Air Travel Fares and the September 11 Security Charge: A Lesson of Tax Incidence

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Abstract

Tax incidence is a well-studied topic in public economics and in industrial organization. However, little work focuses on the taxes in the US airline industry. This paper investigates the relationship between airfare and the September 11 Security Service Charge, which experienced the first increase on July 21, 2014, since its imposition back in 2002. We test two theoretical hypotheses: (1) September 11 Security Charge is being over-shifted onto passengers, and (2) such tax incidence decreases as competition increases. We contribute to the literature by providing fresh evidence of tax incidence in the airline industry, and demonstrating heterogeneity of the pass-through rates in some products. Consistent with existing literature, on average, evidence of over-shifting of the tax is found: every one-dollar increase in the tax results in approximately a three-dollar increase in the fare. Segmenting the dataset based on market structures reveals that tax incidence decreases as competition increases, which is consistent with theoretical predictions. Premium cabin passengers surprising do not bear as much incidence as coach passengers. Non-direct services and one-way itineraries bear more incidence compared to direct services and roundtrip tickets, respectively. Our results are robust to accommodating industry-wide structural changes, instrumenting potentially endogenous fleet choice, and altering market definitions. We call for future mechanisms to potentially contain this over-shifting behavior.

JEL-Classification: H22, L11, L93, R41
Keywords: Tax incidence, Pass through, Airline industry

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1 Introduction

In 2012, the US Department of Transportation (DOT) implemented the full-fare disclosure rule, which requires carriers to include all relevant taxes and fees in published fares. As a result, the airfare displayed by airlines and online travel agencies is always tax-inclusive and may contain a service fee. If passengers are to wonder what relevant taxes are charged, they would need to examine the receipt to find out the imposition of different taxes, and more importantly, the amount of tax charges. In some countries, online travel agencies or airlines display before-tax prices for air travel tickets. Customers need to proceed with the checkout process to actually determine the final airfare, including all relevant taxes. At this point, customers find out the displayed fare is not necessarily that cheap.

Currently, airlines in the U.S. are free to choose which markets they serve and what fares to charge. However, airports must be managed, and federal and local governments have continued to provide air traffic services along with airlines. Especially after September 11, security screening has been enhanced and expanded to ensure travelers' safety. These functions are supported through passengers paying necessary taxes. Four taxes are currently levied on domestic plane tickets: the Ticket Tax, the Passenger Facility Charge, the Segment Tax, and the September 11 Security Charge. The Ticket and the Segment Tax are collected by the Federal Aviation Authority (FAA). The Passenger Facility Charge is paid to airports. Their levels have been changing over the course. For example, the September 11 Security Charge was just increased in July 2014. [1] The September 11 Security Charge supports security-related activities directed by the Transportation Security Administration (TSA). See Section 3 for details.

In economics, the go-to question in taxation is how much of the tax incidence falls on the consumer and/or the producer side. Questions in this arena include: how do these fares change when any of the taxes change? Do the customers and firms share the tax burden? Are there any differences in the tax incidence for different products? In the context of the airline industry, is the tax incidence different for different service classes; is the tax incidence greater for roundtrip or one-way tickets? These questions are of scholarly interest and are essential for designing appropriate public policy pertaining to these taxes. In particular, it may be undesirable for a carrier to over-shift the tax, which essentially means that the carrier is benefiting from the imposition (or change) of the tax. Relying on the standard assumption of full optimization, under the condition of a perfectly competitive market, across different products, may resulting misleading conclusions.

In this paper, we choose the September 11 Security Charge to investigate these questions. Under-shifting occurs if for every one-dollar increase in the tax leads to a less-than-one-dollar increase in the fare. Full-shifting represents a one-to-one tax to fare relationship. Over-shifting occurs when a one-dollar increase in the tax is accompanied by a more-than-one-dollar increase in the fare, holding everything else constant. As theory suggests, this can occur if the market is imperfectly competitive. The paper tries to detect to what extent the September 11 Security

[1] For international travels, there are also international departure and arrival fees with $ 17.70 each for FAA as of July 2015.

Charge is shifted onto passengers, following its increase in July 2014.

Inspiration for the current paper credits Huang and Kanafani (2010), in which they examine the tax incidence of the passenger facility charge (PFC). However, the sample period they investigate is between 1993 and 1995. In the past two decades, many events have occurred that may ultimately lead to a structural break or changes in airfares. For example, the September 11 terrorist attacks fostered the emergence of the security charge. The 2007-2009 Recession may theoretically also affect demands for domestic travel, thus affecting the ability of airlines to shift the tax charges. Moreover, the tax of interest in the current study is the September 11 Security Fee instead of the previously-studied PFC. Therefore, it makes sense that the estimates of Huang and Kanafani (2010) would be statistically different from the estimates of the current study. In earlier thesis work, Karlsson (2006) investigates tax incidence of the all the domestic tickets and finds the incidence of the ad valorem Ticket Tax is greater than that of unit taxes (Segment Tax, PFC, September 11 Security Charge, all combined). That paper focuses on two different periods before 2005, which is also distant from our sample timeframe.[2] Hence, it may not be surprising for our results to be statistically distinguishable from that study.

Traditionally, studies on tax incidence require implicit or explicit assumptions of a competitive industry and constant marginal cost (see Besley and Rosen (1999), and Kenkel (2005)). This paper makes a contribution to the literature by studying a common theme (tax-shifting and tax incidence) in an imperfectly competitive, oligopolistic market - the airline industry, in which airlines are price setters.[3] Taxation theory suggests that in a Cournot oligopolistic market where firms are price setters, tax-shifting may be more or less than 100 percent. We complement the existing literature by specifically investigating tax incidence of the September 11 Security Charge, for which has yet to be studied fully, to the author's knowledge. This study also serves as an empirical testing of the theoretical predictions seen in the literature, such as Stern (1987), Anderson, de Palma, and Kreider (2001), and Weyl and Fabinger (2013). Following Besley and Rosen (1999)'s framework, we also present a different way to construct a proxy variable that captures the fuel cost at the itinerary level, which becomes useful in our reduced-form analysis.

The sample time for the study is from the third quarter of 2013 to the third quarter of 2015. A major change of the September 11 Security Charge took place in July 2014. Due to limitations of the raw data, the third quarter of 2014 is subsequently excluded from the study, however. With a pooled panel dataset, evidence of over-shifting of the tax on average is found: every one-dollar increase in the tax results in approximately a three-dollar increase in the fare. By segmenting the route/market by market structures using definition from Dana and Orlov (2014), we show that tax incidence decreases as competition increases, which is consistent with theoretical predictions. To be exact, in monopoly routes, tax incidence is roughly five dollars per dollar of the security charge. In duopoly routes, such an incidence drops to approximately three dollars. As competition

[2]Karlsson (2006) uses demand and supply shifters for regressions. He recognizes potential limitations in the lack of information of fare classes and other factors. The current paper does incorporate a richer set of control variables, namely ticket, coupon, and market characteristics from the DB1B database.

[3]Perloff (2008) states that oligopolistic firms are price setters rather than price takers.

further increases on routes, the incidence falls to about two dollars. At the market level, results do not change qualitatively. Premium cabin passengers surprising do not bear as much incidence as coach passengers. Non-direct services tickets and one-way itineraries on average bear more incidence compared to direct services and roundtrip tickets, respectively. Those routes/markets with direct services tend to be more competitive, and therefore this result is not surprising. Those purchasing one-way tickets may be more inflexible in their scheduling, and therefore the inelastic price elasticity of demand could play a central role in explaining the result. Legacy carriers shift more of the tax to the passengers in non-competitive routes/markets, while such a trend reverses in a more competitive setting. Several robustness checks help confirm that our findings are not a result of implicit assumptions involved. We call for future research to devise mechanisms with the aim to potentially contain this over-shifting behavior that 'benefits' firms.

The remainder of the paper is structured as follows. Section 2 presents a literature review in tax incidence, both theoretical and empirical. Section 3 provides a brief overview of the taxes in the US Airline Industry. Section 4 discusses the source as well as descriptions of the data. Section 5 establishes an empirical estimation strategy, building on a theoretical framework. Section 6 offers results and general robustness checks. Section 7 acknowledges the limitations of the study and concludes with a brief summary and final remarks.

2 Literature Review

Standard tax incidence theory posits that the extent of tax burden on consumers and producers depends on the price elasticities of supply and demand. In a perfectly competitive market with constant marginal costs, 100 percent of the tax incidence falls on the consumers. With imperfect competition, such incidence, in the long run, can be larger or smaller than 100 percent.[4]

Despite its importance in the discipline of economics, not many studies actually look into the effect of air travel taxes on ticket prices. Huang and Kanafani (2010) look at the incidence of the passenger facility charge using data between 1993 and 1995. By treating the imposition of passenger facility charges as natural experiment, they conclude that a three-dollar increase in the passenger facility charge leads to a 6.5-dollar increase in the airfares. In other words, the tax burden on passengers is more than 200 percent. Bradley and Feldman (2016) look into the effect of full-fare disclosure rule on tax incidence. They discover that the display of the tax-inclusive ticket prices is associated with a reduced tax incidence for passengers and the reduction depends on market concentration.

Nevertheless, the evidence of over-shifting the tax is not new to the economic literature; several papers present theoretical bases. Stern (1987) shows that over-shifting the tax is theoretically possible with monopolistic competitive firms and Cournot oligopolistic markets. Anderson, de Palma, and Kreider (2001) extend this analysis to Bertrand firms.

Many scholars have devoted substantial efforts to this tax shifting literature in different in-

[4]See Kotlikoff and Summers (1987), Fullerton and Metcalf (2002), and Tresch (2015) for more detailed discussions.

dustries. Harris (1987) finds a nine-cent per pack cigarette tax led to a 16-cent increase in the price per pack. In the classic paper by Besley and Rosen (1999), they use data from the American Chamber of Commerce Researchers Association (ACCRA) to investigate the relationship between sales tax and the prices of different grocery commodities. They find that for some groceries, the tax-shift is 100 percent, meaning consumers bear the entire tax burden; for other items, there is tax-overshifting, suggesting that if the tax is increased by one dollar, the price to consumers increases by more than one dollar. Young and Bielińska-Kwapisz (2002) detect over-shifting of state and federal alcohol taxes imposed on retail alcohol prices, and the price increase occurs within three months of the tax imposition. Kenkel (2005) conducts telephone surveys before and after the 2002 alcohol tax hikes in Alaska, and he finds evidence of tax over-shifting. Hanson and Sullivan (2009) discover that Wisconsin's $1 tobacco tax increase was over-shifted to the customers with a premium around 8-17 cents per pack.

In some other industries, however, taxes are shown to be entirely passed onto customers. Using monthly data from 48 states and the District of Columbia, and applying fixed effects, reduced form, seemingly unrelated regressions, Chouinard and Perloff (2004) find that the federal specific gasoline tax falls equally on consumers and wholesalers; whereas state specific taxes fall almost entirely on consumers. Using retail gasoline prices of the 50 U.S. states between 1984 and 1999, Alm, Sennoga and Skidmore (2009) find full-shifting of state gasoline taxes.

Additional papers have also concluded that tax under-shifting occurs. Delipalla and O'Donnell (2001), investigating the tax incidence of both ad valorem and specific taxes in the European cigarette industry, find undershifting under both scenarios, with the specific tax having a larger impact on prices.[5] Using gas-station level daily prices before and after the temporary suspension of the gasoline sales tax in Illinois and Indiana in 2000, Doyle and Samphantharak (2008) find that 70% of the tax suspension is passed on to consumers, reducing the gasoline prices, while 80% to 100% of the subsequent tax reinstatements are passed on to consumers. Harding, Leibtag, and Lovenheim (2012) discover that state cigarette taxes are borne by both consumers and producers. Chiou and Muehlegger (2014) also find the majority of the burden of state cigarette tax hike is borne by the consumers.

3 Taxes in the US Airline Industry

Currently in the United States, four different taxes are levied on all domestic tickets. The four taxes are collected by different parties. The ticket tax, an ad valorem tax collected by the Federal Aviation Authority, is charged at 7.5% of the base fare. It has been stable at 7.5% for more than a decade. The passenger facility charge, collected by each airport involved in the itinerary, is charged per takeoff; its rate varies by airports. The segment tax, collected by the Federal Aviation Authority, is currently charged at four dollars per takeoff. It has gradually increased from one

[5] Some formulae derived in Delipalla and O'Donnell (2001), however, has been proven incorrect by Reny, Wilkie and Williams (2012).

dollar in 1997 to the current rate. [6][7]

The focus of the current paper is the September 11 Security Charge, for which the idea was fostered after the September 11 Terrorist Attacks. The attacks and the threat of future potential attacks fostered the need for more and better security screenings as well as safety measures. These attacks led Congress to enact the Aviation and Transportation Security Act [8], which establishes the Transportation Safety Administration as a governmental agency within the Department of Transportation.

Sometimes referred to as the Federal Security Service Fee (FSSF), the September 11 Security Charge was first introduced in December 2001. Started from February 2002, it is imposed on "passengers of domestic and foreign air carriers in air transportation, foreign air transportation, and intrastate air transportation originating at airports in the United States." The fee was initially set at $2.50 per flight segment (enplanement). One cannot be charged with more than two enplanements per one-way (four enplanements per roundtrip). That is to say, the security charge is capped at $5.00 for one-way tickets and at $10.00 for roundtrip tickets.

Figure 1: Federal Ticket Taxes, 1992-2015 [9][10][11]

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[6] Throughout the paper, we follow the definitions adopted by the Federal Aviation Authority. Using definitions in 49 CFR 1510.3, a passenger enplanement is defined as "a person boarding in the United States in scheduled or nonscheduled service on aircraft in intrastate, interstate, or foreign air transportation." A roundtrip is defined as "a trip on an air travel itinerary that terminates at the origin point." Letter from Air Transportation Association to Docket TSA-2001-11120 defines one-way trip as "continuous travel from a point to another point during which a stopover does not occur." A stopover refers to "a break in travel of more than 4 hours between two domestic flights or 12 hours between a domestic flight and an international flight or two international flights." See Federal Register Vol. 79, No. 119 for more details.

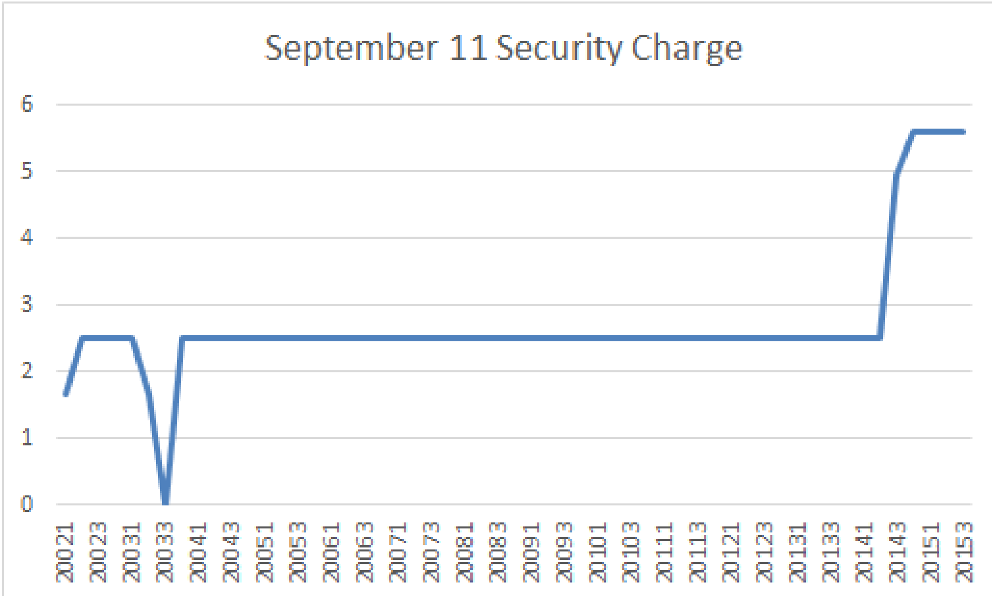
[7] For a detailed tax structure of the airline industry in the US as of 2014, visit: `http://www.faa.gov/about/office_org/headquarters_offices/apl/aatf/media/14.1.17ExciseTaxStructureCalendar2014.pdf`. For 2015, visit: `https://www.faa.gov/about/budget/aatf/media/ExciseTaxStructureCalendar2015.pdf`.

[8] See Public Law 107-71 (ATSA).

[9] Note that not all of the tax changes are administered at the beginning of the quarter. Following MIT's strategy, taxes are pro-rated by the number of days when variations occur within a quarter. For example, the September 11 Security Service Fee was increased to $5.60 per one-way starting July 21, 2014. Therefore, such a fee in the third quarter of 2014 is calculated by the weighted average of the former tax ($2.50) and the new tax ($5.60) with the weights being the number of days in the quarter during which such a tax were in effect.

[10] This matching strategy is different from Huang and Kanafani (2010). In their strategy, if the change of PFC is put into practice on the first day of February, May, August, or November, the change is assigned to the same quarter. However, if the change takes place on the first day of March, June, September, or December, the change is then assigned to the subsequent quarter.

[11] Congress mandated a fee suspension period from June 1, 2003 through September 30, 2003. Hence a temporary decline in the rate is seen.



Source: MIT Airline Ticket Tax Project, updated by the author.[12]

TSA claimed that the security charge collected was insufficient to cover TSA's cost for providing civil aviation security services. Following the Bipartisan Budget Act of 2013 (hereafter Budget Act), the service charge was "restructured." Effective July 21, 2014, the September 11 Security Charge imposed on domestic tickets was increased from \$2.50 per flight segment (enplanement) with a \$5.00 per one-way (or \$10.00 per roundtrip) cap, to \$5.60 per one-way with no cap. The actual taxed amount depends on whether the itinerary has a layover of four or more hours. For domestic flights (not including to Alaska and Hawaii) with a layover of four or more hours, the portions before the layover and after the layover are considered as two one-ways, which adds an additional \$5.60 to the calculation of the tax.

The effect of this tax increase can either be small or large, depending on itineraries. Consider a one-way itinerary from New York (JFK) to Chicago (ORD). Prior to the policy change, this itinerary consisted of just one enplanement, and therefore the charge is \$2.50. After the change, this is an one-way trip, so the charge is \$5.60. Imagine a roundtrip itinerary that consists of five segments with stopovers at the end of each segment, such as Newark (EWR) to Chicago (ORD), Chicago (ORD) to Denver (DEN), Denver (DEN) to Las Vegas (LAS), Las Vegas (LAS) to Chicago (ORD), and Chicago (ORD) to Newark (EWR).[13] Passengers are only charged \$10.00 since the itinerary involves four chargeable enplanements and it was capped at \$10.00 before the change. With the new policy, each stopover counts as a single one-way, increasing the tax charge to \$28.00.

Effective December 19, 2014, the new policy was slightly modified to include a cap for roundtrip tickets at \$11.20. For most of the itineraries, this small modification did not alter the Security Charge much. For instance, for the Newark-Chicago-Denver-Las Vegas-Chicago-Newark itinerary

[12] One can retrieve the information at `http://web.mit.edu/TicketTax/download.html`. The graph is simplified to reflect the minimum charge one faces for this tax.

[13] This example comes from the Transportation Security Authority at `https://www.tsa.gov/for-industry/passenger-fees-faq`.

mentioned above, the new charge is $11.20 since it is considered a roundtrip with two chargeable one-ways.

4 Data

4.1 Sources

The first data source for the study comes from the Airline Origin and Destination Survey Database (DB1B), maintained by the Bureau of Transportation Statistics (BTS). It represents approximately 10 percent of the domestic tickets as major airlines are required to report tickets meeting certain characteristics.[14][15] Data variables include origin, destination, as well as itinerary-related details. The database is divided into three closely-connected tables: DB1BMarket, DB1BCoupon, and DB1BTicket.

In DB1BMarket, the dataset is composed of directional market characteristics, including reporting carrier, origin, destination, prorated market fare, number of market coupons, market miles and indicators of carrier change. DB1BCoupon provides coupon-specific information for each domestic itinerary, including operating carrier, airport of origin and destination, number of passengers, fare code, trip break indicator, and distance. DB1BTicket records ticket-related characteristics, such as reporting carrier, itinerary fare, the number of passengers, origin, roundtrip indicator, and miles flown. In each table, there is an exclusive ID assigned to each itinerary. Such a variable allows us to combine all three tables together to produce a more comprehensive dataset.

The airfares reported in DB1B are tax-inclusive. We need to work backwards to calculate all the relevant tax charges. To obtain the detailed tax rates and charges, we turn to the second and the third data sources: the Federal Aviation Administration (FAA), and the MIT Airline Tax Project[16]. We are then able to determine the different tax charges and manually match the DB1B dataset with different levels of the September 11 Security charge according to ticket characteristics.[17]

We obtain cost-related information from the Air Carrier Financial Report Schedule P-12(a), the fourth source, reported by BTS. In the report, we specifically utilize the per unit fuel cost. We then combine fuel efficiency data for each aircraft and the distance of each segment of the itinerary to calculate the final minimum fuel cost for any specific itinerary, which serves as a proxy for the operating cost for a given itinerary. The need of a proxy is justified in Section 5.

Market structures can play a major role in determining tax incidence, as theory suggests. Hence, we segment the market into three distinct market structures based on market shares. Conventional

[14] Major airlines are required to report each ticket with a serial number ending in 0 or if ten or more passengers are on that specific itinerary.

[15] For detailed explanations of the variables and tables, visit: `http://www.transtats.bts.gov/DatabaseInfo.asp?DB_ID=125&Link=0`.

[16] The MIT Airline Tax Project provides detailed tax charges from 1992 to 2011. Subsequent data from 2012 onward are updated from the author using data obtained from FAA.

[17] See Appendix A.2 for examples on how taxes are matched.

to the industrial organization literature, we also use data from DB1B to do so.[18][19] Since there is not an uniform definition on how market share is calculated, we use the number of passengers enplaned for a particular route over the total number of passengers for that route, as seen also in Dana and Orlov (2014).[20]

Airports with nonstop service in between the endpoints tend to be more competitive, compared to those without direct services. For example, LAX-SFO, a route with multiple carriers providing nonstop service every day, is definitely more competitive than LAX-LNK, a route without nonstop services. We utilize this generality to also segment our dataset into two partitions: direct services and nondirect services. Effectively, for a given itinerary, the following must hold: (i) there are no more than two segments, and (ii) it must be a roundtrip if the ticket has exactly two segments. Any itineraries violating the aforementioned criteria are considered with nondirect services.

4.2 Sample Discussion

The entire dataset after merging with all relevant information is a panel dataset, spanning from the third quarter of 2013 to the third quarter of 2015. To circumvent potential interactions with other taxes, as illustrated in Besley and Rosen (1999), the timing of the sample was specifically chosen so that all other tax rates on domestic air travels barely change.[21][22] Since the change of the September 11 Security Charge was administered on July 21, 2014, and that our dataset does not provide details to the days, we need to eliminate the third quarter of 2014 in fear of contaminating our analysis. The obtained dataset (before any steps of refining) contains roughly 3.5 million observations in each quarter studied.

The original comprehensive dataset is too large, so that some steps must be taken to shrink the dataset for timely estimation. Any itineraries with more than six coupons (enplanements) are dropped. Domestically, it is highly unusual for one to have more than six segments in an itinerary. We make several restrictions on fares. Ticket fares exceeding $10,000 are also dropped. Zero fare itineraries are also excluded. Itineraries with a negative base fare are eliminated also.[23] Ticket prices for economy class is restricted to be in no more than $1,500, while premium cabins tickets can only be as cheap as $50 and as expensive as $4,000. We consequently drop those itineraries with the total miles flown being more than 10,000 miles. Tickets purchased in bulk are disregarded.

[18] The Herfindahl-Hirschman Index (HHI) is a commonly-used measure of market concentration. However, the nature of it being endogenous warrants the need of instruments when it enters the reduced-form regression as an explanatory variable. Instead, we opt for segmenting the market into three distinct market structures based on market shares to circumvent the endogeneity problem.

[19] Some other papers also use both DB1B and T-100 as data sources. See Cristea (2011). The under-representation of DB1B suggested by Cristea (2011) does not apply here because we restrict our focus on domestic travels only.

[20] Dana and Orlov (2014), however, uses also DB1B for market shares.

[21] Besley and Rosen (1999) include some other tax rates as explanatory variables and patterns of significance do not seem to be altered.

[22] In the last two quarters of 2013, the segment tax was at $3.90 per segment. We specifically make sure that this is reflected in the construction of the dataset. Here, we make an innocuous assumption that there is no interaction between the taxes.

[23] We use the tax-inclusive fare as well as characteristics from the dataset to determine the base fare and any associated tax charges.

Itineraries with zero dollar credibility are dropped. To make tax incidence analysis simple, we do not allow changes in ticketing carriers in any itinerary. [24] The only exception here is US Airways and American Airlines due to their merger. After the second quarter of 2014, US Airways and American Airlines are considered the same carrier.[25] To accurately capture the effect of service class, all the itineraries included in the study will not have any change of cabin classes. This means, for example, that if in an itinerary the first segment is economy class and the other segment(s) is/are business or first class, this itinerary is dropped. Any coupons that are not of U.S. reporting carrier flying between two U.S. points are dropped also. Multi-city tickets are excluded. After that, we randomly sample 10% of all the remaining observations.[26] Lastly, we collapse observations, weighting the fare, September 11 Security Charge, and the fuel cost by the number of passengers in a given itinerary.

It is important to note the distinction between a route and a market. Here a route refers to any origin and destination pair, regardless of whether a layover takes place. That is to say, Los Angeles (LAX) to Lincoln (LNK) is considered as a route, even though a layover is necessary as there are no direct flights. Also, routes are directional, so that LAX-LNK is not the same as LNK-LAX. It is possible that a carrier is operates as a monopoly from A to B and from B to C, but yet faces stiff competition from A to C.[27] Throughout the paper, we conduct our analyses at both the route level and the market level. A market is different from a route in the sense that a market refers to any location to location pair. [28] Table 1 provides summary statistics of the resulting dataset for key variables, one panel presenting the route level, and the other the market level.

There is not a big difference when one compares the variables in panel A and in panel B. The majority of the itineraries used in the dataset are in economy class, and about eighty percent of the itineraries are ticketed by traditional legacy carriers. Only 18 percent of the itineraries are travels without the need of a transfer somewhere. However, note that the share for market structures changes as we move from the route level to the market level. At the route level, for example, ORD-JFK is considered different from ORD-EWR. The two are the same at the market level, however. Figure 2 presents such an example. It is therefore possible that one route is a monopoly, but that market is indeed competitive. As we see, the share of monopoly routes decreases, while on the opposite the share of competitive routes increases. Hence, it is not surprising that the monopoly share is higher at the route level, and the share of competition is higher at the market level. In general, a monopoly route may be in a monopoly market, a duopoly market, or a competitive

[24] For example, an itinerary originating at Denver (DEN) with a stopover at Los Angeles (LAX) before arriving at destination Seattle (SEA) is dropped if the ticketing carrier for the first segment is United and the second is Delta.

[25] This timing is chosen by the fact that starting March 30, 2014, US Airways left the Star Alliance to join OneWorld, of which American Airlines is a member.

[26] This means that the resulting sample is less than a hundredth of the population.

[27] For example, Delta operates as a monopoly in both LNK-MSP and MSP-ATW (Appleton, WI). However, United operates such a route LNK-ATW by providing the connection at its hub ORD, which makes the route non-monopolistic.

[28] For example, JFK-ORD is considered a different route from LGA-ORD. Both routes, however, considered the same market, NYC-CHI. Similar examples include, but not limited to, Dallas, Houston, San Francisco, Washington D.C., etc. See Appendix A.8 for the complete list.

Table 1: Summary Statistics

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Panel A. Route Level ($N = 670,894$)				
Fare	438	236	31	3,963
Fuel Cost Proxy	11,707	8,449	1433	89,103
911 Security Charge	7.822	2.933	2.5	33.6
Roundtrip	0.544	0.498	0	1
LCC	0.202	0.401	0	1
Economy Class	0.933	0.25	0	1
Direct	0.183	0.387	0	1
Monopoly	0.153	0.36	0	1
Duopoly	0.399	0.49	0	1
Compete	0.448	0.497	0	1
Panel B. Market Level ($N = 559,707$)				
Fare	443	235	31	3,963
Fuel Cost Proxy	11,445	8,336	143	89,103
911 Security Charge	7.826	2.937	2.5	33.6
Roundtrip	0.547	0.498	0	1
LCC	0.197	0.397	0	1
Economy Class	0.931	0.254	0	1
Direct	0.19	0.392	0	1
Monopoly	0.116	0.32	0	1
Duopoly	0.341	0.474	0	1
Compete	0.543	0.498	0	1

market. Similarly, a duopoly route can be in a duopoly market, or in a competitive market. A competitive route will always be in a competitive market. Figure 3 presents a graphical comparison of a route and a market.

Figure 2: Example: Routes under the CHI-NYC Market
Top Panel: Routes from Chicago-O'hare to New York City
Bottom Panel: Routes from Chicago-Midway to New York City

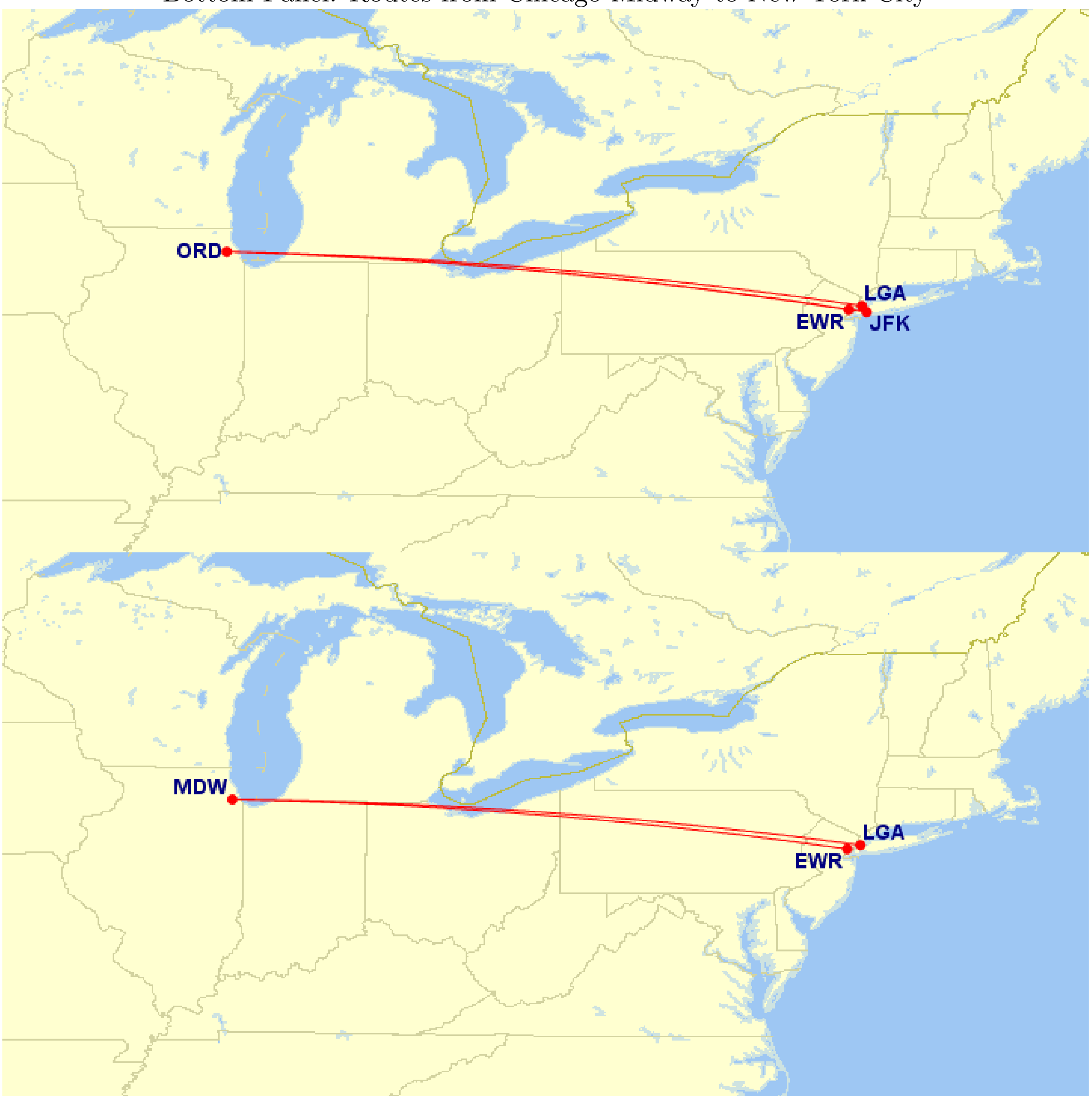
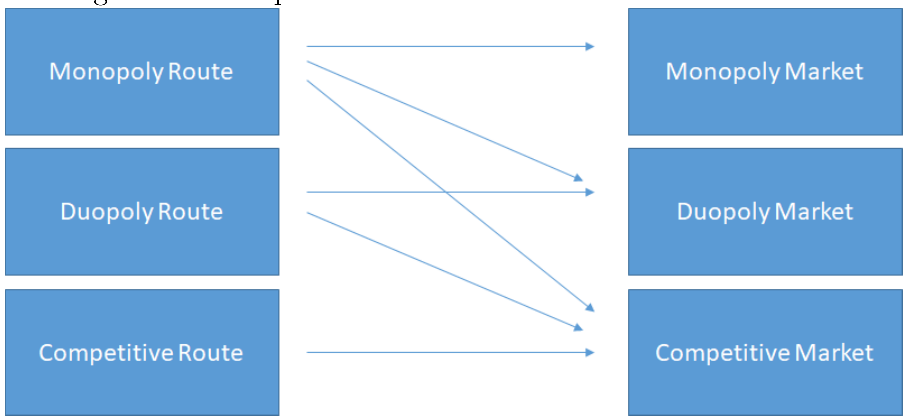


Figure 3: A Graphical Illustration of A Route and A Market



As suggested earlier, we segment the dataset into three distinct partitions based on levels of competition for the given route or market. We choose not to use HHI to partition the dataset. There are different approaches on how to define market structures in the industrial organization literature. Here, we adopt the one from Dana and Orlov (2014), which represents a modified version from Borenstein and Rose (1994). Specifically, a monopoly market is where the largest carrier's market share is at least 90 percent. A duopoly market is characterized by which a market has two largest firms totalling a combined 80 percent or more market shares, and that the third firm's market share is no more than ten percent. All other routes (non-monopoly and non-duopoly) are considered competitive routes. Table 2 presents some summary statistics by different market structures. The number of monopoly markets and duopoly markets drop, and on the other hand, competitive routes increase. It is apparent that at the route level there is not much difference in fares or the September 11 Security Charges across market structures. However, at the market level, differentials in fares are more clear that tickets in monopoly markets are higher than duopoly markets, and duopoly market tickets are more expensive than those in competitive markets.

5 Analysis

The central question to be answered in this paper is: Does the tax burden of September 11 Security Charge fall on the passengers entirely? Is there over-shifting, full-shifting, or under-shifting? Also, how does market concentration affect tax incidence? To tackle these problems, we present a theoretical model based on existing literature as follows, and we use the model to formalize the two hypotheses in the paper.

5.1 Theoretical Framework

5.1.1 Perfect Competition

Modern discussion of tax incidence dates by to Harberger (1962), where he shows that the incidence of a tax depends on both the price elasticity of demand and price elasticity of supply. To see this,

Table 2: Key Summary Statistics by Market Structures

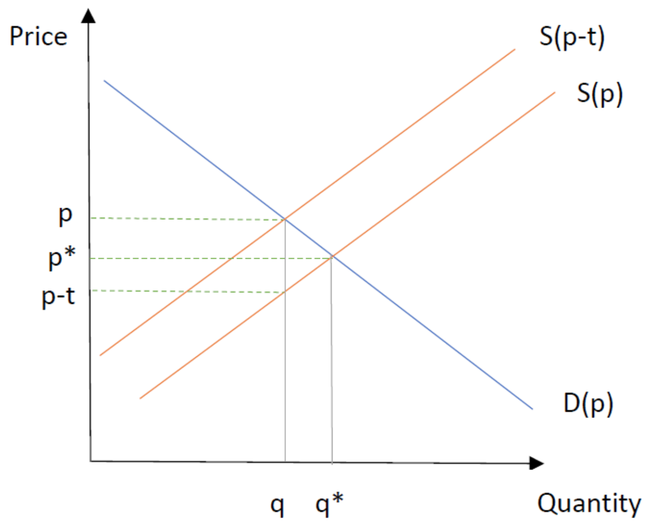
	Route Level			
	Mean	St. Dev	Minimum	Maximum
A. Monopoly ($N = 102,372$)				
Fare	441	244	31	3,412
Fuel Cost Proxy	9,599	7,771	169	79,170
Sep 11 Security Charge	7.99	3.02	2.5	28
B. Duopoly ($N = 267,991$)				
Fare	437	230	31	3,963
Fuel Cost Proxy	10,509	7,695	143	78,864
Sep 11 Security Charge	7.87	2.95	2.5	33.6
C. Compete ($N = 300,531$)				
Fare	439	237	31	3,949
Fuel Cost Proxy	13,493	8,944	181	89,103
Sep 11 Security Charge	7.72	2.88	2.5	33.6
	Market Level			
	Mean	St. Dev	Minimum	Maximum
A. Monopoly ($N = 64,176$)				
Fare	486	245	31	3,321
Fuel Cost Proxy	9,992	8,004	169	69,797
Sep 11 Security Charge	8.37	2.90	2.5	28
B. Duopoly ($N = 190,831$)				
Fare	444	221	31	3,412
Fuel Cost Proxy	10,047	7,572	143	74,445
Sep 11 Security Charge	8.02	2.93	2.5	28
C. Compete ($N = 304,161$)				
Fare	433	241	31	3,963
Fuel Cost Proxy	12,631	8,670	181	89,103
Sep 11 Security Charge	7.59	2.93	2.5	33.6

consider the supply and demand for a given good in a perfectly competitive market is illustrated in Figure 4 below. Here, in equilibrium, we have

$$D(p^*) = S(p^*) \tag{1}$$

where $D()$ is the demand function and $S()$ is the supply function. Absent the tax, the price producers receive is exactly the same as the price consumers pay, so $p^* = p$.

Figure 4: Tax Incidence Levied on a Good



Now, consider a tax t that is levied on the producers in this market, so that in equilibrium:

$$D(p) = S(p - t) \tag{2}$$

Note that p is the price consumers pay, and $p - t$ is the net price producers receive. Taking total differentials on both sides of (2) produces:

$$D'dp = S'dp - S'dt \tag{3}$$

It is then immediate that one can rewrite (3) to get:

$$\frac{dp}{dt} = \frac{S'}{S' - D'} \tag{4}$$

At the same time we have the price elasticity of demand ε_D and the price elasticity of supply ε_S as follows:

$$\varepsilon_D = \frac{p}{D}\frac{dD}{dp} = \frac{p * D'}{D} \tag{5}$$

$$\varepsilon_S = \frac{p}{S}\frac{dS}{dp} = \frac{p * S'}{S} \tag{6}$$

At market equilibrium, $D = S$. One can then combine (5) and (6) into (4) to get:

$$0 < \frac{dp}{dt} = \frac{\varepsilon_S}{\varepsilon_S - \varepsilon_D} < 1 \tag{7}$$

Based on the above derivation, undergraduate textbooks usually conclude that a tax increases the price paid by consumers and reduces the net price received by producers, with the burden of such a tax is generally shared by both the consumer and the producer. In the case of (relative) perfectly elastic demand or supply, the tax burden falls completely on the producer or the consumer, respectively. These results hold if the market is perfectly competitive. However, this is hardly true empirically, as perfect competition markets, in which firms are price-takers, are rarely seen in real life.

5.1.2 Imperfect Competition

The airline industry is considered to be an oligopolistic market, and carriers exercise market power (to some extent). Theorists have shown that in oligopolistic markets, such a pass-through rate can be more than 100 percent under certain demand conditions.[29] In particular, Seade (1985) uses the stability conditions derived in Seade (1980) to discuss the conditions that the elasticity of the slope of inverse demand has to satisfy for over-shifting of the tax.[30] Following Seade's (1985) derivation and Marion and Muehlegger's (2011) notation, for a price-setting firm i with market power, profit-maximization behavior ensures that the prices are given by

$$p = \frac{mc + t}{1 + \frac{1}{\epsilon_i}} \tag{8}$$

where mc represents marginal cost, and $\varepsilon_i < 0$ is the price elasticity of demand for the firm i. It follows that:

$$\frac{dp}{dt} = \frac{1}{1 + \frac{1}{\epsilon_i}} \tag{9}$$

As the profit-maximizing firm sets the price on the elastic portion of the demand curve ($\varepsilon_i < -1$), up to the point where marginal revenue equals to marginal cost, we have:

$$\frac{dp}{dt} > 1 \tag{10}$$

Expression (10) highlights the possibility of tax over-shifting when the market is not perfectly competitive. Hence, this is our first crucial hypothesis: there is over-shifting of the September 11 Security Charge in the airline industry on average.[31] By Seade (1985), the same result applies to

[29] See also Karp and Perloff (1989), Anderson, de Palma, and Kreider (2001), Hamilton (1999), Seade (1980), and Seade (1985).

[30] In fact, in Seade (1985), such elasticity has to be greater than one [in absolute values].

[31] In Kenkel's (2005) setting, it is empirically equivalent that we are determining the value of ν in the equality: $\varepsilon_{price} = \varepsilon_{tax}(P/\nu t)$. If ν is one, this means full tax-shifting (onto consumers). ν larger than one suggests over-shifting, whereas ν smaller than one means under-shifting so that tax incidence is born by both passengers and airlines.

symmetric Cournot or conjectural-variations oligopoly. This is essentially what Stern (1987) also shows, that over-shifting the tax is also theoretically possible with monopolistic competitive firms and Cournot oligopolistic markets. Anderson, de Palma, and Kreider (2001) extend this hypothesis to Bertrand firms.[32][33]

We formalize our second hypothesis in the airline industry specifically in details. Let ε_m, ε_d, and ε_c denote the the price elasticity of market demand in a monopoly (m), duopoly (d), or a competitive environment (c), respectively. In a monopoly setting, demand is inelastic. Market concentration decreases when we move away from monopoly. In a duopoly setting, passengers now see more choices, and demand is no longer that inelastic. As market concentration continues to decrease, so that we reach a competitive setting, demand is, comparatively, much more elastic. In other words, we have:

$$|\varepsilon_m| < |\varepsilon_d| < |\varepsilon_c| \tag{11}$$

It follows that:

$$\frac{dp}{dt}|_m > \frac{dp}{dt}|_d > \frac{dp}{dt}|_c \tag{12}$$

Expression (12) conveys the second crucial hypothesis: tax incidence in a monopoly setting is greater than the incidence in a duopoly setting, which is greater than that in a competitive setting. In other words, tax incidence decreases as competition intensifies.

5.2 Econometric Framework

To investigate the two central hypotheses in the paper: (a) whether there is under-shifting, full-shifting, or over-shifting of the September 11 Security Charge, and (b) tax incidence decreases as the environment gets more competitive, we proceed with a reduced-form regression approach. For a route/market i ticketed by carrier c, and operated at time t, we consider the following model using ordinary least squares (OLS)[34]:

$$fare_{ict} = \alpha + \beta(911SecCharge)_{it} + \gamma T_i + \phi C_{ict} + \epsilon_{ict} \tag{13}$$

$911SecCharg_{it}e$ is the level of the September 11 Security Charge at the particular year and quarter. T, C represent vectors of ticket- and carrier-specific characteristics, respectively. Throughout the

[32] Forward-shifting means that the tax is levied on the producers, and the economic incidence falls on the consumers.

[33] See more discussion in Fullerton and Metcalf (2002). In the Dixit-Stiglitz model used in that handbook chapter, it is assumed that all products compete with others equally. This assumption may not seem to be appropriate in the airline industry: one can argue that different people have different tastes so that low cost carriers may or may not compete equally with legacy carriers; it is also plausible to say lie-flat business class seats may be preferred to standard recliner seats in narrow-body aircrafts. See further in the chapter for more on using Salop (1979) circle model and subsequent modifications by Kay and Keen (1983).

[34] Traditional regressional techniques such as difference-in-differences (DD) and regression discontinuity (RD) cannot be applied here in this study. DD requires a treatment group and a control group in order to utilize the parallel trend assumption to determine the effect of the investigated policy. Here, since every single itinerary is subject to the new tax (change), there is no control group at all. As a result, it is impossible to apply DD framework here. Similarly, there is neither a random assignment of treatment nor a cutoff that determines whether a given ticket is subject to the new tax (change), which also renders RD framework ineffective in this context.

paper, in all estimations, we include the standard year and seasonality fixed effects, ticketing carrier fixed effects, as well as route/market effects.[35] ϵ_{ict} is the standard i.i.d. error term, capturing unobserved characteristics to econometricians. As mentioned in Section 4.2, we run the reduced form regression for the three partitions of the sample based on market structures: monopoly, duopoly, and competition, and all at the route and the market level.

A proxy for cost is a variable that helps explain, in this context, the operating cost for operating such an itinerary. We include this variable since it is expected to have a positive impact on the fare for any given route. The inclusion of this variable is spirited by Besley and Rosen (1999). If operating costs at the route level is readily available, that would be the ideal variable to include in the analysis. However, due to the fact that information on airline costs are proprietary, we will need to manually construct this variable to approximately proxy such costs at the itinerary level. Fuel cost fulfills such a role since it is a significant portion of the costs at any given route. In other words, the correlation between the fuel cost proxy and the actual operating cost is strong. Kahn and Nickelsburg (2016) indicate that jet fuel cost accounts for approximately 25 percent of a carrier's operating cost.

We compute the proxy as follows: for each itinerary i with coupon (segment) s being operated by carrier j, at time t, the fuel cost proxy $ProxyCost$ (in dollars) is:

$$ProxyCost_i = \sum_s [Price_{stj} * (\sum_{a=1}^{n} w_{aj} * Eff_{aj}) * NM_s] \tag{14}$$

where $Price$ is the unit fuel cost (in dollars per gallon), n is the number of different types of aircraft, Eff is the fuel efficiency for aircraft type a (in gallons per nautical miles), w is the weight for the fuel efficiency, which is calculated as the number of aircrafts for aircraft type a over the total number of aircrafts for the operating carrier j, and NM is the distance of the segment s in nautical miles.[36] If a carrier only operates using a single type of aircraft, $\sum_{a=1}^{n} w_{aj} * Eff_{aj} = Eff_j$. If the operating carrier does not report fuel costs (for any month), it is replaced by using the ticketing carrier's fuel cost.

Constructing the proxy in this manner allows us to control for different key aspects of operating costs. First, different airlines operate using different aircraft types. For example, Boeing 747 is still seen in United Airlines and Delta Air Lines, but it is no longer in service at American Airlines. Due to differences in the number of seats, fuel usage for the same route using a Boeing 747 and a Boeing 777 will be different.[37] Similarly, fuel usage for a CRJ-900 and an Embraer 170 is also different under the same route. Second, the number of aircrafts for a given aircraft type is also essential. Imagine an airline with just one Boeing 737-900 and 99 Airbus A321-100s. The probability of flying

[35] An earlier version of the paper present origin and destination fixed effects separately as opposed to route fixed effects. Results are quantitatively and qualitatively equivalent.

[36] The DB1B dataset records distances in track miles, which can be transformed into nautical miles simply by dividing track miles by 1.15.

[37] Even if both United and American operates A321-200s with different seat configurations, we cannot differentiate them. Therefore, the fuel efficiency is the same for the same aircraft type across carriers.

on a A321-100 is significantly higher than flying on a 737-900. In such case, it is more reasonable to weight the fuel efficiency by the respective proportion of fleet. In fact, such weighting is necessary as we do not have the exact information on which aircraft is being used in a specific route. Also, it is possible that a single carrier uses more than one type of aircraft. For example, in the Chicago O'hare (ORD) to Madison (MSN) route, United Airlines uses Airbus A320 and regional carriers providing feeder services for United uses Embraer or Canadian Regional Jets in this route. Such weighting allows one to capture the richest set of aircraft possibilities.[38] Lastly, needlessly to state, distances within two endpoints are important for computing the fuel cost. In addition to that, the fuel efficiency for that aircraft type is also crucial. All of the above factors can take a role in determining operating costs, and shall be incorporated into the proxy calculation. [39][40]

6 Results

6.1 Main Results

To proceed with analysis, we run OLS regression of the estimating equation (13). Pooled panel results are reported in Table 3. We first start by examining the coefficients of the control variables. Direct services are more expensive compared to nondirect services. The coefficient on the variable *roundtrip* is positive across specifications. The sign is as expected as roundtrip tickets are more expensive, relative to the omitted group, one-way tickets. The negative sign on *economy_class* relays that economy class tickets are cheaper, compared to business or first class tickets. Low cost carriers are known for cutting services to allow for their low airfare. The negative sign across different specifications confirms that tickets purchased from low cost carriers are cheaper than those from legacy or traditional carriers. The fuel cost proxy is positive and significant, meaning that, as expected, higher fuel costs for the given route/market translates into higher fares. The September 11 Security Charge is the focus of this analysis. This coefficient captures the tax incidence of the investigated tax, holding everything else constant. The result suggests thata one-dollar increase in the September 11 Security Charge leads to on average approximately a three-dollar increase in the airfare, *ceteris paribus*. Essentially, this suggests a over-shifting of the September 11 Security Charge by the carriers. This over-shifting pattern is seen both at the route level and at the market level.

One may argue that the market share a carrier possesses at a given airport can significantly impact the airfare it charges. Indeed, in the industrial organization literature, researchers have included the Herfindahl-Hirschmen Index as an explanatory variable, attempting to capture the effect of market power on prices.[41] In this paper, we choose to instead segment the dataset based

[38]A major concern of the proxy is that larger wide-body aircrafts are probably very unlikely to be used in a route that is usually served by regional jets. We, however, does not rule this possibility out by the nature of our proxy.

[39]Throughout the sample time studied, US Airways and American Airlines report fuel costs separately, even after the merger. As a result, we treat those companies separately for the purpose of computing fuel cost proxy.

[40]In the appendix, we provide an example from our dataset to illustrate the calculation numerically.

[41]The inclusion of HHI may raise a econometric concern. It is apparent that HHI directly affects the airfare. On the other hand, however, it may also be the case that the lower the fare the carrier charges, the higher HHI gets. The

on market structures to incorporate the effect of market shares on fares.[42] Table 4 presents the results by market structures.

Table 3: Pooled Regression Results

	(1) Route Level	(2) Route Level	(3) Market Level	(4) Market Level
911 Security Charge	3.117***	2.685***	2.886***	2.478***
	(0.256)	(0.268)	(0.279)	(0.294)
Direct	30.445***	29.767***	31.862***	31.221***
	(0.876)	(0.882)	(0.933)	(0.940)
Roundtrip	108.644***	110.565***	109.412***	111.233***
	(1.355)	(1.401)	(1.466)	(1.519)
Economy Cclass	-197.747***	-197.777***	-202.065***	-202.094***
	(2.572)	(2.572)	(2.659)	(2.658)
LCC	-16.412***	-16.700***	-21.244***	-21.459***
	(0.920)	(0.921)	(0.927)	(0.928)
Fuel Cost Proxy	0.007***	0.007***	0.007***	0.007***
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	428.525***	440.330***	436.774***	448.027***
	(2.864)	(3.085)	(2.983)	(3.231)
Fixed Effects	Year, Quarter	Year × Quarter	Year, Quarter	Year × Quarter
Observations	670,894	670,894	575,529	575,529
R^2	0.433	0.433	0.439	0.439

All specifications include in addition ticketing carrier, and route/market fixed effects.
Robust standard errors in the parentheses. $^{+}p < 0.10, ^{*}p < 0.05, ^{**}p < 0.01, ^{***}p < 0.001$.

Let us focus on the results at the route level. Tax incidence is clearly higher in monopolistic routes. As monopoly power decreases and we enter a duopolistic route, the incidence drops. As we approach closer to (perfect) competition, the tax coefficient continues to decrease. It should be noted that in our definition of market structures, competition does not mean perfect competition, in which the coefficient should theoretically be at most one. This pattern is as expected: higher market

two effects work in the opposite direction, and create an issue of endogeneity. To resolve this issue, the instrument variable approach is typically utilized. One may argue that carriers decide the prices they charge before flights are performed. Previous literature has seen carriers using historical data on the number of passenger, load factor, and some other factors to help determine prices. Evans, Froeb and Werden (1993) uses one-year-lagged HHI as the instrument as well. They suggest that with panel data, using both fixed effect procedures and instrumental variable approach eliminate biases in the estimates. However, recent literature has suggested that such a strategy may not be as effective as researchers have thought, as shown in Bellemare, Masaki, and Papinsky (2017).

[42]We thank Lorenzo Magnolfi and Alan T. Sorensen for this helpful suggestion.

power allows a carrier to price discriminate more, and over-shift the tax by a larger margin. It is also worth noticing that tickets on monopoly routes with direct services available are cheaper than tickets on monopoly routes without direct services, but that such negative coefficient disappears when there are more competition. Low cost carriers charge more than the legacy carriers in monopoly routes, but as soon as competition kicks in they charge less than legacy counterparts. All other coefficients behave the way they are expected: economy class tickets are cheaper, and that roundtrip tickets are more expensive than one-way tickets.

Changes in the tax coefficients are observed when we look at the market level. It is surprising that the tax coefficient actually increase slightly as we move from monopolistic markets to duopolistic routes. Our conjecture is that there may be potential interactions between the two carriers in the market that we do not take into consideration, and that such interactions leads to a higher over-shifting. There are more markets that fall under the "competitive" category. The incidence in this case is slightly larger than one but insignificant, which suggests that carriers in competitive markets bear the entire cost of the tax.

Note that in the above models it is implicitly assumed that the pass-through rates of the September 11 Security Charge are the same across different airline products, different ticket types, and different types of carriers (low cost carriers vs. legacy carriers). Here we relax these assumptions by estimating regressions separately and test for the equivalence of the tax coefficients. It is of interest for researchers to see how different the responses are when carriers are faced with a tax hike. Economic theory predicts that if the demand (supply) for consumers (producers) are more inelastic, they bear more of the tax burden.

Seasonality plays a significant role in determining prices. We typically see more demand for air travel during the summer and the holiday season. We next test for any differentials among the pass through rates for different quarters. Results are shown in Table 5. At the route level, again, as we move from monopoly to duopoly to competition, tax incidence generally decreases. In some cases the coefficient is not statistically distinguishable from zero. At the route level, we do see that in some situations the incidence drops below zero statistically. It is not unusual to see a negative incidence, as seen in Besley and Rosen (1999). F-tests reveal the inequality of the tax incidence. From this table, however, one cannot generalize a ranking order of the incidence by different quarters. Ideally, with a monthly data, one should be able to detect much higher and significant incidence on those months with heavy travel demands.

There may be different tax effects on different airline products. Routes or markets served by direct services may be more expensive. Economy class tickets are cheaper than those in premium cabins. Roundtrip tickets are generally more expensive than one-way tickets. With the differences in fares in the aforementioned examples, it would be naive to assume equality of the incidence. We explore the potential heterogeneity in different airline products. Table 6 shows the tax incidence by service classes. One would consider those flying in premium cabins to be less price-sensitive. Because of their relative inelastic demand, it would put them at the disadvantaged side in terms of bearing the tax burden. In particular, one would expect premium cabin flyers to bear a lot more incidence compared to coach flyers. However, this is hardly true based on the statistical evidence here. Across different market structures and levels of aggregation, economy class flyers bear significantly more incidence than premium cabin travelers. Premium cabin flyers even enjoy a premium with the tax hike. This is a puzzling finding that warrants further investigation. A potential explanation could be that carriers are simply benefiting from the coach class passengers, which accounts for 93% of the observation. In fear of potentially losing the high-margin passengers sitting in premium cabins (or antagonizing 'high-revenue' passengers), carriers provide a premium to them and extract that surplus back from economy class flyers. Essentially, in this explanation, carriers are simply charging more of the tax to those who play less.

Table 4: Regression Results by Market Structures

	Route Level			Market Level		
	(1)	(2)	(3)	(4)	(5)	(6)
	Monopoly	Duopoly	Competition	Monopoly	Duopoly	Competition
911 Security Charge	5.073***	3.180***	2.004***	6.288***	6.651***	0.256
	(0.549)	(0.402)	(0.446)	(0.865)	(0.424)	(0.413)
Direct	-38.648***	41.971***	37.793***	-46.119***	29.002***	36.559***
	(2.356)	(1.321)	(1.397)	(4.582)	(1.476)	(1.240)
Roundtrip	77.197***	101.836***	128.475***	85.526***	89.680***	127.067***
	(2.818)	(2.136)	(2.390)	(4.477)	(2.340)	(2.152)
Economy Class	-122.679***	-186.649***	-214.219***	-116.242***	-119.062***	-232.481***
	(9.568)	(3.972)	(3.565)	(14.598)	(4.794)	(3.204)
LCC	13.941**	-17.775***	-18.757***	10.965	-20.243***	-19.800***
	(4.755)	(1.503)	(1.234)	(8.376)	(1.625)	(1.179)
Fuel Cost Proxy	0.010***	0.008***	0.006***	0.008***	0.007***	0.007***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	382.501***	414.016***	448.049***	400.663***	355.989***	461.667***
	(10.222)	(4.479)	(4.253)	(15.759)	(5.237)	(3.824)
Observations	102,372	267,991	300,531	64,716	190,831	304,160
R^2	0.676	0.451	0.388	0.675	0.479	0.399

All specifications include year, quarter, ticketing carrier, and route/market fixed effects.

Robust standard errors in the parentheses. $^+p < 0.10, ^* p < 0.05, ^{**} p < 0.01, ^{***} p < 0.001$.

Table 5: Regression Results: Tax Incidence by Quarter

	(1) First Quarter	(2) Second Quarter	(3) Third Quarter	(4) Fourth Quarter
Route Level				
Panel A. Monopoly				
911 Security Charge	5.004***	6.242***	5.154**	5.142***
	(1.514)	(1.364)	(1.596)	(1.298)
Observations	23,252	25,011	28,017	26,092
R^2	0.780	0.806	0.795	0.789
Panel B. Duopoly				
911 Security Charge	2.162*	0.996	2.569**	4.096***
	(0.973)	(0.906)	(0.964)	(0.835)
Observations	63,490	69,620	67,550	67,331
R^2	0.527	0.546	0.552	0.543
Panel C. Competition				
911 Security Charge	-1.149	-0.707	2.884**	2.799**
	(1.078)	(0.950)	(0.939)	(0.886)
Observations	72,236	82,204	73,092	72,999
R^2	0.408	0.441	0.465	0.445
Market Level				
Panel A. Monopoly				
911 Security Charge	3.871	8.087**	6.297**	5.159*
	(2.496)	(2.508)	(2.427)	(2.168)
Observations	14,611	15,497	18,071	16,537
R^2	0.818	0.820	0.813	0.811
Panel B. Duopoly				
911 Security Charge	5.462***	5.260***	6.580***	7.793***
	(1.078)	(0.951)	(1.010)	(0.873)
Observations	45,118	49,547	48,275	47,891
R^2	0.562	0.590	0.596	0.582
Panel C. Competition				
911 Security Charge	-1.938*	-2.276**	-0.197	0.835
	(0.978)	(0.879)	(0.907)	(0.826)
Observations	73,033	82,289	74,376	74,462
R^2	0.414	0.442	0.458	0.450

All specifications include year, quarter, ticketing carrier, and route/market fixed effects. Robust standard errors in the parentheses. $^{+}p < 0.10, ^{*}p < 0.05, ^{**}p < 0.01, ^{***}p < 0.001$.

Table 6: Regression Results: Tax Incidence by Cabins

	(1) Business/First Class	(2) Economy Class
Route Level		
Panel A. Monopoly		
911 Security Charge	-3.328	5.997***
	(3.931)	(0.517)
Observations	3,644	98,728
R^2	0.849	0.698
Panel B. Duopoly		
911 Security Charge	-9.298***	5.291***
	(2.478)	(0.327)
Observations	16,850	251,141
R^2	0.724	0.495
Panel C. Competition		
911 Security Charge	-15.082***	4.647***
	(2.721)	(0.318)
Observations	24,367	276,164
R^2	0.639	0.450
Market Level		
Panel A. Monopoly		
911 Security Charge	6.520	6.303***
	(7.284)	(0.854)
Observations	1,419	63,297
R^2	0.923	0.686
Panel B. Duopoly		
911 Security Charge	-2.785	7.216***
	(3.080)	(0.394)
Observations	8,198	182,633
R^2	0.778	0.508
Panel C. Competition		
911 Security Charge	-15.767***	3.587***
	(2.174)	(0.282)
Observations	29,267	274,893
R^2	0.620	0.469

All specifications include year, quarter, ticketing carrier, and route/market fixed effects. Robust standard errors in the parentheses. $^{+}p < 0.10, ^{*}p < 0.05, ^{**}p < 0.01, ^{***}p < 0.001$.

Next, we turn our focus to different service types: whether the route or market has direct services. Those routes or markets without direct services are typically those that are more remote or less popular. In other words, it exhibits less competition, holding everything else constant. Therefore, we should expect the incidence for those with only non-direct services to be higher than those served by direct flights. Essentially, this is what Table 7, which reports the results by types of service, shows. Again, holding service types constant, as we move from monopoly to duopoly to competition, tax incidence at the route level decreases. At the market level, a similar finding that tax incidence is slightly higher in duopolistic markets, is observed. Those with direct services have a near-zero tax incidence, suggesting that carriers bear the burden completely. An alternative explanation may also be plausible. In terms of the actual tax change, with the exact same itinerary, the September 11 Security Charge increases by three dollars and ten cents (from \$2.5 to \$5.6) for direct services, and by a dollar and twenty cents for non-direct services (from \$10 to \$11.2).[43] Carriers are over-shifting the tax to those who do not actually observe a big change in the tax, i.e. those flying without direct services. One may observe too big of a tax increase under direct services if a carrier chooses to over-shift the tax. Hence, carriers may not do so, but instead put the 'extra' incidence on those that require any layovers since they are not hit badly by the increased tax.

It is arguably true that those purchase one-way tickets faces a more inelastic demand curve. Therefore, as theory suggests, tax incidence for one-way tickets are expected to be higher than that of roundtrip tickets. As results in Table 8 shows, incidence on one-way tickets are significantly higher than that of roundtrip tickets. It is of particular interest that the pattern of decreasing tax coefficients as one moves aways from monopoly is not apparent here. In fact, duopoly routes/markets exhibit the highest incidence among the three market structures. For roundtrip tickets, some evidence of negative-shifting is found, which again is a puzzling discovery that needs further explanation in the future.

Now switching the focus to types of carrier, we test whether low cost carriers have different tax pass-through rates compared to legacy carriers. Price-sensitive passengers tend to choose low cost carriers over legacy carriers. Their demand in air travel may be more elastic. This elasticity of demand suggests that, theoretically, one should expect the incidence on legacy carriers should be more than that on low cost carriers. Table 9 reports the result. At the route level, as expected, incidence on monopolistic and duopolistic routes for legacy carriers are slightly higher than their counterpart routes for low cost carriers. Interestingly, such a difference reverses in competitive routes. At the market level, results do not change qualitatively, though the decreasing pattern of the tax pass-through for low cost carriers are less obvious.

To summarize, on average, evidence of over-shifting of the tax is found: every one-dollar increase in the tax results in approximately a three-dollar increase in the fare. Segmenting the dataset based on market structures reveals that tax incidence decreases as competition increases, which is consistent with theoretical predictions. Premium cabin passengers surprising do not bear as much

[43]For this comparison, we are assuming people choose direct flights flights with layovers. We treat nonstop flights to be same as direct flights in this context. Note, however, that the two have different meaning in the airline industry since we cannot differentiate the two based on the data obtained.

incidence as coach passengers. Non-direct services and one-way itineraries bear more incidence comparing to direct services and roundtrip tickets, respectively. Low cost carriers shift more of the tax in competitive settings, whereas legacy carriers over-shift more in monopolistic and duopolistic routes/markets. Despite of some irregularities, inelastic demand plays a central role in explaining our results. In the next section, we perform some robustness checks to see whether our implicit assumptions about the industry and/or the market play any significant role in explaining our results.

Table 7: Regression Results: Tax Incidence by Services

	(1) Non-direct Services	(2) Direct Services
Route Level		
Panel A. Monopoly		
911 Security Charge	7.937***	-1.298*
	(0.969)	(0.658)
Observations	77,716	24,656
R^2	0.647	0.698
Panel B. Duopoly		
911 Security Charge	7.109***	1.398+
	(0.589)	(0.769)
Observations	216,705	51,286
R^2	0.449	0.572
Panel C. Competition		
911 Security Charge	6.145***	-0.002
	(0.613)	(0.965)
Observations	253,385	47,146
R^2	0.374	0.552
Market Level		
Panel A. Monopoly		
911 Security Charge	9.439***	-1.390
	(1.618)	(1.026)
Observations	54,566	10,150
R^2	0.653	0.742
Panel B. Duopoly		
911 Security Charge	10.876***	0.221
	(0.674)	(0.727)
Observations	158,873	31,958
R^2	0.464	0.633
Panel C. Competition		
911 Security Charge	4.608***	-0.180
	(0.619)	(0.808)
Observations	240,113	64,047
R^2	0.379	0.542

All specifications include year, quarter, ticketing carrier, and route/market fixed effects. Robust standard errors in the parentheses. $^{+}p < 0.10, ^{*}p < 0.05, ^{**}p < 0.01, ^{***}p < 0.001$.

Table 8: Regression Results: Tax Incidence by Ticket Types

	(1) One-way	(2) Roundtrip
Route Level		
Panel A. Monopoly		
911 Security Charge	17.035***	-0.977
	(1.409)	(0.701)
Observations	42,338	60,034
R^2	0.706	0.690
Panel B. Duopoly		
911 Security Charge	20.358***	-5.214***
	(0.862)	(0.506)
Observations	118,928	149,063
R^2	0.427	0.420
Panel C. Competition		
911 Security Charge	17.040***	-7.131***
	(0.933)	(0.559)
Observations	144,446	156,085
R^2	0.315	0.319
Market Level		
Panel A. Monopoly		
911 Security Charge	16.310***	0.780
	(2.266)	(1.110)
Observations	24,183	40,533
R^2	0.744	0.688
Panel B. Duopoly		
911 Security Charge	23.024***	-1.521**
	(0.989)	(0.519)
Observations	82,143	108,688
R^2	0.461	0.450
Panel C. Competition		
911 Security Charge	16.343***	-8.508***
	(0.851)	(0.519)
Observations	147,130	157,030
R^2	0.328	0.338

All specifications include year, quarter, ticketing carrier, and route/market fixed effects. Robust standard errors in the parentheses. $^{+}p < 0.10, ^{*}p < 0.05, ^{**}p < 0.01, ^{***}p < 0.001$.

Table 9: Regression Results: Tax Incidence by Carrier Types

	(1) Legacy Carriers	(2) Low Cost Carriers
Route Level		
Panel A. Monopoly		
911 Security Charge	5.588***	4.535***
	(0.868)	(0.587)
Observations	79,854	22,518
R^2	0.636	0.685
Panel B. Duopoly		
911 Security Charge	4.307***	3.828***
	(0.531)	(0.504)
Observations	224,458	43,533
R^2	0.427	0.581
Panel C. Competition		
911 Security Charge	2.037**	4.385***
	(0.620)	(0.506)
Observations	231,116	69,415
R^2	0.350	0.542
Market Level		
Panel A. Monopoly		
911 Security Charge	6.006***	5.546***
	(1.025)	(1.381)
Observations	60,153	4,563
R^2	0.647	0.773
Panel B. Duopoly		
911 Security Charge	8.963***	5.021***
	(0.570)	(0.502)
Observations	162,906	27,925
R^2	0.448	0.641
Panel C. Competition		
911 Security Charge	-0.583	3.169***
	(0.596)	(0.443)
Observations	226,648	77,512
R^2	0.355	0.536

All specifications include year, quarter, ticketing carrier, and route/market fixed effects. Robust standard errors in the parentheses. $^{+}p < 0.10, ^{*} p < 0.05, ^{**} p < 0.01, ^{***} p < 0.001$.

6.2 Robustness Check

In this section we present variants of the models estimated above by altering earlier assumptions in order to test the robustness of our results.

American Airlines (AA) and US Airways (US) merged in 2014. As illustrated earlier, the two carriers have been considered the same carrier since the second quarter of 2014. The merger between the two key players in the industry may present a structural change that affects the entire industry but is not directly included as explanatory variables. Therefore, we drop all the routes or markets that are affected by this merger, which includes but not limited to, all the itineraries ticketed by either US Airways and American Airlines, and all tickets that originate and/or end at one of the hubs of those two carriers. We present our results in Table 10. The general pattern of decreasing tax coefficients as competition increases is still present. However, compared to estimates in Table 4, it is apparent that the differences in coefficients has in general shrunk. In addition, the tax coefficients are generally higher than was found in Table 4, both at the route level and at the market level. This is not surprising: in this scenario we are removing AA and US from competition, and since the level of competition is lower, tax incidence is expected to be higher. Although that the differences of the incidence as one moves away from monopoly have decrease, over-shifting is still present even if we remove the routes and markets that are heavily affected by the AA-US merger.

Recall that we use the definition from from Dana and Orlov (2014) to segment our dataset by market structures. We are suspicious that based on their definition, for example, routes like LNK-LAX will be categorized as competitive, since there is not a third carrier operating out of LNK, whereas in reality this route is closer to a duopoly. We attempt to adjust this situation by removing from the definition for a duopoly route the condition that the third carrier must be present and that its market share is no more than ten percent. Note that making such a change increases the number of observations under duopolistic routes, and decreases the number of competitive routes, while there are no changes to monopoly counterparts. We do not observe significant changes in our results using the modified definition of market structures.

Table 10: Regression Results: Removing AA and US

	Route Level			**Market Level**		
	(1)	(2)	(3)	(4)	(5)	(6)
	Monopoly	Duopoly	Competition	Monopoly	Duopoly	Competition
911 Security Charge	5.174***	4.589***	4.355***	6.395***	7.410***	2.506***
	(0.614)	(0.523)	(0.545)	(1.028)	(0.533)	(0.488)
Direct	-51.953***	13.337***	18.544***	-64.037***	5.928**	12.046***
	(2.679)	(1.699)	(1.685)	(5.683)	(1.891)	(1.461)
Roundtrip	78.618***	103.753***	131.600***	87.534***	93.233***	128.211***
	(3.295)	(2.870)	(2.948)	(5.485)	(2.987)	(2.645)
Economy Class	-334.933***	-430.817***	-430.599***	-389.943***	-367.263***	-442.435***
	(18.921)	(7.596)	(6.295)	(29.393)	(9.670)	(5.473)
LCC	45.103***	-11.438**	-38.734***	41.632**	-13.246**	-35.745***
	(11.745)	(3.611)	(3.608)	(15.824)	(4.632)	(3.334)
Fuel Cost Proxy	0.009***	0.008***	0.005***	0.008***	0.007***	0.006***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	589.511***	654.547***	675.459***	676.132***	603.765***	684.950***
	(21.521)	(8.348)	(7.531)	(32.095)	(10.654)	(6.514)
Observations	68,046	138,413	150,806	41,953	106,937	157,438
R^2	0.724	0.568	0.516	0.708	0.568	0.525

All specifications include year, quarter, ticketing carrier, and route/market fixed effects.
Robust standard errors in the parentheses. $^+p < 0.10, ^* p < 0.05, ^{**} p < 0.01, ^{***} p < 0.001$.

In Section 5.2, we presented the way in which we construct our fuel cost proxy variable. Recall that a key component in the calculation is the weighted fuel efficiency, with the weight being the proportion of the different aircraft types in the entire fleet of the given carrier. One may argue that the choice of fleet itself is a decision variable that depends on the carrier's choices, similar to the fact that ticket prices being a choice of the carrier. In other word, this proxy variable may introduce some potential endogeneity into the regression which makes OLS estimates biased. Airlines typically order or lease aircraft ahead of time. It is common for carriers to place the order of a particular aircraft at a given time, but do not receive delivery until years later. In fact, carriers still operate aircrafts that are at least ten years old. Therefore, we do not suspect this potential endogeneity being a major issue. Nevertheless, we still acknowledge the concern and carry out an instrumental variable estimation with two-staged least squares (2SLS) estimates. Specifically, the fuel cost proxy, expression (14), is being instrumented by a new variable IV_Eff, as calculated below: for each itinerary i with coupon (segment) s in the range bin b being operated by carrier j, at time t, the fuel cost proxy instrument IV_Eff (in dollars) is:

$$IV\_Eff_i = \sum_s [Price_{stj} * (1 + MEff_b - MEff_{bj}) * NM_s] \tag{15}$$

$MEff_b$ is the fuel efficiency of the most efficient aircraft across carriers in the range bin b, whereas $MEff_{bj}$ represents the fuel efficiency of the most efficient aircraft within a specific carrier j in the range bin b. There are four range bins: regional, short haul, medium haul, and long haul. Such an instrument is strongly correlated to the original fuel cost proxy, and at the same time it alleviates the endogeneity problem by introducing the fuel efficiency of the most efficient aircraft in the range bin, which is not something a given carrier necessarily has control over, into the calculation. Qualitatively, such a practice does not generate much difference, compared to the OLS results. Over-shifting is still present, and so is the pattern of decreasing tax incidence as competition increases.

Lastly, we expand our definition of the routes being classified under the same market. In all our analyses up to this point, we use the market definition as provided by the DOT and the database DB1B. However, there are some other cities in which there are more than one commercial airports serving the same area. For those "extended airports" we decide to also include them under the same market.[44] Not surprisingly, this minor change does not generate meaningful significance across the results.

7 Conclusion

7.1 Summary

In the United States, airfares people pay for air travel tickets typically include the base fare, collected by the airline, and various relevant taxes, received by the federal and/or the state government. Four

[44]See Appendix A.8 for a complete list of the airports.

taxes are levied on U.S. domestic air travels: the Ticket Tax, the Passenger Facility Charge, the Segment Tax, and the September 11 Security Fee. We focus on the September 11 Security Charge, which was first introduced in February 2002 to help combat the rising need of better and more thorough security measures. It was increased in July 2014 with slight adjustments in December 2014. Using data from the Bureau of Transportation Studies (BTS) and the Federal Aviation Administration (FAA), this paper investigates the tax incidence of such a charge using simple OLS. The author extends the literature by investigating tax incidence in the airline industry, in which little work has been found in this topic. We also demonstrate heterogeneity of the pass-through rates in some products.

We control for year, quarter, ticketing carrier, and route/market fixed effects in all of our estimates. With a panel dataset, our estimates suggest that this September 11 Security Charge is being over-shifted onto passengers. *Ceteris Paribus*, a one-dollar increase in the tax on average leads to approximately a three-dollar increase in the fare. We partition the dataset based on market structures. We observe a greater over-shifting in monopolistic routes than in duopolistic routes. As competition further increases, such over-shifting decreases to about two-dollars for every one-dollar increase in the tax. At the route level, results do not change much. Next, we further document the discovery that negative shifting of the tax is found, which remains a mystery at this moment. Economy cabin passengers appear to bear more of the tax, compared to those flying in business or first class cabins. Low cost carriers over-shift more in competitive routes, while legacy carriers over-shift a little bit more in monopolistic and duopolistic routes. Non-direct tickets and one-way tickets, for which the demand is generally thought to be less elastic, bear a lot more incidence compared to tickets with direct services and roundtrip tickets. Although seasonality plays a central role in determining prices, we cannot document a general pattern of tax incidence across different quarters. This may be a result of the less optimal data frequency that the original data source provides. In short, on average, the September 11 Security Charge is over-shifted onto the passengers. However, a closer analysis reveals the heterogeneity of the pass-through rates for airline products, and in most cases, the inelastic demand plays a central role of explaining them. [45]

[45] There are several limitations worth mentioning. Firstly, the dataset does not include information on whether tickets are purchased online or not. This information is not available when DOT receives data from carriers. Empirically, research has shown tickets purchased online are roughly 11 percent lower than those purchased offline.[46] Inability to control for this characteristic may affect our results to some extent. Secondly, at the stage of manually matching the September 11 Security Charge to each itinerary, we had to make an assumption that all the layovers in all the itineraries are less than four hours. This assumption is necessary, as from the dataset we cannot tell whether such long layover is made. We do not have flight numbers or departure or arrival time in the dataset. These information are simply not available when DOT receives data from carriers. Thirdly, the data do not come at a monthly basis, which is necessary if one would like to check heterogeneity of the incidence across different months. As demonstrated, we can establish a general trend of the incidence across different quarters. Lastly, the fact that information on aircraft type not being available in the dataset leads to our potentially imprecise measure of the fuel cost proxy. Wide-body aircrafts most likely are not used in regional routes served by regional jets. We fully recognize the above limitations to our study.

7.2 Future Prospects

In most of the estimates, carriers over-shift the tax to passengers, which are supported by our theoretical analyses. Nevertheless, over-shifting essentially means that carriers are 'benefiting' from the imposition (or change) of the tax. The question is: can we or the government prohibit this kind of behavior? It is of great significance for related authorities and researchers to determine or devise mechanisms to alleviate this potential problem. Also, a puzzle in the paper to be further examined is the negative (and significant) tax responses in some of our estimates. For future research in this arena, tax salience can be a topic of interest. Following ideologies from Chetty et al. (2009), one can ideally replicate field experiments by partnering with major travel agencies, booking sites, or even airlines, to conduct such a study. Questions which may be investigated include: Is the tax more salient when applying the tax increase with the posted pre-tax airfare than with the posted after-tax airfare? Airlines often misrepresent fare surcharges as taxes. Hence, one can also ask the question: Do airlines increase their fees in order to compensate for potential losses in the demand, as a result of increases in airport- or ticket-related taxes? Does the tax (increase) affect the employees of airlines or airports? Since these questions require substantial knowledge in labor economics, public economics, industrial organization, and other economic disciplines, additional research is in great need to shed light on those mysteries.

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A Appendix

A.1 Carriers in the Study

This appendix provides a list of carriers along with their classifications included in this study. Carriers are sorted by alphetical orders of carrier codes. IATA-assigned carrier codes are in the parentheses. Air Tran merged into Southwest and therefore stopped reporting beginning 2015. US Airways merged into American Airlines late 2015.

Legacy Carriers	Low Cost Carriers (LCC)	Regional Carriers
American Airlines (AA)	Jet Blue (B6)	PSA Airlines (16)
Alaska Airlines (AS)	Frontier Airlines (F9)	Endeavor Air Inc. (9E)
Delta Air Lines (DL)	Air Tran (FL)	Compass Airlines (CP)
Hawaiian Airlines (HA)	Allegiant Air (G4)	ExpressJet (EV)
United Airlines (UA)	Spirit Air (NK)	GoJet Airlines (G7)
US Airways (US)	Virgin America (VX)	Envoy Air (MQ)
	Southwest Airlines (WN)	SkyWest Airlines (OO)
		Horizon Air (QX)
		Chautauqua Airlines (RP)
		Shuttle America (S5)
		Mesa Airlines (YV)
		Republic Airlines (YX)
		Air Wisconsin Airline Corp. (ZW)

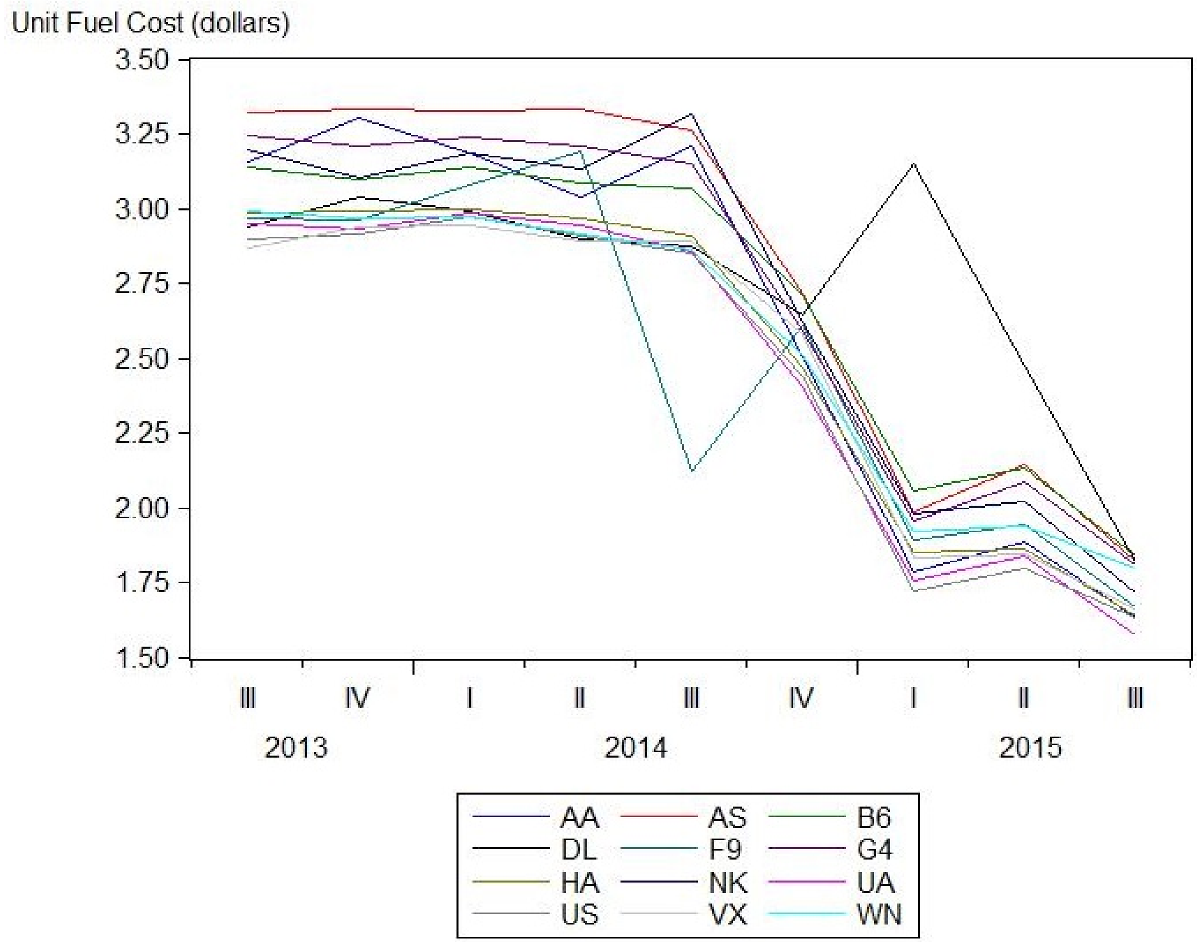
A.2 An Example of Domestic Ticket Taxes Calculation

On February 29, 2016, a round-trip itinerary operated by Delta Air Lines is purchased. The routing is Madison (MSN) to Los Angeles (LAX) on July 4, 2016, and Los Angeles (LAX) to Madison (MSN) on August 31, 2016. In both ways, a layover at Minneapolis (MSP) is required. The tax-inclusive airfare is \$329.20, which includes the base airfare of \$264.18 and relevant fees and taxes of \$65.02. Tax breakdown is as follows.

Tax	Amount	Remarks
Ticket Tax	\$19.82	\$264.18 * 7.5% = \$19.82.
Septmeber 11 Security Fee	\$11.20	Round-trip ticket, 2 chargeable one-ways at \$5.60 each.
Passenger Facility Charge	\$18.00	4 take-offs. LAX, MSN, and MSP all charge \$4.50 per takeoff.
Flight Segment Tax	\$16.00	4 segments charged at \$4.00 each segment.
Total Tax	\$65.02	

A.3 Quarterly Jet Fuel Price by Carrier

This appendix presents a graph of the jet fuel price used in this paper. Carriers are differentiated according to their respective IATA-assigned carrier codes. Data come from `http://www.transtats.bts.gov/fuel.asp?pn=1`.



A.4 Aircraft Data, Number of Aircrafts, and Fuel Efficiency

This appendix provides detailed information on the types of aircraft each carrier utilizes, as well as the number of aircrafts for each type of aircrafts and their respective fuel efficiency. Aircraft data come from official websites of respective airlines as of February 2016.[47] Fuel efficiency data come from `http://planes.axlegeeks.com/`. The notation "16-AA(33)", for example, refers to PSA Airlines (16) operating for American Airlines (AA) and the number of aircrafts of that type is 33. For aircraft types, A refers to Airbus Industrie, B refers to Boeing, CRJ refers to Canadian Regional Jet, EMB refers to Embraer, MD refers to McDonnell Douglas, and Bom refers to Bombardier. Fuel efficiencies with a single asterisk means that the fuel information for that specific type of aircraft is unavailable. In such cases, we use the most similar aircraft and apply that fuel efficiency. Double asterisks mean that the fleet size is not available. GPNM means gallons per nautical mile (on average).

[47] We have excluded the types of aircrafts that were delivered to the carrier after our sample timeframe.

Type of Aircraft	Fuel Efficiency (GPNM)	Carriers (Number of Aircrafts)
A319-100	2.16	AA(32), DL(57), F9(31), G4(11), NK(29), UA(56), US(93), VX(10)
A320-200	2.18	B6(130), DL(69), F9(23), G4(16), NK(42), UA(97), US(56), VX(48)
A321-200	2.48	AA(62), B6(26), F9(5), NK(2), US(114)
A330-200	5.07	DL(11), HA(22), US(15)
A330-300	4.03	DL(26), US(9)
ATR42-500	1.95	HA(3)
B717-200	2.57	DL(88), FL(88), HA(18)
B737-300	2.00	FL(52), WN(117)
B737-400	1.49	AS(20)
B737-400C	1.49*	AS(5)
B737-500	2.00	WN(10)
B737-700	2.00	AS(14), DL(10), UA(40), WN(476)
B737-800	2.21	AA(266), AS(61), DL(73), UA(130), WN(106)
B737-900	2.45*	AS(12), UA(12)
B737-900ER	2.45	AS(35), DL(52), UA(129)
B747-400	7.89	DL(9), UA(22)
B757-200	2.95	AA(50), DL(107), G4(5), UA(60), US(24)
B757-300	3.38	DL(16), UA(21)
B767-300	4.00*	DL(14)
B767-300ER	4.00	AA(41), DL(58), HA(8), UA(35)
B767-400ER	4.26	DL(21), UA(16)
B777-200	5.92	UA(19)
B777-200ER	5.85	DL(21), UA(55)
B777-200LR	4.78	DL(8)
B777-300ER	6.50	AA(19)
B787-8	4.56	UA(12)
B787-9	4.37	UA(14)
Bom Q-400	1.08	QX-AS(**), YX-UA(25)

Type of Aircraft	Fuel Efficiency (GPNM)	Carriers (Number of Aircrafts)
MD-82	2.85	AA(44)
MD-83	2.80	AA(50), G4(45)
MD-88	2.85	DL(116), G4(6)
MD-90	2.80	DL(65)
CRJ-100	1.59*	OO-DL(4), OO-UA(2)
CRJ-200	1.59	16-AA(35), OO-AA/US(14), OO-DL(63), OO-UA(67), ZW(71)
CRJ-200ER/LR	1.59	9E-DL(35), EV-AA/US(13), EV-DL(46)
CRJ-700	2.38	16-AA(26), MQ-AA(37), OO-AS(9), OO-DL(19), OO-UA(70), YV-UA(20)
CRJ-700ER	2.38	EV-DL(41), G7-DL(22), G7-UA(25)
CRJ-900/ER	2.77	9E-DL(81), EV-DL(28), G7-DL(6), OO-DL(36) YV-AA/US(64)
CRJ-900Next Gen	2.77	16-AA(39)
EMB-135LR	1.09*	EV-AA/US(5)
EMB-140	1.09*	MQ-AA(40)
EMB-145LR	1.09	EV-AA/US(16), EV-UA(89), MQ-AA(89), RP(41), S5-DL(42)
EMB-145XR	0.98	EV-UA(81)
EMB-170	1.46	CP-DL(6), S5-DL(14), S5-UA(30), YX-AA/US(20)
EMB-175	1.54	CP-AA/US(20), CP-DL(36), OO-AS(7), OO-UA(40), S5-DL(16), YV-UA(31), YX-AA/US(88)
EMB-190	1.78	B6(60), US(20)

A.5 List of Carrier's Hub

This appendix provides a list of the domestic hubs and focus cities for each of legacy carriers as well as low cost carriers.[48] Since regional carriers mainly operate on behalf of the mainline carriers, their hubs and/or focus cities are not listed here. The asterisks refer to the hubs that American Airlines acquired through the merger with US Airways.

Legacy Carrier	**Hubs**
American Airlines (AA)	CLT*, DCA*, DFW, JFK, LAX, LGA*, MIA, ORD, PHL*, PHX*
Alaska Airlines (AS)	ANC, LAX, PDX, SEA
Delta Air Lines (DL)	ATL, BOS, CVG, DTW, JFK, LAX, LGA, MSP, SEA, SLC
Hawaiian Airlines (HA)	HNL, OGG
United Airlines (UA)	DEN, EWR, GUM, IAD, IAH, LAX, ORD, SFO
US Airways (US)	CLT, DCA, LGA, PHL, PHX
Low Cost Carrier	**Focus Cities**
Jet Blue (B6)	BOS, FLL, JFK, LGB, MCO, SJU
Frontier Airlines (F9)	ATL, CLE, CVG, DEN, LAS, MCO, ORD, PHL, TTN
Air Tran (FL)	ATL, BWI, MCO, MKE
Allegiant Air (G4)	AZA, CVG, FLL, LAS, LAX, MYR, OAK, PGD, PIE, PIT, SFB
Spirit Air (NK)	ACY, ATL, DFW, DTW, FLL, IAH, LAS, LAX, MYR, ORD
Southwest Airlines (WN)	ATL, BNA, BWI, DAL, DEN, FLL, HOU, LAS, LAX, MCO, MDW
	MKE, OAK, PHX, SAN, SNA, STL, TPA
Virgin America (VX)	DAL, LAX, SFO

[48]Some airlines also have overseas hubs. For example, United Airlines has a hub at Tokyo-Narita Airport (NRT). Delta Air Lines has hubs at Amsterdam Airport Schiphol (AMS), Paris Charles de Gaulle Airport (CDG), and Tokyo-Narita Airport (NRT). Those hubs are not listed here.

A.6 List of Hubs by Hub Size According to Enplanement Share

This appendix provides the hub size of each airport using the data published for 2014. According to the Bureau of Transportation Statistics of the Department of Transportation, an air traffic hub is "a community whose area includes airport(s) that serve at least 0.05% of all enplaned (boarded) passengers in the United States. All [airports] displayed here had a total enplanement of 30,000 or more for 2014." The information here is obtained from `http://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/`. Airports not listed here are considered without any hub status (none hub or without commercial services).

Hub Size	**Airports**
Large Hub	ATL, BOS, BWI, CLT, DCA, DEN, DFW, DTW, EWR, FLL, HNL, IAD, IAH, JFK, LAS, LAX, LGA, MCO, MDW, MIA, MSP, ORD, PDX, PHL, PHX, SAN, SEA, SFO, SLC, TPA
Medium Hub	ABQ, ANC, AUS, BDL, BNA, BUF, BUR, CLE, CMH, CVG, DAL, HOU, IND, JAX, MCI, MKE, MSY, OAK, OGG, OMA, ONT, PBI, PIT, RDU, RSW, SAT, SJC, SJU, SMF, SNA, STL
Small Hub	ACY, ALB, AVL, BHM, BIL, BLI, BOI, BTV, BZN, CAE, CAK, CHS, CID, COS, DAY, DSM, ECP, ELP, EUG, EYW, FAI, FAR, FAT, FNT, FSD, GEG, GRR, GSN, GSO, GSP, GUM, HPN, HSV, ICT, ISP, ITO, IWA, JAN, KOA, LBB, LEX, LGB, LIH, LIT, MAF, MDT, MEM, MFE, MHT, MSN, MYR, OKC, ORF, PIE, PNS, PSP, PVD, PWM, RIC, RNO, ROC, SAV, SDF, SFB, SGF, SRQ, STT, SYR, TUL, TUS, TYS, XNA

A.7 An Example of Fuel Cost Proxy Calculation

This appendix shows an example of the calculation of our proxy variable for fuel cost. We use information from Appendix A.4 to show the example.

Example. Itinerary ID: 201,524,821,074, departed in the second quarter of 2015. There are four segments in this itinerary. Segment 1: STL-DTW, operating Carrier: WN, ticketing Carrier: WN, distance in track miles: 440. Segment 2: DTW-MDW, operating Carrier: WN, ticketing Carrier: WN, distance in track miles: 228. Segment 3: MDW-MSP, operating Carrier: WN, ticketing Carrier: WN, distance in track miles: 349. Segment 4: MSP-STL, operating Carrier: WN, ticketing Carrier: WN, distance in track miles: 448. This is a roundtrip ticket from St. Louis (STL) to Minneapolis (MSP). From Appendix A.4, 117, 10, 476, and 106 are the numbers of aircraft in service for different types of aircraft in Southwest Airlines, and 709 is the total number of aircraft in service. 2.00 (three of them) and 2.21 are the respective fuel efficiency (GPNM). Dividing the distance in track miles by 1.15 gets the distance in nautical miles. Given that the unit jet fuel price is \$1.94 for the second quarter of 2015, we compute the proxy using the formula in (11) as follows:

$$Cost_{Segment1} = 1.94*(117/709*2.00+10/709*2.00+476/709*2.00+106/709*2.21)*(440/1.15) = 1,507.83 \tag{16}$$

$$Cost_{Segment2} = 1.94*(117/709*2.00+10/709*2.00+476/709*2.00+106/709*2.21)*(228/1.15) = 781.33 \tag{17}$$

$$Cost_{Segment3} = 1.94*(117/709*2.00+10/709*2.00+476/709*2.00+106/709*2.21)*(349/1.15) = 1,195.98 \tag{18}$$

$$Cost_{Segment4} = 1.94*(117/709*2.00+10/709*2.00+476/709*2.00+106/709*2.21)*(448/1.15) = 1,535.24 \tag{19}$$

One can then sum up the costs (16) through (19) for all segments to get:

$$Proxy\_Cost_{201524821074} = Cost_{Segment1} + Cost_{Segment2} + Cost_{Segment3} + Cost_{Segment4} = 5,020.38 \tag{20}$$

A.8 The List of the Routes Considered as the Same Market

This appendix provides the list of the routes considered as the same market. We use two separate sets of definitions, one from the DOT and the database DB1B (referred to as the corresponding airports), and the other acknowledging the fact that there are additional airports in the same city but some of those are not accounted for in the official source (referred to as the extended airports).

Any routes that depart or arrive at any of the airports listed below will be categorized as the same respective market. That is, for example, routes that depart or arrive at ATL or PDK are considered the same, as long as the other market of the origin-destination pair is the same.

Market	**Corresponding Airports (DB1B)**	**Extended Airports**
Atlanta	-	ATL, PDK
Boston	BOS, MHT, PVD	ORH
Buffalo, NY	-	BUF, IAG
Charlotte	-	CLT, USA
Chicago	MDW, ORD	RFD
Cleveland	CAK, CLE	-
Columbus	CMH, LCK	-
Dallas	DAL, DFW	-
Houston	HOU, IAH	-
Los Angeles	BUR, LAX, LGB, ONT, SNA	-
Miami	FLL, MIA	PBI
New York City	EWR, HPN, ISP, JFK, LGA, SWF	TTN
Orlando	-	MCO, MLB, SFB
Philadelphia	-	ACY, ILG, PHL
Phoenix	AZA, PHX	-
San Francisco	OAK, SFO, SJC	STS
St. Louis	-	BLV, STL
Tampa	PIE, TPA	SRQ
Virginia Beack/Norfolk	ORF, PHF	-
Washington D.C.	DCA, IAD, BWI	-