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Taxation in the Aviation Industry: Insights and Challenges

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Abstract

Taxation in the aviation industry has evolved considerably over the last 25 years. Despite the vital role aviation and airports play in efficiently moving goods and people, the effect of taxation in this industry is understudied. Understanding how passengers and carriers respond to taxes and government fees is crucial to efficiently raising government revenue. After an overview of how taxation has evolved in the industry, this paper estimates how fares adjust in response to tax changes. Exploiting variation in taxes across similar routes and over time, the results suggest taxes are over-shifted to consumers (i.e., a $1 increase in taxes results in more than a $1 increase in the total fare). The paper discusses potential explanations for this result: the nature of competition in the industry and the propagation of taxes within a network.

Taxation influences a wide range of behavior. For example, taxes in the aviation industry may affect a passenger's fare, the size of the aircraft a carrier operates on a route, and the number of departures from an airport. Understanding the influence of taxes on passengers, carriers, or airports is valuable in ensuring government finances are raised efficiently without placing undue burden on participants. Aviation taxes are substantial. The mean effective tax rate, defined as the total taxes and fees divided by the passenger fare, was approximately 15% in 2015.

Furthermore, how the government raises and dispenses funding has changed dramatically in the aviation industry over the last 25 years. Despite this change, relatively little research studies the extent of taxation or analyzes its influence on economic variables such as the price. This paper makes two contributions to fill this void in the literature. The first portion describes how aviation taxation in the United States (U.S.) has evolved since the early 1990s. The second portion develops an empirical model that exploits variation in the level of taxes across similar routes and over time to estimate how equilibrium fares change in response to taxes. Initial results suggest taxes are over-shifted to consumers (i.e., a $1 increase in taxes results in more than a $1 increase in the tax-inclusive fare for the consumer). The paper then discusses potential explanations for this result: the nature of competition in the industry and the propagation of taxes within a network.

Studying taxation in the aviation industry is difficult because the primary data set on fares contain only total fares without any decomposition into the base fare, taxes, or fees. Despite this difficulty, several studies have documented the role of taxes in the aviation industry. In a 1997 *Transportation Research Record* article, Heimlich provides a history of the U.S. Ticket Tax, arguing the regulation of the industry in its formative years and airline travel's characterization as a luxury good influenced the level of taxation (*1*). In a 2004 article, Karlsson et al. provide a cross-sectional description of domestic airline tickets for the second quarter of 2002 and find an effective tax rate of approximately 15.5% (*2*). Garrow et al. describe how the recent trend of unbundling fares has the potential to impact revenue given the domestic tax structure (*3*). More recently, Agrawal et al. write about a tax calculator that identifies the precise taxes paid on a given itinerary to document spatial and temporal variation in the industry (*4*). Prior to this paper and their study, no research had comprehensively tracked taxes in the industry over a prolonged period. International aviation markets are also taxed quite substantially and have a similarly sparse literature. In a recent paper, Bradley and Feldman examine the influence of international taxes on the airline industry (*5*). However, they focus on the salience of taxes and not the effect of major tax rate

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Table 1. Major Tax Changes and Lapses—1993–2015

Tax	Type	Change	Year	Description
U.S. Ticket Tax	Ad Valorem	Lapse	1996	Lack of reauthorization: 0%[a]
		Lapse	1997	Lack of reauthorization: 0%
		Statutory	1997–1999	Periodic decline: 10–7.5%
		Lapse	2011	Lack of reauthorization: 0%[a]
PFC	Specific	Statutory	2001	Max increased to $4.50[a]
Segment	Specific	Statutory	1997–2015	Periodic increase: $1.00–$4.00
September 11th Fee	Specific	Statutory	2002	Initially $2.50 per segment[a]
		Lapse	2003	Lack of reauthorization: $ 0[a]
		Statutory	2014	Changed to $5.60 per direction[a]
AK/HI Travel Facilities Tax	Specific	Statutory	1993–2015	Periodic increase: $6.00–$8.90

Note: AK/HI = Alaska and/or Hawaii; PFC = passenger facility charge.
[a]Indicates vertical bar in Figure 1.

reforms over time. They find taxes are largely passed through but not over-shifted to passengers. Comparing empirical estimates of pass-through between international and domestic markets is difficult because of differences in the demand elasticity, supply elasticity, and other market characteristics. In the subsequent sections, this paper contributes to the literature by studying the effect of taxes on fares.

Overview of Aviation Taxation

To summarize aviation taxation and interpret the empirical analysis in the following section, one must define terminology specific to the aviation industry. A market is defined by the ordered pair of its origin and destination airports as well as by its round-trip status. Thus, for cities A and B, four potential markets are A to B round-trip, A to B one-way, B to A round-trip, and B to A one-way. Within a market, a route is defined as the path or ordered set of airports used in traveling from an origin to a destination, as well as the return for round-trip markets. Thus, two passengers with the same origin and destination but different connecting airports are flying two different routes within the same market. Throughout the paper, the word "tax" is used to generically cover both taxes and government fees added to a ticket.

In 1993, carriers were responsible for collecting two taxes on domestic flights in the continental U.S., both still collected today. First, the U.S. Ticket Tax is a percentage-based tax added to a base fare. Second, a Passenger Facility Charge (PFC) is a dollar amount added to a base fare for enplanements at a subset of airports that levy them. Subsequently, the U.S. ticket tax rate changed (dramatically at times), per-segment taxes were added, various exceptions for rural routes were added and eliminated, and new fees such as the September 11th Security Fee were added and modified. Table 1 summarizes the set of taxes and fees and how they have changed since 1993.

Broadly speaking, two types of taxes are applied to tickets in the United States: ad valorem taxes, which are a percentage of the base fare set by the carrier, and specific or unit taxes, which add a set dollar amount to that base fare. The bold line in Figure 1 displays the mean effective tax rate, which is the passenger-weighted average of tax rates across all routes in a given period. The figure also shows the effective tax rate for a select sub-set of routes. The tax rates on individual routes are the total tax due for the route in a year-quarter divided by the mean fare for that route in the given year-quarter. Aside from the lapse of the U.S. Ticket Tax during 1996 and 1997, discussed in greater detail below, the mean effective tax rate has remained between 10% and 15% but can be higher or lower for a particular route. Taxes not related to air travel, such as corporate income taxes or taxes on jet fuel, are not included in these figures or in our analysis.

While the mean rate of all routes has remained relatively stable, taxation on individual routes varies considerably. For example, even excluding the lapses in 1996 and 1997, taxes on a round-trip ticket from Memphis (MEM) to Orlando (MCO) via Atlanta (ATL), ranged from 10.9% to 25.8%. Variation is driven by non-tax-related changes to the base fare, but statutory changes and congressional and Federal Aviation Administration (FAA) authorization to levy certain taxes are also important factors. The vertical bars in the figure indicate notable tax events, summarized in Table 1, over the past 25 years. From left to right in Figure 1, these events are the lapse of the U.S. Ticket Tax in 1996, the increase in 2001 of the PFC maximum per enplanement to $4.50, the September 11th Security Fee introduction in 2002 as well as lapse in 2003, the lapse of the U.S. Ticket Tax in 2011, and finally the change in structure of the September 11th Security Fee in 2014.

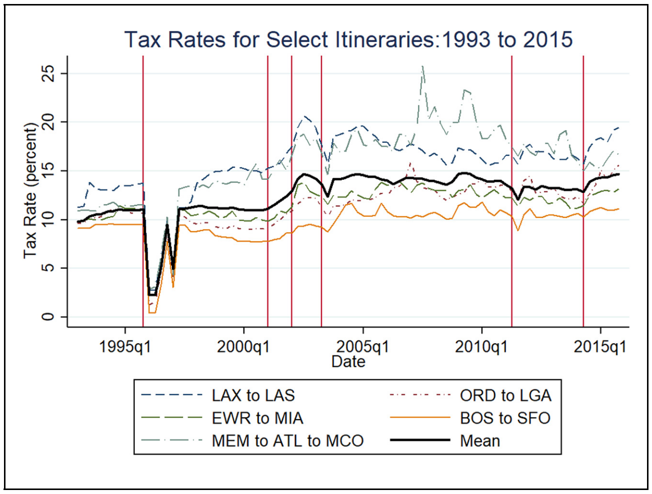

Figure 1. Total tax rates. Select itineraries presented are Los Angeles (LAX) to Las Vegas (LAS), Chicago (ORD) to New York-LaGuardia (LGA), Newark (EWR) to Miami (MIA), Boston (BOS) to San Francisco (SFO), and Memphis (MEM) to Atlanta (ATL) via Orlando (MCO).

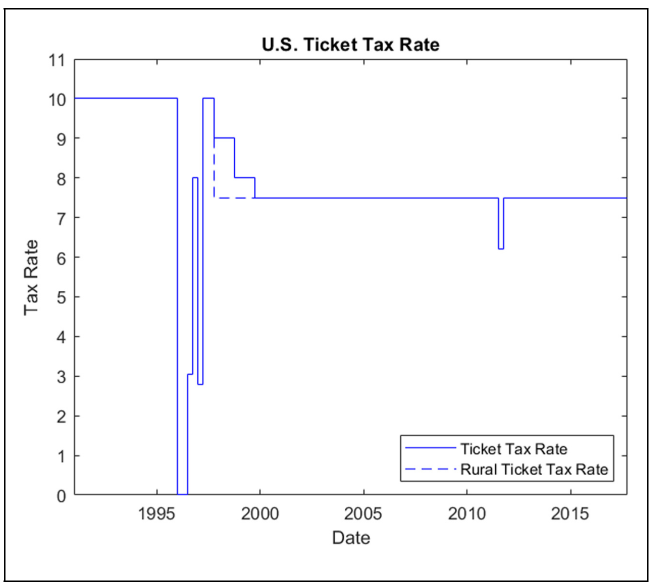

Figure 2. U.S. Ticket Tax rate.

To better explore what drives statutory changes in the tax rates in Figure 1, it is instructive to outline how each of the individual taxes in Table 1 has changed. The U.S. Ticket Tax (also called U.S. Domestic Transportation Tax or the U.S. Excise Tax) is the only ad valorem tax applied to the base fare. Figure 2 shows the tax rate of the U.S. ticket tax from 1993 through 2015 for flights in the continental U.S. Figure 2 also highlights two notable features of Ticket Tax policy over the last 25 years. In the 1990s and again in 2011, Congress allowed authorization to collect taxes for the Airport and Airway Trust

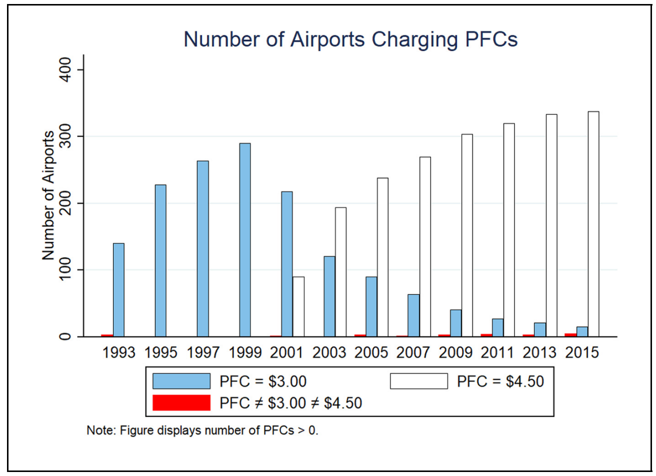

Figure 3. Breakdown of PFCs by charge level.

Fund (AATF) to expire. First, from January 1, 1996, through August 26, 1996, itineraries were not subject to the Ticket Tax. Shortly thereafter, Congress again failed to authorize the AATF from January 1 to March 6 of 1997. Finally, in 2011, authorization again expired from July 23 to August 7. To calculate the tax rate, when taxes are in effect for part of the quarter, it is weighted by the number of days in the quarter for which the tax was not expired.

The second notable feature of the U.S. Ticket Tax is that routes involving certain designated airports have a reduced rate. As indicated by the dashed lines in Figure 2, from the 4th quarter of 1997 to the 4th quarter of 1999, flight segments along a route which involved at least one rural airport were subject to a lower rate. Additionally, but not depicted in the figure, for domestic flights involving Alaska or Hawaii, the tax does not apply to the portion of the flight which occurs over international water or land. In lieu of paying the full U.S. Ticket Tax, flights with one endpoint in Alaska or Hawaii and an origin or destination in the continental U.S. are required to pay the Alaska and Hawaii Travel Facilities Tax, a specific tax which has gradually increased from $6 in 1993 to $8.90 in 2015, along with a prorated Ticket Tax rate covering the portion of the flight over U.S. territory.

Besides the Alaska and Hawaii Travel Facilities Tax, three other taxes or fees also apply to flights in the U.S.: U.S. Federal Segment Fees, PFCs, and the September 11th Security Fee (also called U.S. Passenger Civil Aviation Security Fee). A U.S. Federal Segment Fee, or the federal segment tax, is a per-segment dollar amount added to the base fare. It was introduced at a rate of $1 per segment by the Taxpayer Relief Act of 1997 and gradually increased to $4.00 per segment by 2015. One notable feature of the segment tax is flight segments involving rural airports are exempt from the tax.

PFCs are airport-specific fees assessed when a passenger enplanes at the designated airport. For an airport to assess the charge, the PFC must be authorized by the FAA. The revenue is treated as local funds and restricted to use on specific long-term capital projects. First introduced in 1992, PFCs initially had a maximum allowable charge of \$3.00 per airport. In 2001, the Wendell H. Ford Aviation Investment and Reform Act for the 21st Century increased the maximum charge to \$4.50 (the second vertical bar in Figure 1). A maximum of two PFCs can be assessed on a one-way trip and four on a round-trip flight. Figure 3 displays the number of airports assessing various levels of nonzero PFCs since 1993. The number of airports charging a PFC has steadily increased over time. By 2015, over 350 airports were charging a PFC, with approximately 95% of them charging the maximum allowable \$4.50. Just before the maximum allowable PFC was raised to \$4.50 in 2001, many airports charged the then maximum of \$3.00, although this was not always the case historically. After the 2nd quarter of 2001, airports steadily sought and received approval to institute or raise the PFC to the new cap.

The September 11th Security Fee was instituted in February 2002 (the third vertical bar in Figure 1) to fund transportation security infrastructure and Transportation Security Administration (TSA) operational expenses resulting from the terrorist attacks of September 11, 2001. Initially, passengers were charged \$2.50 for each segment, with total fees capped at \$5.00 per one-way trip and \$10.00 per round-trip ticket. Authorization for the fee lapsed from June 1 to September 30 of 2003, which caused a slight decline in the average fee for that quarter (visible by the fourth vertical bar in Figure 1). In the 3rd quarter of 2014, the structure of the tax was changed (the fifth vertical bar in Figure 1). Since this reform, the fee is \$5.60 for a one-way trip and \$11.20 for a round-trip itinerary, regardless of the number of segments. Given a route, depending on the number of stops and round-trip status, the reform resulted in a slight (\$ 0.60) to moderate (\$6.20) increase in the tax burden.

Effect of Taxation on Fares

The party legally required to remit a tax does not, in general, bear the economic burden of a tax. In perfectly competitive environments, the less elastic party bears a greater burden of the tax; furthermore, the change in the consumer price from a \$1 tax increase is bounded between \$0 and \$1. With constant marginal costs, consumer prices rise by a full dollar. In more complicated settings, however, a tax may be over-shifted to one party (i.e., a \$1 increase in taxes results in more than a \$1 increase in the price). Over-shifting could arise because of market power, products being close complements or substitutes, or cost complementarities between a firm's products (*6, 7*). For the aviation industry, specifically, carriers' market power and cost complementarities from network transactions (i.e., the cost of a flight depending on other related flights) imply a wide range of theoretical possibilities, including over-shifting. These concerns frame the discussion following the results presented here.

Itinerary data are from the Data Bank 1B (DB1B) of the U.S. Department of Transportation's Origin and Destination Survey, a 10% sample of all domestic itineraries in the U.S. The sample period ranges from 1993 to 2015 and the data are aggregated so an observation is at the route-carrier-year-quarter level. Because DB1B does not contain tax data directly, information from federal legislation, the Internal Revenue Service (IRS) code, federal memorandums, and industry documentation dating back to the 1990s are used to determine the federal taxation on a route in a given quarter. Itinerary fares are decomposed into the base fare set by the carrier and the individual statutory taxes owed at the time of the flight based on the itinerary's route. For a more detailed description of how the itinerary fares are decomposed and the restrictions placed on the data, see Agrawal et al. (*4*). The natural log of population and income for the origin and destination cities is from the Bureau of Economic Analysis. The remaining control variables are constructed using route characteristics and flight information reported in the DB1B. *Number of Carriers* is the number of carriers operating in the market. *Airport Presence* is the share of routes a carrier serves out of the originating airport. *HHI* is the Herfindahl-Hirschman Index (sum of squared market shares) for the market. *LCC in Market* equals 1 if there is a low-cost carrier operating in the market and zero otherwise. Brueckner et al. highlight the influential role low-cost carriers play in determining the competitive conditions within a market (*8*). *Miles* and *Miles Squared* are the number of miles flown along the route.

Routes often have different tax treatments, both relative to other routes within their market and across time as taxes lapse or changes to the law occur. To estimate the influence of taxes on fares, one must control for factors correlated with taxes which influence the fare and restrict comparisons with similar routes with different tax treatments. The baseline model, presented in Equation 1, compares fares of routes with the same origin and destination, number of segments, and round-trip designation. Using a panel data fixed effects approach, the average level of a route's fare in a year-quarter is explained by taxes, a set of controls common to the airline literature, and time, carrier, and market-segment fixed effects. By identifying the effect within routes that have the same origin and destination (i.e., market) and number of segments, this specification allows for comparisons of routes with similar demands as well as cost considerations. Formally,

Table 2. Impact of Taxes on Fares

	(1)	(2)
Passenger facility charges	1.65***	na
	(0.21)	na
Total specific taxes	na	1.14***
	na	(0.10)
Number of carriers	−1.77***	−1.84***
	(0.43)	(0.43)
Airport presence	59.20***	58.46***
	(13.31)	(13.65)
HHI	38.80***	38.10***
	(3.04)	(3.06)
LCC in market	−44.75***	−45.61***
	(2.21)	(2.21)
Miles	37.08***	36.68***
	(2.15)	(2.15)
Miles squared	−4.95***	−5.05***
	(0.29)	(0.29)
Origin population	16.54	20.00*
	(10.46)	(10.64)
Destination population	46.71***	46.95***
	(10.16)	(10.23)
Origin income	41.80***	43.60***
	(12.12)	(12.30)
Destination income	13.14	15.26
	(12.16)	(12.31)
Carrier fixed effects	Yes	Yes
Year-quarter fixed effects	Yes	Yes
Market-roundtrip-segment fixed effects	Yes	Yes
N	15,133,306	15,133,306

Note: HHI = Herfindahl-Hirschman Index; LCC = Low Cost Carrier; na = not applicable (the variable was excluded from the regression). The dependent variable is the tax-inclusive mean fare for a route in a year quarter. Standard errors, clustered at the market level, are in parentheses. Markets which have fewer than 1000 passengers per quarter on average are dropped. Within a market, carriers who never serve 10% are dropped from that market. Taxes are measured in dollars. Miles are measured in thousands. Population and Income controls are the natural log of the origin and destination cities on the route.
$^{*}p < 0.10$; $^{***}p < 0.01$.

$$Fare_{r,t} = \zeta_{m,s} + \zeta_t + \zeta_c + \beta Tax_{r,t} + \mathbf{X}_{r,t}\gamma + \epsilon_{r,t} \quad (1)$$

where the dependent variable $Fare_{r,t}$ is the mean fare (i.e., base fare inclusive of taxes) for route r in time period t, $\zeta_{m,s}$ are market fixed effects interacted with indicators for the number of segments and whether the trip is round-trip, ζ_t are time fixed effects, and ζ_c are carrier fixed effects. Depending on the specification, $Tax_{r,t}$ captures either the total PFC or the total specific taxes on the route in period t. The vector $\mathbf{X}_{r,t}$ is the full set of controls outlined below. The model builds on an extensive literature in economics and transportation research which examines how demand and cost factors correspond to equilibrium fares (*8–10*).

Failure to control properly for demand or cost considerations may bias results, especially if implementation of taxes is correlated with uncontrolled demand or cost changes. Because they are unobservable to the researchers, many factors determining prices cannot be directly controlled for in the regression but are intended to be captured by the model's fixed effects. For example, the model relies on time fixed effects to capture fuel price changes under the assumption fuel price is set in a national market. This may not be true to the extent, for example, that state and local sales and excise taxes cause after-tax prices of fuel to differ across the U.S. Time fixed effects also capture macroeconomic shocks over the panel. Changes to the broader economy which impact all routes are captured with the time fixed effect, but market-specific temporal shocks would not be.

Besides time fixed effects, the model utilizes market fixed effects. These dummy variables capture time-invariant factors common to an origin-destination airport pair, such as the non-stop distance between endpoints, and expected conditions at the endpoints. Because demand-side characteristics and supply-side costs may differ for one-way and round-trip flights and by the number of segments flown, the market fixed effects are interacted with a full set of indicators for the number of segments and round-trip status. These capture cost considerations such as the number of landings and takeoffs. While it may be tempting to narrow the fixed effects to the route level, the identifying assumption is that time-invariant demand and supply-side variables are market, rather than route, specific. Further, route fixed effects would eliminate all within-market variation and rely exclusively on temporal variation to identify the effect of taxation on fares. Given many taxes are a function of the number of segments, limiting comparisons to those with the same number of segments is prudent, allowing use of some within-market variation while also controlling for costs.

Table 2 presents the results. The staggered implementation of PFCs at airports across the country provides an intuitive source of variation to initially exploit. The coefficient on *Passenger Facility Charges* implies a $1 increase in the total PFC along a route results in an average increase of $1.65 on the tax-inclusive fare. The coefficients on the control variables each have the expected sign. An additional carrier, especially if a low-cost carrier, is associated with a decline in the fare on average. Higher levels of concentration at either the airport or market level, as captured by *Airport Presence* and *HHI* respectively, imply higher fares on average. Longer routes are associated with higher fares, although at a declining rate as indicated by the negative coefficient on *Miles Squared*. It is difficult to know the correct expected sign of the population and income coefficients, as either could be associated with higher demand or lower cost. Given the controls and fixed effects, all four coefficients are positive, although some are not statistically significant. Relative to a model without controls, the coefficient on *Passenger Facility Charges* is stable, suggesting the fixed effects are capturing many factors correlated with *Passenger Facility Charges*.

If the implementation of PFCs, even if not federal policy, is correlated with the introduction of other taxes on average, as suggested by Figure 3 and Table 1, then the over-shifted estimates from column (1) may be erroneously assigning fare changes from all taxes to some PFC changes. In column (2) all the specific taxes and fees present on a route for a year quarter (segment taxes, September 11th fees, Alaska Hawaii ticket tax, and PFCs) are summed together to generate *Total Specific Taxes*. This represents our preferred specification. While there is some evidence of over-shifting, the coefficient is reduced substantially in magnitude and is not statistically different from full pass-through at a 95% confidence level. However, the estimate is statistically greater than one at lower confidence levels. That pass-through is less than or equal to one with a p-value of 0.08 can be statistically rejected. Using the point estimate from this regression, a $1 increase in taxes is associated with an approximately $1.14 increase in the tax-inclusive fare. The specification with total specific taxes is especially appealing because carriers may only be concerned with the pass-through of taxes overall, as opposed to the pass-through of individual types of taxes.

Implications and Justifications for Over-Shifting

While fares increasing by more than a tax may seem counterintuitive, the prior economic literature suggests over-shifting is common for many goods (*11–13*). This section discusses potential theoretical justifications for this finding which may warrant further research.

Even with over-shifting, the results do not imply profit increases for carriers or that carriers would support tax increases. Higher fares do not imply higher profits because passenger quantities and costs are likely to change as well. The preferred estimate of $1.14 refers to an increase in the passenger fare. Within the increased price, the dollar of tax revenue is not kept by the carrier and, on the margin, the increase in fare above the tax further reduces the quantity demanded. Also, the quantity reduction could cause per-unit costs to rise (e.g., switching to a smaller plane). An increased fare may cause profit per passenger to increase but weakly decreases total profit relative to an untaxed scenario.

Network industries are especially difficult to model, and the policy implications of these results should be interpreted cautiously. First, aviation taxes appear to be largely passed through to passengers. This would be true even if the estimate of pass-through was merely equal to $1 but not over-shifted. Second, taxes share similar properties with other cost shocks to inputs in production, and those cost shocks may be largely passed through, or even over-shifted, to passengers as well.

Aviation taxation, and the industry in general, is complex. A number of topics, such as the relationship between the unbundling of fares and taxes, or the precise impact of the U.S. Ticket Tax lapse on carrier profits, while interesting, are outside the scope of this paper. Rather than attempt to draw broader conclusions regarding aviation policy, the results speak to the need to conduct further research and explore potential theoretical justifications, such as market power and network effects, which could cause the tax to be over-shifted.

Market Factors Influencing Tax Incidence

One possible explanation of over-shifting is that airlines have market power on routes. Recent theoretical work highlights the complex relationship between competition, demand, and supply elasticities, and how changes in equilibrium outcomes affect incidence (*6, 14, 15*). These studies suggest over-shifting may arise with imperfect competition. With imperfect competition, the pass-through of taxes depends on whether competitor firms are expected to match the price increase or expected to try to steal market share. Without additional assumptions, it is difficult to explore how market power interacts with the overall result. Simply utilizing a given measure of competition, such as *Number of Carriers* or *HHI*, is unlikely to be sufficient.

Beyond the theoretical complications, utilizing the empirical model to make predictions, or to accurately estimate how competition and taxation interact in the aviation industry, is difficult for a number of industry-specific reasons. It is not immediately obvious what dimension of competition is most important when setting fares. Empirical evidence has shown market power at both the route-level and airport-level is important for allowing carriers to set fares above marginal cost (*16*). Economic theory provides little guidance on formulating a hypothesis on how a carrier's airport presence might influence the pass-through rate of taxes. One possibility is an increase in a variable such as *Airport Presence* represents an increase in a dimension of market power leading to a higher level of pass-through. Alternatively, as a carrier's *Airport Presence* increases, it has greater incentive to internalize the impact from changes in fares and pass-through taxes at a lower rate. This effect is enhanced by the disbursement of some aviation taxes, such as PFCs, back to their original point of taxation. Furthermore, effects of competition are likely to have substantial non-linearity. The marginal effect of going from a monopoly to duopoly is likely very different than adding a third or fourth carrier. Even with a long-panel and relatively rich data, the model presented here cannot fully address these effects. Taxes may be passed through at substantially different rates depending on the number of carriers, the price sensitivity of passengers, and the ease of entry in a market. The results presented above likely mask interesting heterogeneity along multiple dimensions of market power which could have rich regulatory and antitrust implications.

Network Impact

Airline networks, rather than simply connecting passengers between an origin and destination, are structured so routes have a greater "density" or quantity of passengers along routes. These "economies of density" are motivated by engineering cost considerations, notably larger planes with a lower cost per passenger mile, and the ability of carriers to route passengers in different markets onto the same plane to maximize cost savings. Many economists attribute the hub-and-spoke structure of the network as the natural outcome of carriers reacting to economies of density (*17, 18*). Economies of density interact with many economic variables of interest, producing interesting paradoxes for researchers to resolve.

Even a simple theoretical model can provide some intuition for how the role of a network might influence pass-through and cause the estimates above to be overshifted. Imagine a simple network with three cities: two spoke cities A and B, and a hub H. Passengers can fly directly from A to H or B to H (or vice-versa) but not directly from A to B. Passengers wishing to travel from A to B must connect via H. As a result of economies of density, the more passengers on a flight, then the cheaper the cost, and hence the lower the fare. Now, for simplicity, imagine a tax is assessed only on passengers enplaning at airport A. Passengers flying from A to H, including passengers with final destination B, will pay this tax, but a passenger flying only from H to B would not. The tax will directly dissuade some A to H and A to B passengers from flying, as it raises the fare on those routes. This lowers the number of total passengers on both flights A to H and H to B (because there are fewer A to B passengers). The marginal cost of the flights increases because there are fewer passengers aboard. Because the marginal cost of the H to B flight increases, then, all else equal, the fare for passengers flying from H to B will increase as well, despite not being taxed. Thus, cost complementarity between different routes may cause taxes to increase fares on both directly taxed routes as well as other closely connected routes. As prior studies have shown, cost complementarities are likely substantial in the U.S. aviation industry (*17, 18*). These arise from larger, more efficient aircraft, using those aircraft at higher load factors, and more intensive use of airport facilities.

Without more information, the empirical model presented above cannot account for the network structure or any cost complementarity which arises as a result of that structure. If network characteristics, whether cost complementarities or another factor, influence how taxes are passed through to passengers, then the model could find over-shifting, because tax changes occurring on related routes may be attributed to the direct tax change occurring on the route.

Conclusion

Taxation in the U.S. aviation industry has changed dramatically over recent decades. This paper documents those changes and estimates a $1 increase in taxes leads to a $1.14 increase in fares on average. This provides preliminary evidence taxes are largely passed through to consumers and might even be over-shifted. Empirically estimating pass-through in an industry as complex as U.S. domestic commercial aviation is challenging. The precise mechanism explaining these results should be interpreted cautiously, as there are a number of potential explanations for this result. First, as recent theoretical work has shown, when estimating pass through in oligopolistic settings, one should ideally account for factors such as the precise type of competition, the curvature of demand, and the elasticity of competition (*6*). Second, a defining characteristic of the aviation industry is that economic activity occurs within a network. Even for simple models, the role of network characteristics should be accounted for when one is estimating tax incidence. Subsequent research should seek to address more fully the possible mechanisms explaining the result presented in this paper.

Author Contributions

The authors confirm contribution to the paper as follows—study conception and design: QW, DRA, JWW; data collection: QW, DRA; analysis and interpretation of results: QW, DRA, JWW; draft manuscript preparation: QW. All authors reviewed the results and approved the final version of the manuscript.

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