135	161.4182
FTTRate	0.0966	0.0967
UnitTax	3.8987	3.1041
TTF	18.2637	17.0595
ATACostIndex	167.8086	167.8192
Unempr	0.0530	0.0485

Table 5.12: Weighted averages: Before, during, and after tax shock (2002Q1-2005Q3)

Variable	Competitive	Concentrated
	Before tax shock: 2002Q1-2003Q1	
TF	195.3802	117.8519
FTTRate	0.0750	0.0750
UnitTax	11.5994	9.5673
TTF	24.4213	17.1220
ATACostIndex	187.2131	187.0224
Unempr	0.0621	0.0599
	During tax shock: 2003Q2-2003Q3	
TF	191.6266	123.8337
FTTRate	0.0750	0.0750
UnitTax	10.1461	7.9935
TTF	22.8076	16.0754
ATACostIndex	191.4006	191.5005
Unempr	0.0632	0.0615
	After tax shock: 2003Q4-2005Q3	
TF	176.7323	123.8686
FTTRate	0.0750	0.0750
UnitTax	11.9781	10.2836
TTF	23.4726	18.2081
ATACostIndex	184.2171	184.2544
Unempr	0.0543	0.0532

In the concentrated pool, tax inclusive prices increase during the decrease in taxes. This result is counter to theory, unless explained by other factors. It is however, consistent by with some of the findings documented by the GAO (2004). This may indicate that carriers which dominate a market are able to respond to a tax change differently than other carriers. Hence, the method developed here to determine market concentration through an estimate of the lower and upper bounds of HHI seems in fact to have identified two types of markets with different behavior.

For the 2003 security tax holiday, fares in the competitive markets drop when the tax decreases, as expected, but by an amount somewhat larger than the change in taxes. However, similar to what is found in the aggregate analysis, fares also drop when the security tax is reinstated. This result may in part be explained by the decrease in costs, as shown by the drop in the ATA cost index. In the concentrated markets, the that fares increase as the tax drops. Again, this may support the hypothesis that carriers in dominant markets react to tax changes differently. However, it could also be explained by increases in costs or the combination of low levels of variation and other unexplained factors.

Table 5.13: Weighted averages of markets where dominant carrier is bankrupt

Variable	Competitive	Concentrated
	Before tax shock: 2002Q1-2003Q1	
TF	185.1201	188.7542
FTTRate	0.0750	0.0750
UnitTax	13.1134	10.2338
TTF	25.1139	22.6887
ATACostIndex	187.1036	186.7573
Unempr	0.0609	0.0536
	During tax shock: 2003Q2-2003Q3	
TF	177.8502	223.9317
FTTRate	0.0750	0.0750
UnitTax	11.2380	8.3463
TTF	22.8622	23.3872
ATACostIndex	191.3568	191.6667
Unempr	0.0617	0.0544
	After tax shock: 2003Q4-2005Q3	
TF	163.4999	185.5880
FTTRate	0.0750	0.0750
UnitTax	13.2095	10.7738
TTF	23.6949	22.9702
ATACostIndex	184.2769	184.3440
Unempr	0.0529	0.0490

During the 2002Q1-2005Q3 episode there were a number of legacy carriers operating in bankruptcy protection (see Table 4.11). In order to conduct a preliminary evaluation of whether these carriers behave differently when facing tax changes, passenger weighted averages are provided in Table 5.13 for the subset of markets in which a bankrupt carrier is the dominant carrier. Out of the twenty competitive markets, eight are dominated by bankrupt carriers, compared to six out of twenty for the concentrated markets.

In the competitive markets, the results are not substantially different than those observed for the overall pool. This is not surprising, since the bankrupt carriers generally have a lower market share in these markets compared to the concentrated markets. This may mask differences in price competition between bankrupt and other carriers. In the concentrated markets, however, the bankrupt carriers have larger market share. Here, increase when the tax drops and prices decrease when the security tax is reintroduced. Compared to the results for all concentrated markets, the price changes are much larger. These results are difficult to interpret, but suggest that routes where large market shares are held by bankrupt carriers differ from other markets. Since this possibility is not explicitly controlled for in the regression model, a more rigorous analysis of the impact of bankrupt carriers is an area where future research is warranted.

The regression results for the first episode are shown in Table 5.14. The primary model used for this period is the semilogarithmic specification given by Equation 59. An alternative fully linear specification is shown in Table 5.15. The coefficients on the ad valorem tax rate and unit tax are of the expected sign, but only the former is statistically significant. This is true for both the primary and alternate specifications. The general result, again, is that the point estimates for ad valorem taxation is close to one. The tax incidence for unit taxation indicates overshifting. However, similar to the aggregate estimation, the standard errors on the coefficients on unit taxation are relatively large, resulting in large confidence intervals. The point estimate on unit taxes in the concentrated pool is considerably lower than that in the competitive pool and is in fact below one (again, with a wide confidence intervals, however).

Table 5.14: Results (semilog): Competitive and concentrated pools (1994Q1-1997Q4)

	Competitive markets				Concentrated markets		
	Dependent variable: lnP				Dependent variable: lnP		
	Primary specification: semilog				Primary specification: semilog		
	n	320			n	320	
	k	30			k	30	
	R^2	0.902			R^2	0.920	
	Adj. R^2	0.892			Adj. R^2	0.912	
Coefficient	Estimate	S.E.	P-value	Coefficient	Estimate	S.E.	P-value
Intercept	3.020	2.890	0.3092	Intercept	11.029	3.014	0.0017
FTTRate	0.865	0.253	0.0029	FTTRate	0.613	0.186	0.0038
lnUnitTax	0.091	0.070	0.2082	lnUnitTax	0.009	0.010	0.3866
lnATACostIndex	0.325	0.565	0.5714	lnATACostIndex	-1.307	0.609	0.0452
Unempr	3.683	5.287	0.4944	Unempr	11.106	6.705	0.1141
Q2	-0.020	0.019	0.2978	Q2	-0.054	0.036	0.1467
Q3	-0.080	0.030	0.0143	Q3	-0.085	0.053	0.1243
Q4	-0.069	0.034	0.0555	Q4	-0.031	0.039	0.4388
Y1995	-0.037	0.067	0.5883	Y1995	-0.009	0.100	0.9314
Y1996	-0.107	0.092	0.2588	Y1996	0.201	0.082	0.0240
Y1997	-0.061	0.118	0.6119	Y1997	0.341	0.127	0.0146
BDLSFO	0.748	0.073	<.0001	ATLCVG	0.360	0.004	<.0001
BOSMSY	0.262	0.029	<.0001	ATLDAY	0.130	0.009	<.0001
BOSSAN	0.583	0.053	<.0001	ATLRIC	0.309	0.023	<.0001
BWISAN	0.262	0.055	0.0001	AUSELP	-0.652	0.073	<.0001
CLEORD	-0.572	0.041	<.0001	AUSLBB	-0.882	0.069	<.0001
CMHTPA	-0.333	0.033	<.0001	BDLPHL	0.186	0.046	0.0007
COSIAD	0.252	0.098	0.0191	BHMMSY	-0.980	0.056	<.0001
EWRSEA	0.716	0.003	<.0001	BOSPHL	-0.238	0.038	<.0001
FLLLAX	0.366	0.072	<.0001	BOSPIT	0.074	0.040	0.0806
FLLLGA	-0.055	0.030	0.0810	BOSROC	-0.120	0.083	0.1643
LASORD	0.110	0.035	0.0051	CLTPHL	0.305	0.019	<.0001
LAXMCI	-0.062	0.080	0.4492	DCAPVD	0.062	0.030	0.0557
LAXMKE	0.300	0.057	<.0001	DTWMKE	0.142	0.016	<.0001
LAXMSY	0.240	0.089	0.0144	DTWMSP	0.597	0.018	<.0001
LGAPBI	-0.028	0.025	0.2648	INDPHL	0.271	0.013	<.0001
MCOSEA	0.418	0.029	<.0001	MCIOKC	-0.965	0.019	<.0001
MCOSFO	0.548	0.064	<.0001	MKEMSP	0.113	0.076	0.1539
ORDPHX	0.250	0.039	<.0001	PHLPIT	-0.286	0.055	<.0001
PHXSEA	-0.089	0.029	0.0055	SANSMF	-1.317	0.178	<.0001

The ATA cost index and market unemployment rate have little explanatory power in the competitive pool. The coefficient on the cost index is negative in the concentrated pool, and statistically significant. This may be an indication of some level of detachment between price and costs in markets where air carriers enjoy a high level of dominance, but is otherwise a counterintuitive result. It could also suggest one or more omitted variables. Some of the price changes observed here are likely due to factors not fully captured in the model. Correlation between an omitted variable and the ATA cost index, could possibly explain the observed results.

Table 5.15: Results (lin-lin): Competitive and concentrated pools (1994Q1-1997Q4)

	Competitive markets				Concentrated markets		
	Dependent variable: TF				Dependent variable: TF		
	Alternate specification: lin-lin				Alternate specification: lin-lin		
	n	320			n	320	
	k	30			k	30	
	R^2	0.905			R^2	0.896	
	Adj. R^2	0.896			Adj. R^2	0.886	
Coefficient	Estimate	S.E.	P-value	Coefficient	Estimate	S.E.	P-value
Intercept	22.779	87.274	0.7969	Intercept	205.533	83.718	0.0239
FTTRate	136.253	35.603	0.0011	FTTRate	91.449	28.739	0.0049
UnitTax	5.528	3.431	0.1236	UnitTax	0.801	2.370	0.7391
ATACostIndex	0.421	0.426	0.3349	ATACostIndex	-1.183	0.520	0.0346
Unempr	668.150	703.498	0.3542	Unempr	2428.036	1044.050	0.0313
Q2	-4.182	2.896	0.1651	Q2	-6.784	4.100	0.1144
Q3	-13.899	4.256	0.0041	Q3	-9.839	6.181	0.1279
Q4	-12.959	5.209	0.0223	Q4	-2.012	5.652	0.7258
Y1995	-7.856	10.176	0.4496	Y1995	7.011	13.315	0.6046
Y1996	-17.567	12.306	0.1697	Y1996	37.389	12.871	0.0091
Y1997	-12.535	14.158	0.3870	Y1997	62.444	19.901	0.0054
BDLSFO	169.377	10.143	<.0001	ATLCVG	65.675	0.716	<.0001
BOSMSY	44.955	3.511	<.0001	ATLDAY	18.545	1.008	<.0001
BOSSAN	121.274	7.270	<.0001	ATLRIC	55.896	3.522	<.0001
BWISAN	46.080	7.313	<.0001	AUSELP	-95.698	11.284	<.0001
CLEORD	-56.577	6.403	<.0001	AUSLBB	-115.472	11.900	<.0001
CMHTPA	-34.570	5.010	<.0001	BDLPHL	29.087	7.969	0.0017
COSIAD	43.605	13.158	0.0036	BHMMSY	-117.448	8.653	<.0001
EWRSEA	156.168	0.823	<.0001	BOSPHL	-40.007	7.257	<.0001
FLLLAX	68.067	10.383	<.0001	BOSPIT	6.798	6.277	0.2924
FLLLGA	-4.195	5.590	0.4622	BOSROC	-30.623	12.931	0.0286
LASORD	21.047	5.571	0.0013	CLTPHL	55.399	3.010	<.0001
LAXMCI	-4.844	11.456	0.6772	DCAPVD	9.534	5.104	0.0773
LAXMKE	54.481	8.365	<.0001	DTWMKE	27.512	2.772	<.0001
LAXMSY	42.879	12.397	0.0026	DTWMSP	124.686	4.154	<.0001
LGAPBI	-0.863	5.031	0.8657	INDPHL	48.536	4.968	<.0001
MCOSEA	77.647	4.022	<.0001	MCIOKC	-97.885	3.545	<.0001
MCOSFO	110.004	9.375	<.0001	MKEMSP	25.326	11.389	0.0385
ORDPHX	44.937	7.074	<.0001	PHLPIT	-49.143	8.477	<.0001
PHXSEA	-7.280	5.867	0.2298	SANSMF	-170.814	28.143	<.0001

Quarter fixed effects are negative, but vary in significance. They indicate fares are lowest in the third quarter, which may be consistent with late summer fare wars. Year fixed effects vary in sign and significance, but generally indicate no time trend in the competitive markets compared to some evidence for price increases over time in the concentrated markets. This may suggest that airlines have more pricing power in markets where they dominate. Route fixed effects are almost all statistically significant in both pools, demonstrating that there are strong unobserved effects specific to the selected routes. One of these is likely to be the impact of route distance, which is not otherwise controlled for. The regression is generally robust to model specification.

Results from hypothesis testing for the 1994-1997 episode are shown in Table 5.16. Except for the hypothesis $H_0 : \beta_2 = 1$, all inferential testing is based on the primary model specification. Hypothesis testing comparing the competitive and concentrated pools is conducted separately and is discussed later (see Table 5.22).

Table 5.16: Hypothesis testing: Competitive and concentrated pools (1994Q1-1997Q4)

Coeff. value	H_0	H_1	P-value	Outcome
Competitive markets				
$\beta_1 = 0.865$	$\beta_1 = 0$	$\beta_1 \neq 0$	0.0029	Reject H_0
$\beta_2 = 0.091$	$\beta_2 = 0$	$\beta_2 \neq 0$	0.2082	Do not reject H_0
$\beta_1 = 0.865$	$\beta_1 = 1$	$\beta_1 \neq 1$	0.5935	Do not reject H_0
$\beta_2 = 5.528$	$\beta_2 = 1$	$\beta_2 \neq 1$	0.1880	Do not reject H_0
	$(1+\tau)\beta_1 = \frac{p^D}{t}\beta_2$	$(1+\tau)\beta_1 \neq \frac{p^D}{t}\beta_2$	0.3137	Do not reject H_0
Concentrated markets				
$\beta_1 = 0.613$	$\beta_1 = 0$	$\beta_1 \neq 0$	0.0038	Reject H_0
$\beta_2 = 0.009$	$\beta_2 = 0$	$\beta_2 \neq 0$	0.3866	Do not reject H_0
$\beta_1 = 0.613$	$\beta_1 = 1$	$\beta_1 \neq 1$	0.0384	Reject H_0
$\beta_2 = 0.801$	$\beta_2 = 1$	$\beta_2 \neq 1$	0.9331	Do not reject H_0
	$(1+\tau)\beta_1 = \frac{p^D}{t}\beta_2$	$(1+\tau)\beta_1 \neq \frac{p^D}{t}\beta_2$	0.8407	Do not reject H_0

The regression results for the second episode are shown in Table 5.17. The primary model is the linear specification given by Equation 68, with an alternative logarithmic specification shown in Table 5.18.

The estimation results from the second episode provide the strongest indication yet of overshifting of the unit tax. The coefficient in the concentrated pool is clearly statistically different from zero, and in the competitive pool it is nearly so. The point estimates are close to five.

Table 5.17: Results (lin-lin): Competitive and concentrated pools (2002Q1-2005Q3)

	Competitive markets				Concentrated markets		
	Dependent variable: TF				Dependent variable: TF		
	Primary specification: lin-lin				Primary specification: lin-lin		
	n	300			n	300	
	k	29			k	29	
	R^2	0.866			R^2	0.876	
	Adj. R^2	0.852			Adj. R^2	0.863	
Coefficient	Estimate	S.E.	P-value	Coefficient	Estimate	S.E.	P-value
Intercept	74.802	104.065	0.4810	Intercept	-7.996	116.121	0.9458
UnitTax	4.997	2.910	0.1022	UnitTax	4.883	2.109	0.0319
ATACostIndex	-0.276	0.446	0.5434	ATACostIndex	0.812	0.547	0.1545
Unempr	1348.742	1290.311	0.3090	Unempr	-1302.593	858.569	0.1457
Q2	-4.807	4.013	0.2457	Q2	-6.095	3.991	0.1432
Q3	-9.250	5.065	0.0836	Q3	-4.962	2.587	0.0702
Q4	-10.966	6.492	0.1075	Q4	-10.794	4.665	0.0320
Y2003	2.308	5.853	0.6977	Y2003	15.406	5.782	0.0153
Y2004	-17.216	17.415	0.3353	Y2004	7.412	10.149	0.4741
Y2005	1.506	21.759	0.9455	Y2005	-13.295	11.457	0.2603
BOSLAX	97.498	26.958	0.0018	ATLCVG	106.743	5.234	<.0001
BOSPHX	42.972	8.870	0.0001	ATLRIC	66.485	6.283	<.0001
DENMCO	34.701	14.416	0.0264	BHMMSY	-35.665	2.445	<.0001
DFWSLC	64.444	22.339	0.0095	BNAMSY	-27.029	4.117	<.0001
EWRLAX	104.088	29.044	0.0020	BNARDU	-11.598	4.630	0.0215
EWRORD	41.123	29.193	0.1751	BOSPIT	122.979	1.885	<.0001
FLLMCI	-37.890	3.030	<.0001	BOSRSW	9.251	3.666	0.0207
INDSEA	-22.185	11.322	0.0649	DFWSTL	60.307	7.187	<.0001
JAXMDW	-21.300	11.310	0.0750	ELPPHX	-36.143	6.282	<.0001
JFKTPA	-18.452	25.208	0.4731	ELPSAT	14.813	7.507	0.0632
LAXMCO	51.996	24.975	0.0511	LASRNO	-40.267	2.822	0.0000
LAXPVD	6.187	16.047	0.7041	MCIMSP	132.819	2.101	<.0001
LGAMSY	-11.045	20.733	0.6004	MCIOKC	-35.482	1.945	<.0001
LGARDU	3.052	32.031	0.9251	MSYTPA	-25.735	3.013	<.0001
MCIPDX	-10.360	18.067	0.5731	PDXRNO	-28.391	10.863	0.0171
MCISEA	-3.622	15.898	0.8222	PDXSEA	37.810	14.733	0.0189
MKESFO	7.385	17.245	0.6733	PHLPIT	61.883	2.190	0.0000
ORDTPA	-4.479	21.574	0.8377	SANSMF	-19.284	9.591	0.0588
PVDSAN	7.025	17.437	0.6915	SANTUS	-29.881	8.362	0.0020

The coefficients on the ATA cost index and market unemployment rate are of the expected signs only for the concentrated pool, but are not significant in either pool. Coefficients on quarter dummy variables are negative, but generally not significant. They indicate highest prices in the first quarter and lowest in the fourth quarter, which is unexpected. Year fixed effects are not significant and indicate no clear time trend for the four years studied. The exception is a sharp price increase in 2003 in the concentrated pool. This may indicate an ability to restore revenue in non-competitive markets after the difficult years of 2001 and 2002. Route fixed affects are generally not significant in the competitive pool, but significant in the concentrated pool. The estimation appears robust to functional specification, with few differences between the two specifications.

Table 5.18: Results (log-log): Competitive and concentrated pools (2002Q1-2005Q3)

	Competitive markets				Concentrated markets		
	Dependent variable: lnP				Dependent variable: lnP		
	Alternate specification: log-log				Alternate specification: log-log		
	n	300			n	300	
	k	29			k	29	
	R^2	0.877			R^2	0.907	
	Adj. R^2	0.865			Adj. R^2	0.897	
Coefficient	Estimate	S.E.	P-value	Coefficient	Estimate	S.E.	P-value
Intercept	4.415	3.264	0.1921	Intercept	-1.083	4.053	0.7921
lnUnitTax	0.381	0.233	0.1183	lnUnitTax	0.305	0.136	0.0372
lnATACostIndex	-0.168	0.518	0.7497	lnATACostIndex	1.082	0.761	0.1713
Unempr	10.185	5.621	0.0858	Unempr	-9.098	4.799	0.0733
Q2	-0.022	0.019	0.2593	Q2	-0.034	0.029	0.2508
Q3	-0.038	0.024	0.1332	Q3	-0.028	0.021	0.1950
Q4	-0.048	0.026	0.0739	Q4	-0.058	0.029	0.0632
Y2003	0.029	0.043	0.5058	Y2003	0.109	0.032	0.0027
Y2004	-0.052	0.077	0.5044	Y2004	0.056	0.055	0.3183
Y2005	0.059	0.090	0.5244	Y2005	-0.068	0.059	0.2644
BOSLAX	0.434	0.114	0.0012	ATLCVG	0.627	0.033	<.0001
BOSPHX	0.216	0.036	<.0001	ATLRIC	0.411	0.035	<.0001
DENMCO	0.190	0.078	0.0243	BHMMSY	-0.381	0.013	<.0001
DFWSLC	0.305	0.093	0.0040	BNAMSY	-0.275	0.024	<.0001
EWRLAX	0.492	0.134	0.0016	BNARDU	-0.128	0.024	<.0001
EWRORD	0.227	0.148	0.1415	BOSPIT	0.710	0.012	<.0001
FLLMCI	-0.271	0.014	<.0001	BOSRSW	0.079	0.019	0.0007
INDSEA	-0.145	0.060	0.0266	DFWSTL	0.413	0.044	<.0001
JAXMDW	-0.160	0.047	0.0028	ELPPHX	-0.436	0.034	<.0001
JFKTPA	-0.185	0.141	0.2069	ELPSAT	0.103	0.040	0.0178
LAXMCO	0.260	0.114	0.0341	LASRNO	-0.402	0.017	<.0001
LAXPVD	0.005	0.072	0.9449	MCIMSP	0.736	0.011	<.0001
LGAMSY	-0.109	0.086	0.2211	MCIOKC	-0.383	0.013	<.0001
LGARDU	-0.026	0.174	0.8824	MSYTPA	-0.212	0.018	<.0001
MCIPDX	-0.095	0.075	0.2196	PDXRNO	-0.320	0.064	<.0001
MCISEA	-0.050	0.067	0.4596	PDXSEA	0.278	0.084	0.0036
MKESFO	0.010	0.072	0.8941	PHLPIT	0.331	0.013	<.0001
ORDTPA	-0.076	0.107	0.4833	SANSMF	-0.227	0.054	0.0005
PVDSAN	0.009	0.076	0.9062	SANTUS	-0.357	0.047	<.0001

Results from hypothesis testing for the 2003 security tax holiday are shown in Table 5.19. All inferential testing for this episode is based on the primary model specification. In the concentrated markets, the estimate of the incidence of the unit tax is now sufficiently precise to reject the hypothesis that it is equal to zero. This also nearly the case in the competitive markets. Relatively speaking, the standard errors of the coefficients on the unit tax are smaller for this estimation than those obtained in the aggregate estimations. The same holds when comparing the estimation of price effects related to the unit tax for this period with the estimation of the competitive and concentrated pools for the earlier period. The hypothesis that the incidence of the unit tax is equal to one is rejected in the concentrated markets, and is somewhat close to being rejected in the competitive markets. This is the strongest evidence yet of overshifting of the unit tax, given that the point estimates are close to five.

Table 5.19: Hypothesis testing: Competitive and concentrated pools (2002Q1-2005Q3)

Coeff. value	H_0	H_1	P-value	Outcome
Competitive markets				
$\beta_2 = 4.997$	$\beta_2 = 0$	$\beta_2 \neq 0$	0.1022	Do not reject H_0
$\beta_2 = 4.997$	$\beta_2 = 1$	$\beta_2 \neq 1$	0.1708	Do not reject H_0
Concentrated markets				
Coeff. value	H_0	H_1	P-value	Outcome
$\beta_2 = 4.883$	$\beta_2 = 0$	$\beta_2 \neq 0$	0.0319	Reject H_0
$\beta_2 = 4.883$	$\beta_2 = 1$	$\beta_2 \neq 1$	0.0667	Reject H_0

Table 5.20 shows estimates of tax incidence from the analysis of the competitive and concentrated pools, as well as estimates of μ, the ratio of the incidence of the unit tax to the incidence of the ad valorem tax. Table 5.21 shows 90% confidence intervals for both types of tax incidence.

The incidence estimates for the ad valorem tax mostly fall between zero and one (generally closer to one). This is consistent with the findings in the aggregate estimation. In most cases, the incidence on the unit tax appears to be higher, although the confidence intervals are wide. With one exception, the point estimates of the incidence of the unit tax are in the 4-5 range. The exception is the estimated unit tax incidence for the concentrated markets during the

1994Q1-1997Q4 period. This could be explained by the asymmetric tax incidence documented by the GAO (2004). However, it could also be a result of the relatively large standard errors.

Table 5.20: Estimates of tax incidence: Competitive and concentrated pools

Competitive markets					
Period	Incidence of ad valorem tax	S.E.	Incidence of unit tax	S.E.	μ
1994Q1-1997Q4	0.932	0.2726	4.601	3.5318	4.938
2002Q1-2005Q3			4.997	2.9102	
Concentrated markets					
Period	Incidence of ad valorem tax	S.E.	Incidence of unit tax	S.E.	μ
1994Q1-1997Q4	0.661	0.2003	0.542	0.6115	0.820
2002Q1-2005Q3			4.883	2.1089	

Table 5.21: 90% confidence interval of tax incidence: Competitive and concentrated pools

Competitive markets		
Period	90% confidence interval of ad valorem tax	90% confidence interval of unit tax
1994Q1-1997Q4	0.482 to 1.382	-2.296 to 9.359
2002Q1-2005Q3		-1.892 to 7.712
Concentrated markets		
Period	90% confidence interval of ad valorem tax	90% confidence interval of unit tax
1994Q1-1997Q4	0.330 to 0.991	-5.216 to 6.439
2002Q1-2005Q3		-2.693 to 6.911

The value of μ is approximately five in the competitive markets and just under one in the concentrated markets. The former result would indicate the presence of imperfect competition, similar to the finding of the aggregate estimation. The latter result would indicate perfect competition, which is an unexpected result, especially as it is derived from a concentrated pool. This means either that the analytical framework which holds that μ is a measure of market power is not holding or that the estimates of μ are too imprecise. The estimates have wide confidence intervals: In no case is the difference between the two types of tax incidence used to compute μ significantly different from zero.

In order to test whether tax incidence behaves differently across the competitive and concentrated markets, a two sample t-test is conducted on the results of the primary specification for each of the two episodes. The results of this test are shown in Table 5.22. For both episodes, the hypothesis that the incidence differs between the two pools is not supported for either type of tax incidence.

Table 5.22: Hypothesis testing: Competitive vs. concentrated pools

Coeff. values	H_0	H_1	P-value	Outcome
1994Q1-1997Q4				
$\beta_{1,comp} = 0.865$ $\beta_{1,conc} = 0.613$	$\beta_{1,comp} = \beta_{1,conc}$	$\beta_{1,comp} \neq \beta_{1,conc}$	0.4238	Do not reject H_0
$\beta_{2,comp} = 0.091$ $\beta_{2,conc} = 0.009$	$\beta_{2,comp} = \beta_{2,conc}$	$\beta_{2,comp} \neq \beta_{2,conc}$	0.2456	Do not reject H_0
2002Q1-2005Q3				
Coeff. values	H_0	H_1	P-value	Outcome
$\beta_{2,comp} = 4.997$ $\beta_{2,conc} = 4.883$	$\beta_{2,comp} = \beta_{2,conc}$	$\beta_{2,comp} \neq \beta_{2,conc}$	0.9748	Do not reject H_0

Overall, the coefficients between the competitive and concentrated pools are remarkably close in value. There is no evidence that the tax incidence differs across level of competition at the route level. One possible conclusion is that the goal of disaggregating the nationwide results by studying competitive and concentrated markets has not been as effective as hoped. The implication for future research is both to increase the size of the pools, in order to reduce standard errors, and to look at other means of disaggregation. Possibilities include analyzing business vs. leisure fares or performing carrier specific analyses. An alternate conclusion is that there may be no reason to expect the pricing behavior to be different across the two pools. The airlines' revenue management techniques may not differentiate between these pools of markets or their objectives may be the same for both types.

Asymmetric Response to Direction of Tax Change

One of the GAO's findings was that the incidence may differ according to the direction of the tax change. When the tax reduction went into effect, the resulting incidence on the consumer was found to be essentially zero, whereas when the tax reinstated, it was found to be near one. In order to explore this hypothesis, the time series for the second episode is divided into two sub-periods: 2002Q2-2003Q3 and 2003Q3-2005Q4. The first sub-period captures all the decreases in the federal security service fee; the second sub-period captures all the increases. This pooling of the data is not perfect, as one period, 2003Q3, is shared by both data sets. Due to the granularity of the data, however, this is inevitable. No attempt is made to correct for this cross-correlation between the pools, so the following results should be viewed as indicative at best.

For this analysis, the 2002-2005 period is selected over the 1994-1997 period. The second period consisted of two separate shocks (see Figure 4.1), which makes it difficult to clearly identify the direction of the tax change. Also, the GAO's analysis of the 2003 security tax holiday was more rigorous, with over 100 major routes included. For the 1996-1997 tax lapse, only a qualitative analysis of thirteen hand-picked markets was conducted.

The regression uses GLS, weighted by the number of passengers. Only the primary linear specification is shown. Table 5.23 shows the results: Only $\hat{\beta}_2$ is reported, the coefficient on the unit tax.

Table 5.23: Results: Asymmetric tax incidence

Competitive markets					
Episode	n	Adj. R^2	$\hat{\beta}_2$	S.E.	P-value
FSSF decrease	120	0.929	3.697	2.7866	0.1878
FSSF increase	180	0.895	3.499	1.7876	0.0522
Concentrated markets					
Episode	n	Adj. R^2	$\hat{\beta}_2$	S.E.	P-value
FSSF decrease	120	0.947	5.494	3.0135	0.0715
FSSF increase	180	0.843	7.319	3.2964	0.0279

The coefficients are significantly different from zero in all but the first case, and even there the P-value of 0.19 is marginally close to the Type I error rate of 0.10. For the competitive markets, differences in standard errors are primarily driven by the different sizes of the sub-samples. In the concentrated pool, however, the standard error is higher for the period when the security fee increases, despite a higher number of observations. In that case, the higher statistical significance is driven by the coefficient and not the sample size.

To test the GAO's findings of asymmetric incidence, tests are performed on the null hypothesis $H_0 : \beta_{2,increase} \geq \beta_{2,decrease}$. The results of are shown in Table 5.24. In the competitive markets, the estimates of the tax incidence are very close. In the concentrated markets, the estimate of the tax incidence is in fact higher when the tax increases than when it decreases. However, in neither case is the difference statistically significant.

Parts of the GAO's findings imply that the coefficients might have opposite signs, and in particular that the coefficients during the decrease might be negative. There is some agreement between the GAO's findings and the descriptive statistics presented previously. However, the findings do not hold up in an empirical analysis which incorporates controls for other factors, which the GAO clearly states are absent in its analysis. The results presented here, although still limited, do not detect the presence of an asymmetric response.

Table 5.24: Hypothesis testing: Asymmetric tax incidence

	Competitive markets			
	H_0	H_1	P-value	Outcome
$\beta_{2,decrease} = 3.697$ $\beta_{2,increase} = 3.499$	$\beta_{2,decrease} \geq \beta_{2,increase}$	$\beta_{2,decrease} < \beta_{2,increase}$	0.5239	Do not reject
	Concentrated markets			
	H_0	H_1	P-value	Outcome
$\beta_{2,decrease} = 5.494$ $\beta_{2,increase} = 7.319$	$\beta_{2,decrease} \geq \beta_{2,increase}$	$\beta_{2,decrease} < \beta_{2,increase}$	0.3416	Do not reject

Alm, Sennoga, and Skidmore also explore the possibility of asymmetric price response to tax changes in their study on tax incidence in the retail gasoline market. This part of their work is motivated by previous findings in the literature which indicate that gasoline retail prices respond asymmetrically to wholesale prices (Alm, Sennoga, and Skidmore, 2005, p. 15). However, they find no statistical evidence for an asymmetric response to tax changes, but are able to confirm that consumer prices react more quickly to increases in wholesale prices than to decreases (Alm, Sennoga, and Skidmore, 2005, p. 16).

CHAPTER VI

CONCLUSIONS

This study represents an initial exploration of tax incidence in the airline industry, a topic not previously analyzed in the economic literature. The large DB1B origin destination survey is used to compute average fare information for U.S. domestic air travel. The DB1B database reports tax inclusive fares. Ticket taxes and fees are retroactively computed based on the fare and itinerary of each ticket. The effective tax rate for each ticket is also computed.

An econometric analysis is conducted at the aggregate level and for two subsets of the data, one pool of heavily contested routes and another of heavily dominated routes. The analysis covers two episodes when the U.S. ticket tax structure was subjected to relatively large and sudden reductions in taxes. The first episode consists of the periods January 1-August 26, 1996 and January 1-March 6, 1997. During these dates, the federal government’s authority to collect the ticket taxes lapsed as a side effect of congressional negotiations on reforming the ticket tax structure. At that time, the federal ticket tax consisted solely of an ad valorem tax. The second episode lasted from June 1 to September 30, 2003, when the federal security fee was suspended as part of a financial relief package for the airline industry. Longitudinally, the data sets each cover four years, approximately centered on the tax shock.

Reduced form multivariate regression is used to estimate the effect of variations in the ad valorem tax rate and unit taxes on the tax inclusive fare. Additional independent variables are used to control for exogenous demand and supply shifters, including an airline cost index and seasonally adjusted unemployment rates for each city-pair. The aggregate regression also includes controls for quarter fixed effects, overall time trend, and the market share held by low-cost carriers. Market concentration is controlled for by creating pools of twenty competitive and concentrated markets, respectively. Markets are allocated to the pools by estimating lower and upper bounds on the Herfindahl-Hirschman Index. The regression analyses of these pools are also controlled for year, quarter, and route fixed effects.

Several challenges exist to conducting an empirical analysis of tax incidence in the air transportation industry. First, the ad valorem tax has a multiplier effect: Any increase in taxes results in an even higher increase in consumer price, since part of the change is collected as additional tax revenue. Second, the price effects of unit taxes and ad valorem taxes are functionally linked, potentially in non-linear ways. Third, the history of the structure and levels of U.S. ticket taxes and fees excludes the possibility of a natural experiment and lacks substantial simultaneous variations in ad valorem and unit taxes. Fourth, the airline industry is an oligopoly, but is not clearly categorized by any of the standard analytical models of imperfect competition. This complicates the transition from theory to empirical analysis. Finally, there are a number of political and institutional details affecting taxation in the airline industry, which are not captured by current theory. These constitute a particular challenge, especially in analyzing air transportation economics in the post-2001 environment.

Summary of Conclusions

The tax incidence of the ad valorem tax generally falls between zero and one, indicating that the burden is shared between consumers and producers. The estimates are closer to one than to zero, indicating that consumers may carry more of the burden. This is particularly true in competitive markets. This may mimic the theoretical result of a tax incidence of unity in the long run framework of free entry and exit under perfect competition. In conclusion, the empirical estimates of the incidence of the ad valorem tax do not fall outside the bounds of predicted by economic theory. The best available, prior theoretical estimates place the incidence in the range of 0.3 to 0.5 under perfect competition. The results of this study indicate that such values are at the low end of empirically derived confidence intervals.

It should be kept in mind that the data used for the analysis of the ad valorem tax is approximately ten years old. This may limit the potential of generalizing the results obtained here. The 2003 episode only featured variation in the unit taxes and is therefore unable to contribute to an updated understanding of the incidence of the ad valorem tax.

In the case of unit taxes, the incidence generally appears to be higher. However, the estimates are imprecise, to the point where the possibility of negative values cannot be excluded. The historical variation in unit taxes is much smaller than that of the ad valorem tax, which makes it more difficult to determine the price impact of tax changes. At best, it can be concluded that there is weak evidence that the unit tax has a higher incidence than the ad valorem tax. This would imply overshifting of the unit tax onto the consumer and could also indicate the presence of imperfect competition.

The principal airline trade organization in the U.S., the Air Transport Association, has clearly stated that taxation is high priority concern for the industry. ATA asserts that the industry's lack of pricing power prevents it from passing on tax increases to passengers. This is equivalent to a hypothesis that the incidence is equal to zero, so that the producer bears the full tax burden. Provided that the analysis of historical tax shocks presented in this study can be generalized to tax changes in the current economic environment, then this hypothesis can be rejected. There is considerable historical evidence that a significant portion of ticket taxes and fees are borne by passengers.

Note that in the 1994-1997 period there is very little variation in the unit taxes, which is one reason why the estimates of incidence on unit taxes are imprecise for that episode. What little variation exists comes from changes in PFC collections, as well as the introduction of the segment tax towards the end of the period. Nominally, the point estimates of the tax incidence of the ad valorem tax and that of the unit tax show large differences. In particular, the tax incidence of the unit tax appears to be higher in the competitive markets. However, these differences are not statistically significant.

In the 2002-2005 period there is considerably more variation in the unit tax, primarily as a result of the 2003 security tax holiday. For concentrated markets, the estimate of the incidence of the unit tax is statistically significant from zero, and in the competitive market it is nearly so. The point estimates are in the range of four to five, indicating the possibility of overshifting of the unit tax. In this episode there is no variation in the ad valorem tax rate, preventing a comparison of the two types of tax incidence.

The lack of simultaneous variation in both the ad valorem rate and the unit tax degrades the ability to conduct a study of market power in the airline industry based on an analysis of tax incidence. If the two types of tax incidence can be assumed to be consistent over time, then the incidence of the unit tax from the second period can be compared to that of the ad valorem tax from the first period, which would provide some evidence in support of imperfect competition. The benefit of this approach is that it takes advantage of the specific periods which saw the highest variation in unit and ad valorem taxes, respectively. However, a comparison across time is problematic, as substantial structural changes have taken place in the airline industry over the course of time included in this analysis.

In its 2004 report on ticket taxes, the GAO found evidence that the burden lies on the producer when the tax goes down, but shifts to the consumer when the tax goes up. This study is unable to find evidence for this phenomenon, which is excluded by the analytical framework incorporated here. This does not necessarily mean that the GAO’s finding is incorrect. It may simply reflect the difference in granularity of the data (weekly vs. quarterly changes) or a failure of the theoretical framework to adequately explain this outcome.

Various functional forms are evaluated in this study. With few exceptions, the estimates are found to be robust to different model specifications. However, each specification represents a compromise, as the tax incidence of the ad valorem tax and that of the unit taxes cannot be directly estimated simultaneously. There are two basic options: One is to directly estimate the incidence of the ad valorem tax, in which case one can only obtain an elasticity estimate for the unit tax. The second is to directly estimate the incidence of the unit tax, in which case the tax incidence of the ad valorem tax must be scaled by the tax inclusive price, which serves as the dependent variable. The ad valorem tax incidence also includes a non-linear multiplier effect. Further, theory shows that the taxes are linked, which is not accounted for in the empirical framework.

Because of the limitations inherent to empirical models of a joint policy of ad valorem and unit taxes, the estimated coefficients on the taxes are biased. For example, the absence of the multiplier effect tends to bias the coefficient on the ad valorem rate downwards. Other researchers convert the ad valorem tax to a unit tax, which introduces price on the right hand side. This does not eliminate bias as it raises potential endogeneity concerns.

The control variables introduced in the regressions add surprisingly little explanatory power, with the exception of quarter and route fixed effects. This makes it difficult to isolate to what extent fare changes are causally related to the observed changes in ticket tax rates and levels. The lack of a natural experiment poses considerable challenges to estimating the incidence of airline ticket taxes and fees. The lack of a control group makes it particularly difficult to isolate the impact of events which are contemporaneous with tax changes.

Directions for Further Research

In the end, it is possible that all the current results indicate is that taxes are split between airlines and customers. There may be too many unobserved factors to obtain estimates which would allow for other conclusions. Also, the disaggregation of the data may not be sufficient or of the correct form to generate more specific results. The weak statistical significance of exogenous control variables indicates a need for an improved fare model. The intent would be to better isolate the impact of exogenous factors and to more accurately model price competition in the industry. In particular, more sophisticated handling of effects related to market concentration and the presence of bankrupt carriers should be considered. Another possibility is that low cost carriers react to carriers differently than legacy carriers. This hypothesis is only indirectly explored here by separating out competitive and concentrated markets. A more explicit control for LCC behavior should be considered. The use of structural models instead of a reduced form should also be looked at in future efforts.

The current study consists of a partial-equilibrium analysis, which ignores the spending of the tax revenues collected. A limitation of this approach is that it disregards the value that airlines and passengers receive from the public spending of ticket taxes and fees. In order to avoid this limitation, estimating the balanced-budget incidence should be considered in future work.

Even with the existing model, the level of sophistication and detail can be improved. The original data set is extremely rich, with nearly 150 million observations, but it is reduced to at most 320 observations for any one regression. Possible improvements to the analysis include increasing the number of markets, controlling for competition by entering a measurement of concentration into the specification, and controlling for the effect of connections in an itinerary. These measures are excluded because of computational limitations: Increased resources and development of automated techniques would allow to better capitalize on the richness of the original data.

Another limitation on the number of observations is the need to inspect all route-pairs for close substitutes in the pool of concentrated markets. Avoiding this step would easily allow the number of markets to be increased to incorporate the full pool of markets (approximately 750 markets, or up to 12,000 observations for each episode). There is no reason justified by econometrics to limit the pools to twenty routes, or even to have identical numbers of competitive and concentrated markets. Since standard errors are inversely proportional to the number of observations, any increase in the sample size is likely to improve confidence in the results. With the ability of more precisely distinguishing the price impact of the unit tax vs. that of the ad valorem tax, a natural extension would be to estimate market power in the airline industry by examining the ratio of these two types of tax incidence.

It would also be desirable to introduce information about the fare class into the analysis (e.g., restricted leisure fare, unrestricted leisure fare, business class, first class). This information is not available in the DB1BMarket sub-table. It is available in the sub-table DB1BCoupon, which contains segment specific data. It does not include fare data, and is therefore in and of itself not sufficient for the analysis of tax incidence. A relational database could be created by linking the origin-destination records of DB1BMarket to the segment specific records in DB1BCoupon. This would also allow for controlling for differences between round-trip, one-way, and open-jaw itineraries. This would, however, be computationally intensive and certain technical challenges would need to be overcome. For example, the fare class may change between segments, so that any one fare may be associated with multiple fare classes. However, the investment in this approach may be worth it, as it has the potential to substantially improve the estimation of tax incidence.

The GAO observed what may be asymmetric responses to tax changes: Base fares rose when taxes were lowered and rose again when taxes were increased. Limited evidence of asymmetric response is also found in this study, for example in the passenger weighted averages of fares before, during, and after the tax shocks. This result does not directly follow from the theoretical framework presented here, but could be explained by theories which incorporate strategizing, fare wars, or other forms of imperfect competition in the industry. No evidence of asymmetric tax incidence is found in the regressions conducted for this study, but the evaluation of this hypothesis is rudimentary. A more in-depth theoretical exploration of asymmetric price response to tax changes combined with a rigorous treatment of this eventuality in the empirical specification would be valuable.

In addition to possible model improvements, there is also the potential for practical applications of this research. At the time of writing the interest at the national level regarding ticket tax issues remains very high. This is due to the 2007 reauthorization of the Airport and Airway Trust Fund and to the ongoing labor negotiations between the FAA and its air traffic controllers. The majority of controller salaries is funded through federal ticket taxes. It should be recalled that the original lapse in federal tax collection authority was caused by a similarly contentious debate over the reauthorization of the trust fund. This time, the significance of the debate is heightened by the financial struggles of the airline industry.

The FAA has developed a decision support system, the National Airspace System Strategy Simulator (NSS), to analyze potential changes in the federal ticket tax structure. NSS is a macro level model which allows decision makers to predict the impact of policy changes on aviation demand and on federal tax revenues (Ventana Systems, Inc, 2006, p. 1).

Several applied research projects on tax incidence are possible using NSS. There is a basic need to verify whether NSS models tax incidence in a manner that is consistent with theory and which matches empirical findings. The NSS simulates air travel demand using a constant elasticity demand curve with a price elasticity set at −1 (Ventana Systems, Inc., 2006, p. 3). The supply side model, on the other hand, is based on a linear supply curve. These simplifying assumptions place considerable constraints on the theoretical outcomes of tax incidence. One project would be to verify whether the model is internally consistent with its assumptions. A second project would be to improve the model to allow for more complex behavior. General consistency with empirical findings on the incidence of ticket taxes and fees should also be verified. As currently implemented, NSS does not include information on the tax shocks of 1996-1997 and 2003. These tax changes could be entered into the simulation, to verify that NSS reflects historical changes in demand, tax revenue, and tax incidence caused by changes in tax rates and levels.

The combination of very rich data sets, scarcity of previously published research, and high relevance to the crafting of public policy, makes incidence of ticket taxes a particularly appropriate topic for future work. This study provides several initial insights into tax incidence in U.S. air transportation. The study also identifies many challenges, both theoretical and practical, to be addressed in future research. It is hoped that this study will encourage both additional scholarly inquiry and public policy debate on the incidence of ticket taxes and fees, as well as the broader question of how to improve the funding system for air transportation infrastructure.

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