# Hidden Baggage: Behavioral Responses to Changes in Airline Ticket Tax Disclosure

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**Abstract**

We examine the impact of a January 2012 enforcement action by the U.S. Department of Transportation that required U.S. air carriers and online travel agents to modify their web interfaces to incorporate all ticket taxes in upfront, advertised fares. We show that the more prominent display of tax-inclusive prices is associated with significant reductions in consumer tax incidence, demand, and ticket revenues along more heavily-taxed itineraries. In particular, the fraction of unit taxes that airlines passed onto consumers fell by roughly 75 cents for every dollar of tax. These results reinforce prior findings on consumer inattention in a novel institutional setting featuring quasi-experimental variation in tax salience, economically-significant tax amounts, and endogenous price responses.

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# 1 Introduction

A growing body of literature has established that tax salience (i.e. visibility or transparency) can have a pronounced effect on behavioral responses to taxation for a variety of tax and tax-like instruments.[1] One of the earliest and most robust findings from this literature is that consumers often fail to fully internalize total tax-inclusive prices when base prices and sales taxes are disclosed separately, as is the norm for U.S. retail sales (Chetty, Looney and Kroft (2009); Feldman and Ruffle (2015)). Due to the primarily experimental nature of the prior literature vis-à-vis consumption tax salience, however, seller pricing behavior and possible exploitation of salience effects remain less studied. If consumers are inattentive to low-salience taxes, such that the elasticity of demand with respect to taxes is less than the elasticity of demand with respect to tax-exclusive (base) prices, producers will generally find it easier to pass taxes through to consumers and will bear a smaller share of the burden of the tax.[2] Conversely, an increase in tax salience should lead to diminished tax incidence on consumers and a reduction in producer revenue (Chetty, Looney and Kroft, 2009).

We evaluate the effects of increased tax salience on airline ticket pricing, demand, and revenues in the context of a regulatory change to the advertising of commercial airline tickets mandated by the U.S. Department of Transportation (DOT), whereby U.S. air carriers and online travel agents were required as of January 26, 2012 to incorporate all mandatory taxes and fees in their advertised fares. To our knowledge, this constitutes the only instance of a regulatory change from tax-exclusive to tax-inclusive pricing regimes at the national level in the U.S., such that this paper represents the first quasi-experimental test of the basic framework from the prior experimental literature. Moreover, the market for air travel presents a unique setting in which to examine tax salience due to the fact that airline ticket taxes are economically large and account for a non-trivial

[1] See, for example, Chetty, Looney and Kroft (2009), Goldin and Homonoff (2013), Feldman and Ruffle (2015), and Feldman, Goldin and Homonoff (2018) (sales and excise taxes); Finkelstein (2009) (electronic tolls); Bradley (2017) (property taxes); or Chetty and Saez (2013) and Feldman, Katuščák and Kawano (2016) (child tax credits).

[2] If consumers are wholly inattentive such that the tax elasticity of demand is zero, it is easy to see that the tax will fall entirely on consumers, at least in the short run. (See Chetty, Looney and Kroft (2009) or Reck (2016) for a discussion of the implications of longer-run budgetary adjustments.) This situation is indistinguishable in a static environment from complete pass-through resulting from infinitely elastic supply in a perfectly competitive market in long-run equilibrium, even where taxes are fully salient.

fraction of total airfares, such that search costs are unlikely to provide a plausible rationalization for non-standard behavior.[3]

Prior to 2012, DOT regulations allowed airlines and online travel agents to advertise fares to U.S. consumers exclusive of specific (unit) tax amounts so long as ticket taxes and fees were revealed at later stages of the online ticket-buying process. Thus, variation in unit taxes due to differences in itinerary characteristics (including origin and destination airports, the number and location of layovers, and occasionally, operating airlines) remained relatively invisible to consumers in their initial search stages. In that environment—the industry norm—learning about variation in unit taxes would require consumers to initiate the ticket-purchasing process multiple times for different flight itineraries, thereby forcing (attentive) consumers to exert costly effort to compare tax-inclusive prices. Justifying the effort to initiate this process, however, would require prior knowledge of the existence of substantial potential variation in unit taxes—precisely the type of environment where inattention and failure to "learn by noticing" may be particularly concerning (DellaVigna (2009); Hanna, Mullainathan and Schwartzstein (2014)).[4]

Whereas cognitive biases have served to motivate the implementation of various consumer protections, primarily in the area of financial products,[5] the DOT's full-fare advertising rule represents the first instance of an application of tax salience considerations to U.S. federal regulations. These "full fare advertising rules" (henceforth FFAR in our terminology) provide a unique opportunity to study the importance of limited attention in modulating consumer responses to taxation and to quantify the magnitude of taxpayer optimization errors that arose under the prior low-salience

[3]Average and median unit tax amounts in our sample of U.S. international flights amount to roughly $100, or 16 percent of the average total ticket price.

[4]This scenario differs from the sales tax environment examined in Einav et al. (2014) where knowledge of opportunities for cross-border tax avoidance (on- or off-line) is relatively widespread. Indeed, a large proportion of commenters on this paper have noted being surprised to learn that ticket taxes are *not* constant across itineraries serving the same origin and destination market. This view generally holds for *domestic* flights, such that more "experience" in purchasing U.S. domestic air travel may actively deter learning about the true scale of variation that exists for international flights.

[5]See Barr, Mullainathan and Shafir (2009) for a broad discussion of arguments in favor of these types of regulations. Examples of such policies include the Pension Protection Act of 2006 (intended to promote automatic enrollment in retirement savings plans), elements of the Dodd-Frank Act (i.e. the mandatory provision of mortgage escrow accounts to new homebuyers) or the Credit Card Accountability Responsibility and Disclosure Act of 2009 (minimum payment disclosures).

ticket tax regime.[6] Given FFAR's emphasis on consumer protection, we deviate from the literature on optimal tax salience (e.g., Congdon, Kling and Mullainathan (2009); Gamage and Shanske (2011); Goldin (2015)), and we leave aside consideration of any welfare losses attributable to behavioral distortions resulting from increased tax salience.

Using restricted-use (international) ticket data from the Bureau of Transportation Statistics' Origin and Destination Survey (DB1B) over a period of 19 quarters surrounding the DOT rule change, we make use of identifying variation derived from differences in itinerary-specific unit taxes *within* origin-destination city market pairs and find that the more prominent presentation of tax-inclusive air fares following the implementation of FFAR is associated with a sharp decline in pass-through rates for unit ticket taxes. Prior to FFAR, airlines passed through nearly the entire tax onto consumers in the form of higher base and total fares, while in the post-FFAR period, only about 25 cents of every dollar of unit taxes is passed onto consumers. In addition, pass-through rates for other sources of airport- and route-specific costs that were not the subject of the new disclosure rules (e.g. runway fees, gate fees, navigation charges, noise and emissions fees, etc.) were not significantly affected. We also find that reductions in pass-through rates were generally largest in more highly concentrated markets, consistent with the elementary textbook theory of tax incidence under imperfect competition. Airlines thus appear to have partially insulated inattentive consumers from *perceived* fare increases due to the implementation of tax-inclusive pricing through large offsetting reductions in base fares.

On balance, reduced ticket tax pass-through rates combined with the negative effects of unit taxes on ticket demand in the post-FFAR period together translate into significant reductions in

[6] Equivalently, ticket taxes may be viewed through the lens of partitioned pricing as a type of "shrouded attribute" (Gabaix and Laibson, 2006). To this point, FFAR also required airlines to provide more prominent links to information regarding baggage fees, which represent a clear example of partitioned pricing similar to cases considered elsewhere in the behavioral literature, such as printer ink cartridges (Gabaix and Laibson, 2006), shipping costs (Hossain and Morgan, 2007), or booking fees (Blake et al., 2017). Brueckner et al. (2013) examine the incentives for baggage fee unbundling and their resulting impacts on airline revenues, albeit without discussing the role of consumer inattention. Agarwal et al. (2014) provide a methodology for measuring the effects of fee disclosure on consumer welfare with a hypothetical application to baggage fees. We are not able to assess the effects of FFAR's ancillary provisions regarding baggage fee disclosure due to a lack of available data. However, we expect any potential effects to be heavily muted in our sample given our emphasis on international flights, where the major U.S. legacy carriers and their code-share partners have historically waived baggage fees on travelers' first piece of checked luggage.

airline ticket revenues along higher-tax routes, consistent with the predicted consequences of increasing tax salience and substitution away from high-tax routes. Controlling for all unobserved determinants of quarterly passenger demand by origin-destination city market and instrumenting for carriers' endogenously-chosen base fares using a measure of competing carriers' route availability, we find that a $10 increase in unit taxes (roughly equal to the average standard deviation in tax amounts within origin-destination markets) is associated with an 8.4 percent reduction in passenger volume in the post-FFAR period. Allowing for attenuation of these demand effects due to reduced pass-through, price and quantity effects resulting from the same $10 tax increase contribute to a net reduction in airline ticket revenue of 4.8 percent, and we cannot reject equal demand sensitivity to tax and non-tax fare components after the adoption of FFAR.[7] These effects reflect a relatively high elasticity of demand with respect to advertised fares—consistent with a high degree of cross-itinerary substitutability *within* origin-destination city markets.

Taken together, these findings provide strong quasi-experimental support for the main conclusions and predictions about the consequences of inattention to commodity taxes in the tax salience literature. However, relative to the field- and lab-generated experimental evidence presented in Chetty, Looney and Kroft (2009) and Feldman and Ruffle (2015), respectively, a key distinction in our setting is the ability of sellers to adjust pre-tax prices and—in the longer-term—product availability. Demand responses to more salient tax information are therefore partially attenuated through diminished tax incidence on consumers.

Our results also help to inform the relatively narrow literature on commodity tax incidence, including Poterba (1996); Besley and Rosen (1999); or Carbonnier (2013), and we provide the first large-scale estimates of airline ticket tax pass-through rates.[8] Given the nature of the market for

[7]Perhaps not surprisingly, U.S. airlines have lobbied extensively to prevent and subsequently reverse the implementation of FFAR. Consistent with these objectives, the U.S. House passed the "Transparent Airfares Act" in June 2014, which would have allowed airlines to revert to advertising tax-exclusive fares. The bill failed to reach the Senate before the conclusion of the 113$^{\text{th}}$ Congress. The FAA Reauthorization Bill of 2018—which passed the U.S. House on April 27, 2018 by a vote of 393/13—would likewise have eliminated tax-inclusive pricing requirements, but this provision was ultimately dropped from the conference version of the bill. Our within-market identification strategy does not allow examination of aggregate demand or revenue effects which could have resulted from a perception of increased fares following the adoption of the full-fare disclosure regime or—correspondingly—its reversal, but the airline industry's opposition to FFAR offers *prima facie* evidence of such concerns.

[8]Huang and Kanafani (2010) exploit variation in U.S. passenger facilities charges in order to obtain estimates of

air travel, our estimates serve as a test of the theoretical predictions on tax incidence in imperfectly competitive markets (Anderson, de Palma and Kreider (2001); Weyl and Fabinger (2013)) and complement recent estimates by Marion and Muehlegger (2011) and Conlon and Rao (2015) that emphasize the effects of market structure and supply conditions on tax incidence. Finally, our results also extend the literature devoted to studying the impact of consumer disclosures, including Agarwal et al. (2014, 2015), and Keys and Wang (2018).

The remainder of the paper is organized as follows: Section 2 describes the motivation for FFAR and its precise details in the context of the DOT's ongoing regulatory action, Section 3 characterizes the data used in our analysis, Section 4 presents a general estimation framework, Section 5 presents and discusses our empirical results, and Section 6 concludes.

# 2 Full-Fare Advertising Rules

The DOT's full-fare disclosure rule was issued on April 20, 2011 in response to concerns about consumers being mislead as a result of tax- and fee-inclusive prices being less than fully transparent when making online purchases—the method of choice for 72 percent of airline passengers in the period leading up to 2012 (Econometrica, 2011). FFAR subsequently went into effect on January 26, 2012 after a delay requested by U.S. air carriers to comply with technical deployment requirements. Strictly speaking, FFAR was not so much a regulatory change as an enforcement action. Under C.F.R. §399.84, airlines and online travel agents (OTAs) like Expedia, Orbitz, etc. were already required to include all ad-valorem taxes as well as carrier-imposed fuel surcharges in posted prices prior to 2012.[9] However, the DOT had previously exempted taxes that were imposed on a per-passenger basis.

More broadly, there is ample evidence that neither airlines nor OTAs voluntarily included unit

ticket tax incidence. Their results are limited to very modest variation in tax amounts across a sample of 50 U.S. airports. Karlsson, Odoni and Yamanaka (2004) provide descriptive evidence on effective ticket tax rates for domestic U.S. airfares.

[9]Likewise, airport charges levied on a per-movement (i.e., per take-off or landing) rather than per-passenger basis, such as most runway fees, air navigation charges, noise and emissions fees, etc., could not be broken out as separate passenger charges and were therefore incorporated into airlines' base fares before the imposition of FFAR.

taxes in posted prices prior to 2012 and that ticket tax information was only made available to consumers after the initial display of online search results.[10,11] The fact that U.S. airlines collectively requested a delay in order to implement the technical requirements needed to update their websites (and lobbied aggressively against FFAR both before and after its implementation) emphasizes that this was not common practice in the pre-FFAR period. In addition, there are multiple cases where DOT issued fines against U.S. carriers or OTAs for related forms of "false" advertising, such as advertising fares that did not properly include fuel surcharges.[12]

Figure 1 highlights the nature of the potential challenge facing consumers in selecting airline tickets when ticket taxes are not immediately disclosed in advertised fares and consumers exhibit limited attention. The figure shows 18 possible round-trip itineraries between New York City's John F. Kennedy airport (JFK) and Tel Aviv (TLV) ranked by total tax-inclusive total fares versus tax-exclusive base fares (a rank of 1 designating the lowest fare).[13] As shown, itineraries above

[10] Approximately 20 percent of airline tickets are sold by OTAs (Atmosphere Research, 2016). Ownership and contractual agreements between airlines and OTAs imply that airline preferences dictate the terms of OTA fare advertising practices, a representative illustration of which appears in Appendix A.2. We cannot fully refute the existence of specialized fare aggregator websites that might have allowed modifying the default tax-exclusive ordering of fare search results prior to 2012. However, actively seeking such information presumably reflects a higher level of consumer attention and sophistication, and a larger fraction of purchases made on this basis would merely attenuate our estimates of debiasing.

[11] A small number of EU carriers complied with FFAR prior to its enforcement date and issued press releases accordingly at that time. This likely reflects the fact that foreign carriers had already been subject to similar regulations in the EU and Australia, thereby facilitating compliance. Issuing such releases highlights that they were *not* posting tax inclusive prices prior to the end of 2011, and the DOT's Office of the Assistant General Counsel for Aviation Enforcement and Proceedings confirms that their office was not aware of any other (i.e., domestic) carriers or OTAs that complied ahead of the deadline, whereas brief delays in compliance occurred in a small number of cases (as attested to by the screen captures from Expedia.com in Figure A1).

[12] See, for example, "DOT Fines Travelocity for Violating DOT Price Advertising Rule" (`https://www.transportation.gov/briefing-room/dot-fines-travelocity-violating-dot-price-advertising-rule`) or "DOT Fines Southwest for Violating Price Advertising Rule, Assesses Additional Penalties for Violating Previous Cease and Desist Provisions" (`https://www.transportation.gov/briefing-room/dot-fines-southwest-violating-price-advertising-rule-assesses-additional-penalties`).

[13] We define an *itinerary* as a sequence of flight segments and ticketing carriers, while a *route* represents a sequence of flight segments only (i.e., departing and arriving airports, including an origin, final destination, and all stopovers). An *origin-destination airport pair* encompasses all possible itineraries connecting the same origin and final destination airports. The latter are nested within *origin-destination city pairs*, which comprise all airports within a 100-mile radius of the largest population center in the area. For example, JFK DL TLV :: TLV AF CDG AF JFK represents a round-trip itinerary between New York City's John F. Kennedy Airport and Tel Aviv's Ben Gurion Airport with an outbound flight on Delta Airlines and a return trip (with a layover in Paris's Roissy Charles de Gaulle Airport) operated by Air France. The corresponding route, offered by potentially multiple carriers, is JFK TLV :: TLV CDG JFK and the origin-destination airport pair is simply JFK :: TLV. The origin-destination city pair consists of potentially multiple airports located within a 100 mile radius of either origin or destination city. This includes 7 airports in the vicinity of JFK, including New York's La Guardia (LGA); Newark, New Jersey (EWR); and Philadelphia, Pennsylvania (PHL);

the 45-degree line are relatively more expensive in ordinal terms than their base fare rank would suggest, whereas itineraries below the line ought to be more attractive to consumers than their base fare rank would suggest. Thus, for example, one of the two least expensive itineraries on a tax-inclusive basis, JFK DL TLV :: TLV DL JFK, would only be ranked 10th out of 18 flights in tax-exclusive terms (in a three-way tie). A consumer might consequently be more inclined to choose JFK LY CDG LY TLV :: TLV LY JFK (in a three-way tie for the second lowest base fare), despite this itinerary ranking eighth in tax-inclusive terms, and costing about $40 more than the lowest-cost ticket overall. More broadly, much of the differences across total fare amounts can be attributed to relatively wide variation in tax amounts, ranging from a low of $89 for a non-stop Delta flight to a high of $195 for an EL AL flight with a layover in Paris Charles de Gaulle (CDG) in both directions.

Table 1 underscores the specific sources of underlying tax variation by presenting a breakdown of unit taxes for three sample itineraries linking JFK and TLV. The first row lists the base fare, or the fare that would have been advertised to consumers at the first stage of the ticket-buying process pre-FFAR, whereas the total fare inclusive of all taxes (bottom row) would have only appeared at a later stage. As the table illustrates, there are numerous country-specific taxes built into the final prices. As all flights in our data originate or end in the U.S., all incur U.S. taxes. The remaining taxes are determined by the set of foreign airports where the flight "touches down" for a layover or as a final destination, and, in some cases, by route (e.g., based on arriving or departing distance, or whether segments are between EU airports). In rare cases, taxes may also vary by airline flown, and all taxes are subject to changing over time.[14] If ticket taxes are not taken into account by the consumer at the time of initial fare selection, one may think that column (3) offers the lowest price. Once presented with the additional cost attributable to taxes on a subsequent screen in the ticket-buying process, the consumer might infer—without comparable information from other

along with 3 secondary airports.

[14] In practice, statutory unit tax amounts change infrequently and are generally tied to long-term budgetary outlays, such as funding for infrastructure improvement projects, or reflect periodic inflation adjustments. Bilateral exchange rate movements drive more frequent changes in dollar-denominated tax amounts for taxes levied in foreign currencies.

itineraries to suggest otherwise—that taxes would apply uniformly across ticket choices.[15] Instead, the itinerary in column (3) is clearly the most expensive of the three options once unit taxes are included in the total price.

The net effect of this type of route-specific tax variation within and across the 300 largest international origin-destination city markets served by U.S. carriers can be seen in Figure 2 in terms of either unit tax amounts (2a) or effective tax rates (i.e. unit taxes as a percentage of average total fares; 2b). As shown, Western European and Caribbean destinations (purple circles and light blue squares, respectively) tend to exhibit among the highest unit tax amounts as well as the highest standard deviation thereof, reflecting a combination of high taxes at destination airports as well as increased taxes accruing at stopover points on longer routes. Relative to total fares, Caribbean destinations trigger by far the highest effective tax rates (Figure 2b), which exceed 30 percent in certain cases.

Suggestive evidence of passengers substituting toward lower-taxed routes as a result of FFAR within this set of 300 origin-destination city markets is shown in Figure 3. The figure depicts average four-quarter changes in the high-tax share of passenger volume accruing to the set of routes in the top and bottom quartiles of the ticket tax distribution (based on a balanced panel of ever-available route offerings within origin-destination city market). As shown, the share of passengers traveling via relatively high-tax routes was generally growing prior to the implementation of FFAR and remained roughly unchanged in 2012Q1 and 2012Q2 (during which time only a fraction of travelers would have been exposed to tax-inclusive pricing at the time of ticket purchase). Beginning in 2012Q3, however, high-tax routes experienced persistent declines in volume share in favor of lower-taxed routes, with this effect gradually tapering off after eight quarters.

[15]Even post-FFAR, popular fare aggregator websites and airlines' own websites rarely feature the complete breakdown of taxes and fees by levying country that appears in Table 1. This reduces the probability that a consumer could learn, for example, that layovers in CDG contribute roughly $90 in additional taxes and fees relative to a non-stop flight that avoids CDG.

# 3 Data

The primary data for this project are drawn from the restricted-use (international) portion of the DOT's Origin and Destination (O&D) Survey (DB1B) for the period 2009Q4-2014Q2, used in conjunction with data on airport charges from RDC Aviation plus detailed fare composition information scraped via a flexible fare search platform. The DB1B data consist of a 10 percent sample of all complete ticketed itineraries involving a U.S. operating carrier and are reported quarterly, based on date of travel. From this sample, we extract only the set of international itineraries that either originate or terminate at a U.S. airport. Crucially, these data include all route and carrier characteristics, as well as the number of passengers traveling, distance flown, fare class, and the total tax-inclusive fares paid per passenger.

The DB1B ticket data do not, however, provide a breakdown of the fare composition. We consequently rely on data from RDC Aviation and fare scrapes to construct a historical database of itinerary-specific ticket taxes and non-tax charges, which we match to the DB1B data in order to back out tax-exclusive prices (i.e., base fares). This process involves a complex series of steps, which we describe in greater detail in Appendix A.1. In essence, this procedure requires parsing information from RDC Aviation on all applicable airport charges for a sample of over 50000 unique quarterly airport-route-aircraft combinations in order to separate individual charge items into either government-imposed taxes and fees (levied on a per-passenger unit basis and thus, affected by FFAR) or non-tax charges (levied on a per-movement basis, and thus, unaffected by FFAR). Performing this decomposition in turn relies on fare construction information that we gleaned from over 30000 online fare searches performed over the period December 30, 2014 - January 29, 2015. Each scraped itinerary yields an extract of all applicable ticket tax codes, descriptive names, and corresponding dollar amounts, thereby enabling us to flag matching charges from the RDC database at the airport-route level and assemble these across all relevant airport-route segments on a historical basis.[16] This group of initial charge and fare queries represents all routes in the DB1B

[16]The tax amounts recovered through our web-scraping procedure present only a static snapshot of applicable taxes from early 2015. We do not use these scraped tax amounts directly in our analysis due to the risk that this approach might introduce classical measurement error whose variance would grow the further we extrapolate post-FFAR tax

sample flown by more than 36 passengers (in either direction) over the 2012Q4-2013Q3 period (i.e. averaging at least one passenger per day in the full 100 percent sample).[17]

A sample concordance between the set of scraped French ticket taxes levied on a round-trip flight PHL DL CDG and the corresponding set of per-passenger charges for arriving or departing flights in Paris (CDG) as reported by RDC Aviation are given in Table A1. We confirm that the remaining set of 9 charges identified by RDC as being levied at CDG—shown in Table A2—are indeed levied on per-movement basis and fall broadly into the general categories of air navigation, infrastructure, noise, parking, runway, or terminal charges.[18] We divide the resulting total amount for these non-tax charges according to the seating capacity of the aircraft used to service the flight segment in question in order to allocate these on a per-ticket basis.[19] A similar set of tax and non-tax charges likewise apply for the arriving and departing flight segments at PHL, which we consequently combine with the set of applicable charges at CDG to construct complete tax and non-tax charge amounts for the full PHL DL CDG itinerary.[20]

Matching our resulting itinerary-specific unit tax and non-tax charge amounts to the full set of ticketed itineraries in the DB1B yields over 45000 unique matched itineraries with valid ticket tax information, covering more than 4.5 million passenger trips over the period 2009Q4-2014Q2. After subtracting itinerary-specific tax and non-tax charge amounts from total ticketed fares to recover a measure of tax-exclusive base fares, we aggregate each matched observation in the quarter $t$ DB1B sample to the carrier $c$, route $i$-level and define measures of total passenger volume and passenger-

amounts backward through time, thereby potentially biasing our results in favor of finding increased consumer sensitivity to ticket taxes in the more recent past. We do, however, use the scraped tax amounts to cross-validate our calculations based on RDC Aviation's airport charges database and use this information to improve our ticket tax calculator. An earlier draft of this paper using only scraped tax amounts (adjusted historically for bilateral exchange rate movements and a complete history of applicable U.S. ticket taxes) presents qualitatively similar results to the ones presented here. Results involving scraped tax amounts are available upon request.

[17] These routes account for approximately 60 percent of total passenger volume. We exclude lower-volume routes from our set of initial queries out of concern that changes in passenger traffic along these routes might be subject to a high degree of unexplained variability.

[18] Other categories of charges, such as government charges, can encompass either taxes levied on a per-passenger or per-movement basis and require special care.

[19] See Appendix A.1 for a description of data sources used in making determinations of aircraft usage.

[20] U.S. ticket taxes on international flights consist of 6 distinct tax codes. We rely on multiple U.S. government sources, including the FAA, DHS, USDA, and CBP, to construct a complete historical record of airport-specific U.S. ticket taxes rather than use the RDC database for this purpose.

weighted average base fares. Collectively, *ci* constitutes a unique itinerary whose endpoints define an origin-destination airport pair *j*, and origin-destination city market pair *k* (i.e., the product category).

Consistent with other applications of the DB1B data in the literature (see e.g., Brueckner (2003) for a careful description), we focus exclusively on round-trip, coach-class, non-award travel.[21,22] We also exclude tickets flagged by DOT as involving unrealistically high costs-per-mile (conditional on fare class), as well as all ticketed itineraries featuring multiple trip breaks (i.e. extended stopovers) which may trigger the application of different taxes.[23] Likewise, we omit itineraries involving U.S. territories, Alaska, or Hawaii due to the application of different U.S. ticket tax rules.[24] Finally, we exclude all group tickets covering more than 9 passengers on the grounds that these are likely to involve negotiated fares whose purchasers (e.g. tour operators or the U.S. government) are unlikely to be subject to the same behavioral biases as individual consumers.

We ultimately limit our analyses to the top 300 international origin-destination city markets (ranked by total outbound and inbound passenger volume in 2011), each of which are serviced by an average of 6.5 available itineraries and account for 55 percent of total passenger volume in our matched DB1B-tax sample. This restriction has the virtue of excluding thinner markets where idiosyncratic variation in passenger demand may be especially prevalent and contribute to statistical imprecision. Unreported sensitivity analyses involving the complete sample of 498 city markets for which we have non-missing ticket tax and non-tax charge data (and non-zero within-market variation therein) account for 62 percent of matched passenger volume and yield qualitatively similar, yet less precisely-estimated results, consistent with this last concern.

[21] We apply multiple criteria based on cost-per-mile for defining award travel. See Appendix A.1.1 for details. Award travel thus defined appears to account for up to 10 percent of passenger volume.

[22] For tickets featuring different fare class segments, we define an itinerary as coach-class so long as the coach portion of the itinerary accounted for at least 90 percent of miles flown. Tests of differential FFAR reactions by class of service (not shown) suffer from low power. As a result, we cannot conclude whether first and business class travelers are any more or less sensitive than coach passengers to the implementation of tax-inclusive pricing.

[23] The UK Air Passenger Duty, for example, is only payable on flights *originating* in the UK. The tax does not therefore generally apply to international flights with a layover in the UK, *unless the layover exceeds 24 hours in duration*. Similar rules apply to flight segments within the U.S. as part of an international itinerary, with differing application of domestic transportation and segment taxes depending on the duration of these domestic layovers.

[24] With respect to U.S. territories, exceptionally high passenger volume moreover likely reflects the transportation of U.S. military personnel, the majority of whom presumably do not book their own air travel.

Table 2 reports basic summary statistics from our final estimation sample. As shown, total tax- and charge-inclusive fares (*TotalFare*) average \$750, while mean and median specific taxes (*UnitTaxes*) are roughly \$100, with a standard deviation of approximately \$45.[25] Non-tax charges (*NonTaxCharges*) account for a relatively smaller fraction of total fares and amount to roughly \$20, albeit with a greater degree of dispersion around the mean than unit taxes. Owing in part to the difficulty of assembling ticket tax and charges data for secondary airports, we see that the median itinerary in our sample (volume-weighted) features a direct flight. Without weighting by passenger volume, the median roundtrip flight instead features 1 layover in both directions, and the maximum number of layovers in our data is four (i.e. six flight segments).

# 4 Model

## 4.1 Tax Incidence and Tax Salience

Despite FFAR having had no effect on the true level of ticket taxes owed, heightened awareness of these tax amounts should yield a shift in the tax burden from formerly-inattentive consumers onto producers—in proportion to the extent of de-biasing induced by the switch to tax-inclusive pricing. Depending on the magnitude of the resulting reduction in base fares, consumers may have been more or less shielded from perceiving prices as varying by the full amount of unit ticket taxes in the post-FFAR period. Consequently, changes in tax incidence due to FFAR are not only informative with respect to the costs of consumer inattention but are also indicative of the remaining potential for consumer demand to show marked reactions to FFAR.[26]

We adapt Chetty (2009) and Chetty, Looney and Kroft (2009) to derive predictions regarding

[25] For comparison, *within* origin-destination city markets, unit taxes exhibit a mean volume-weighted standard deviation of just over \$10 across all 300 markets. In addition, the volume-unweighted average difference between the highest and lowest taxed itineraries within an O&D city market is roughly \$26 (not shown).

[26] This situation differs from the "sufficient statistics" approach advocated by Chetty, Looney and Kroft (2009), whereby estimates of tax incidence can be recovered as a function of the tax and price elasticities of demand (which differ only due to inattention) and the elasticity of supply. Here, we infer inattention directly from estimated changes in elasticities of passenger demand *conditional* on final prices adjusting endogenously to mitigate the consequences of increased tax salience.

the effect of tax salience on the economic incidence of a unit tax in perfectly competitive versus monopoly markets.[27] Under the standard neoclassical theory of tax incidence, net-of-tax producer prices (e.g., base fares), $p$, adjust to the imposition of a unit tax, $t$, according to the relative elasticities of supply and demand, where the latter elasticity is assumed to be the same regardless of whether changes in gross-of-tax consumer prices ($q = p+t$) are driven by changes in net-of-tax prices or taxes. However, if consumers are subject to limited attention and taxes are less than fully salient, this introduces the possibility that consumers may respond differently to changes in prices that arise from changes in base prices compared to changes that arise from tax changes. We model this possibility by allowing consumers to perceive a fraction $\theta \geq 0$ of the true tax amount, $q_\theta = p+\theta t$, such that observed consumer demand can be expressed as $D(q_\theta) = D(p+\theta t)$. $\theta = 1$ in the full-attention, full-salience case (as in the neoclassical model), and $D(q_\theta) = D(q)$. By assumption, taxes that are included in posted prices are fully salient: $\theta_{Qtr>2012Q1} = 1$. At the other extreme, $\theta = 0$ corresponds to complete inattention or zero salience (i.e. consumers completely ignore the tax when making purchasing decisions). More generally, $\theta$ represents the degree of tax salience (consumer inattention) and can be measured as the ratio of the price elasticities of demand with respect to the tax price versus the base price (evaluated at the perceived tax-inclusive price): $\varepsilon_{D,q|t} = \theta \frac{\partial D}{\partial q} \frac{q_\theta}{D(q_\theta)} = \theta \varepsilon_{D,q|p}$.

Starting from the assumption of perfect competition, total differentiation of the market clearing condition $D(p+\theta t) = S(p)$ yields

$$\frac{\mathrm{d}p}{\mathrm{d}t} = -\frac{\partial D/\partial q_{|t}}{\partial D/\partial q_{|p} - \partial S/\partial p} \equiv -\frac{\theta \cdot \varepsilon_{D,q}}{\varepsilon_{D,q} - \frac{q_\theta}{p}\varepsilon_{S,p}} \tag{1}$$

$$\frac{\mathrm{d}p}{\mathrm{d}\theta} = \frac{\mathrm{d}q}{\mathrm{d}\theta} = -\frac{t \cdot \varepsilon_{D,q}}{\varepsilon_{D,q} - \frac{q_\theta}{p}\varepsilon_{S,p}} \tag{2}$$

where $\varepsilon_{S,p} = \frac{\partial S}{\partial p}\frac{p}{S(p)}$ represents the elasticity of supply at the net-of-tax price.

[27] Agarwal et al. (2014) generate similar qualitative predictions from a model of partitioned pricing that allows for imperfect competition. Their model, however, is not as amenable to straightforward interpretation within the context of changing salience and fixed unit taxes (add-on fees in their context) as the canonical model in the tax salience literature.

When $\theta = 1$, equation (1) produces the standard full-optimization result, whereby the incidence of a unit tax on producer prices is proportional to the magnitude of the elasticity of demand relative to the magnitude of the combined elasticities of demand and supply. The tax burden borne by producers—all else equal—is hence increasing in $\theta$, conditional upon a nonzero demand elasticity. Unsurprisingly, producers bear none of the tax burden ($\frac{\mathrm{d}p}{\mathrm{d}t} = 0$) when the tax is fully obfuscated from inattentive consumers and $\theta = 0$. This situation is empirically indistinguishable from more standard results involving perfectly inelastic demand ($\varepsilon_{D,q} = 0$) or perfectly elastic supply ($\varepsilon_{S,p} = \infty$), as in a perfectly competitive market in long-run equilibrium. Independent variation in $\theta$ (induced by FFAR), $t$, and the degree of market competition are therefore key to separately identifying tax salience effects from demand and supply elasticity effects in our analysis.

Equation (2) characterizes the impact of full de-biasing resulting from a shift in saliency regime (e.g. from tax-exclusive to tax-inclusive pricing in a world where consumers are fully inattentive to taxes that are not advertised in posted prices) on both net-of-tax and gross-of-tax prices in the presence of pre-existing taxes. As equations (1) and (2) suggest, small changes in pass-through rates of ticket taxes to total fares resulting from the adoption of FFAR could result either from $\theta_{PreFFAR} \approx 1$, $\varepsilon_{D,q} \approx 0$, or $\varepsilon_{S,p} \approx \infty$ (or some combination thereof). Regardless of salience effects, consumers might consequently be unaffected by FFAR if the market for international air travel were perfectly competitive and subject to constant marginal costs. Of course, the airline industry is not generally considered to be perfectly competitive, and we exploit the fact that individual markets may differ widely in their degree of market concentration.

In the case of imperfect competition, the monopolist confronted by inattentive consumers must solve the modified profit maximization problem

$$\max_{p} p \cdot D(p + \theta t) - C(D(p + \theta t))$$

which yields the conventional Lerner Formula, with the modification that the marginal cost of production, $C'(\cdot)$, and elasticity of demand, $\varepsilon_{D,q}$, are implicit functions of $\theta$:

$$p^* \left[1 + \frac{D(p^* + \theta t)}{\partial D / \partial q_{|p}} \frac{1}{p^*}\right] \equiv C'(D(p^* + \theta t)) \tag{3}$$

$$\Leftrightarrow p^* = \frac{C'(D(p^* + \theta t))}{1 + \frac{1}{\varepsilon_{D,q|p}} \frac{q^*_\theta}{p^*}} \tag{4}$$

where $p^*$ is the profit-maximizing net-of-tax price for the monopolist.

By the Implicit Function Theorem,

$$\frac{\mathrm{d}p^*}{\mathrm{d}t} = \frac{-\theta \left[1 - \frac{D(\cdot)D''(\cdot)}{(D'(\cdot))^2} - C''(\cdot)D'(\cdot)\right]}{1 + \left[1 - \frac{D(\cdot)D''(\cdot)}{(D'(\cdot))^2} - C''(\cdot)D'(\cdot)\right]} \tag{5}$$

A zero salience tax ($\theta = 0$) again delivers full pass-through onto consumers, but $\theta$ otherwise plays a more nuanced role depending on the underlying nature of demand. For illustration, we consider two simplifying cases involving constant marginal costs, $C'(\cdot) = \kappa$, and either linear demand or constant demand elasticity.

Assuming linear demand of the form $D(p + \theta t) = a - b(p + \theta t)$,

$$p^* = \frac{1}{2}\left[\kappa + \frac{a}{b}\right] - \frac{1}{2}\theta t \tag{6}$$

$$\frac{\mathrm{d}p^*}{\mathrm{d}t} = -\frac{1}{2}\theta \tag{7}$$

$$\frac{\mathrm{d}p^*}{\mathrm{d}\theta} = -\frac{1}{2}t \tag{8}$$

Following standard principles of tax incidence, a fully-salient tax ($\theta = 1$) hence falls equally on both consumers and the monopolist. Correspondingly, full de-biasing leads to the net-of-tax producer price falling by exactly half of the unit tax amount, or $0.50 per dollar. This suggests a large potential impact of FFAR on ticket-tax pass-through rates in imperfectly-competitive markets (assuming approximately linear demand), even if demand is otherwise relatively inelastic or airlines face near-constant marginal costs.

If demand instead exhibits constant elasticity of the form $D(p+\theta t) = A(p+\theta t)^{-b}$, such that $\varepsilon_{D,q|p} = -b$ and $\varepsilon_{D,q|t} = -\theta b$, then

$$p^* = \frac{\kappa}{1 + \frac{1}{\varepsilon_{D,q}} \frac{q^*_\theta}{p^*}} \tag{9}$$

$$\frac{\mathrm{d}p^*}{\mathrm{d}t} = -\theta \cdot \frac{1}{1+\varepsilon_{D,q}} \Rightarrow \frac{\mathrm{d}q^*}{\mathrm{d}t} = \frac{(1-\theta)+\varepsilon_{D,q}}{1+\varepsilon_{D,q}} \tag{10}$$

$$\frac{\mathrm{d}p^*}{\mathrm{d}\theta} = -t \cdot \frac{1}{1+\varepsilon_{D,q}} = \frac{\mathrm{d}q^*}{\mathrm{d}\theta} \tag{11}$$

A fully-salient tax in this (admittedly special) context will be *overshifted* onto consumers whenever $\varepsilon_{D,q} < -1$. Contrary to the perfectly-competitive case or the linear demand monopoly case, $\theta$ thus *amplifies* rather than attenuates tax incidence on consumers, and de-biasing due to the adoption of FFAR could conceivably *raise* profit-maximizing net-of-tax prices. The effect of an increase in tax salience on tax incidence in any given market therefore depends upon market structure and the curvature of marginal costs and demand.

## 4.2 Empirical Specifications

We estimate the average $\frac{\mathrm{d}q}{\mathrm{d}t}$ empirically following Weyl and Fabinger (2013) and Conlon and Rao (2015) as the share of each dollar in ticket taxes that is passed through to total fares according to the following general specification in order to measure consumer ticket tax incidence pre- and post-FFAR:

$$\begin{aligned} TotalFare_{cit} = {} & \alpha_0 + \alpha_1 UnitTaxes_{cit} + \alpha_2 UnitTaxes_{cit} \times I[Qtr > 2012Q1]_t \\ & + \tilde{\gamma}\mathbf{\tilde{X}_{ij}} + \eta_{ct} + \nu_{kt} + \varepsilon_{cit} \end{aligned} \tag{12}$$

$TotalFare_{cit}$ represents the average total fare paid by consumers for a flight operated by carrier $c$ on route $i$ in quarter $t$. Unit taxes ($UnitTaxes_{cit}$) are defined at the corresponding itinerary level, and the post-FFAR period indicator, $I[Qtr > 2012Q1]_t$, is set to 1 in all periods falling after the first quarter of 2012 and is zero otherwise. We omit 2012Q1 data from our analysis given that FFAR went into effect on January 26, 2012 and that our ticket data are dated only by the quarter flown, such that it is uncertain what fraction of 2012Q1 travelers would have been exposed to the new FFAR pricing regime.[28] As a placebo test, we extend (12) with controls for pre- and post-FFAR effects of non-tax charges ($NonTaxCharges_{cit}$), which were always required to be included in advertised fares. Beyond these main variables of interest, $\tilde{\mathbf{X}}_{\mathbf{ij}}$ represents a vector of route and origin-destination airport pair characteristics, including categorical indicators for the number of connecting flight segments as well as cubic polynomials in distance flown, market concentration, capacity utilization, and the log of total carrier passenger volume at the (U.S.) airport of origin (for both domestic and international flights). $\eta_{ct}$ accounts for unobserved time-varying carrier-specific attributes that might be correlated with the tax salience effects of FFAR, such as pre-existing variation in the transparency of tax information on carriers' own websites, or differences in the existence of baggage fees and their associated disclosure. Seasonality effects and secular trends influencing origin-destination city-pair pricing are captured in $\nu_{kt}$. Remaining unobserved sources of variation in total fares are attributed to $\varepsilon_{cit}$. The validity of this approach rests on the assumption that any such unobserved determinants of route $i$ ticket prices are uncorrelated with ticket tax amounts and the timing of FFAR, such that these do not represent a source of omitted variable bias.[29] Insofar as consumers exhibit preferences over itinerary attributes which we are not able to account for explicitly in our empirical specification (e.g. connecting airports, flight schedules, etc.), we assume that any changes in these preferences over time are uncorrelated with

[28] Though statistics on the timing of ticket purchases are scarce, an industry study of 7 million North American and European flight bookings indicates that 23% of tickets are purchased within 10 days of travel and over 50% are purchased within 50 days (`https://www.yieldr.com/consumer?file=consumer_booking_study.pdf`). Moreover, airlines do not generally allow ticket purchases more than 10 months prior to the date of travel. To the extent that a shrinking fraction of passengers traveling in the last three quarters of 2012 might have still purchased their tickets under the pre-FFAR regime, this would tend to attenuate our estimates of the effects of FFAR.

[29] A potential concern in this context is that if taxing authorities are responsive to changes in passenger demand (e.g. such as if airports compete actively for volume), unit tax amounts may respond endogenously to tax salience effects. Given the asynchronous timing between our measurement of ticket tax amounts and the DB1B's reporting of passenger volume on the basis of the date of *travel* as opposed to the date of purchase, this would tend to bias our estimates of the effect of the full-fare advertising rules toward zero (i.e. because an endogenous reduction in ticket taxes due to a reduction in ticket *purchases* in the prior quarter, for instance, would be partially matched with a continued decline in passenger *traffic* in the quarter(s) after the rate cut). As indicated above, statutory changes in unit taxes occur infrequently across the set of airports in our analysis.

the timing and intensity of FFAR treatment.[30]

In our preferred specification involving a full set of origin-destination city × quarter ($\nu_{kt}$) and carrier × quarter ($\eta_{ct}$) fixed effects, identification rests on within-quarter variation in ticket taxes and total fares across itineraries serving the same city pairs, allowing for the relationship between taxes and total fares to vary pre- and post-FFAR. $\alpha_2$ is thus the difference-in-differences estimator of the change in ticket tax pass-through rates associated with FFAR and reflects the impact of de-biasing (i.e. bringing the tax elasticity of demand into alignment with the price elasticity of demand), conditional on market supply conditions. We allow this de-biasing effect to vary more generally with market concentration and capacity utilization in later specifications to test for heterogenous effects related to these supply conditions. In all but our basic specifications, estimation of pre- and post-FFAR pass-through rates for non-tax charges alongside unit taxes offers a valuable comparison given that only the latter were subject to new disclosure rules under FFAR. Accounting for non-tax charges in this manner helps corroborate the validity of our general difference-in-differences identification strategy, despite our inability to exploit more precise timing variation as a result of the manner in which the DB1B data are recorded.

Our empirical strategy with respect to estimating the effects of FFAR on additional demand outcomes involves a similar difference-in-differences approach. Adding controls for average base fares to the empirical model yields a simple adaptation of (12):

$$\begin{aligned} ln(Y_{cit}) = \beta_0 &+ \beta_1 BaseFare_{cit} + \beta_2 BaseFare_{cit} \times I[Qtr > 2012Q1]_t \\ &+ \beta_3 UnitTaxes_{cit} + \beta_4 UnitTaxes_{cit} \times I[Qtr > 2012Q1]_t \\ &+ \beta_5 NonTaxCharges_{cit} + \beta_6 NonTaxCharges_{cit} \times I[Qtr > 2012Q1]_t \\ &+ \tilde{\gamma}\mathbf{\tilde{X}_{ij}} + \eta_{ct} + \nu_{kt} + \varepsilon_{cit} \end{aligned} \tag{13}$$

where $Y_{cit}$ alternately represents either itinerary-level passenger volume or tax-exclusive ticket

[30] Along with FFAR, the DOT's enforcement action encompassed a number of other consumer protections, including rules related to tarmac delay and contingency plans, overbooking and denied boarding compensation, and customer service plans—none of which would reasonably be expected to alter consumer demand for itineraries in a manner related to ticket taxation.

revenue. In this latter case, we exclude $\beta_1 BaseFare_{cit} + \beta_2 BaseFare_{cit} \times I[Qtr > 2012Q1]_t$ from our model in order to measure the combined impact of FFAR on ticket revenue coming from both endogenous price responses (i.e. changes in pass-through rates) as well as changes in passenger demand. Base fares are measured as the difference between total fares and the sum of unit taxes and non-tax charges and we allow consumers to exhibit differing price elasticities of demand pre- and post-FFAR. Naturally, the simultaneous determination of prices and quantities yields biased ordinary least squares estimates of the semi-elasticity of demand with respect to base fares, and this issue is further compounded by the possibility of endogenous variation in pass-through rates resulting from FFAR. Due to the specificity of the set of fixed effects used in our preferred empirical approach, it is difficult to construct instruments with suitable within variation. Consequently, we use a measure of exogenous price competition as an instrument for base fares (alone and interacted with the same $I[Qtr > 2012Q1]_t$ indicator) and estimate (13) via two stage least squares (IV). In line with the IV strategies used in Berry and Jia (2010), our preferred instrument for this purpose is measured as the number of itineraries offered by competing carriers servicing the same O&D airport pair (excluding code-share or alliance partners) in a given quarter in the full DB1B sample. Instrument exogeneity rests on the assertion that FFAR did not impact the number of competing itineraries servicing the same market *after accounting for unit taxes and other controls*.[31]

If ticket taxes were fully salient prior to FFAR, we should expect demand for airline tickets to be equally sensitive to changes in appropriately-instrumented base fares, $\beta_1$, as to variation in unit taxes in the pre-period, $\beta_3$. Correspondingly, $\beta_4$ ought to equal $\beta_2$ (assumed to be zero) in this case. In the alternative, $\theta_{Qtr<2012Q1} \equiv \frac{\beta_3}{\beta_1}$ measures consumer inattention in the pre-FFAR period, whereas $\theta_{Qtr>2012Q1} \equiv \frac{\beta_3+\beta_4}{\beta_1+\beta_2}$ measures consumer inattention post-FFAR. By assumption, consumers are expected to optimize fully with respect to taxes when these are included in posted prices. $\theta_{Qtr>2012Q1} - \theta_{Qtr<2012Q1}$ hence reflects the extent of de-biasing associated with the more

[31] We also consider the use of cost-shifter instruments constructed as an interaction of trip distance and quarterly jet fuel or oil (West Texas Intermediate) prices, or 6-month NYMEX futures thereof. Given heterogeneity in airline fuel and exchange rate hedging strategies coupled with unobserved airport-specific variation in delivered dollar-denominated fuel prices, these instruments suffer from instrument weakness in most tests. Results are available from the authors upon request.

salient presentation of unit taxes under full-fare advertising.

It is important to note that changes in passenger volume in response to FFAR may have arisen either through shifts in aggregate demand (such as if inattentive consumers perceived airfares to have risen across the board as a result of FFAR) or through cross-itinerary substitution. Increased tax salience might for instance induce consumers to substitute towards itineraries with fewer layovers or layovers at more lightly taxed airports to avoid the accumulation of unit taxes at each departing and arriving airport along their route. By exploiting within origin-destination city market $\times$ quarter variation in unit tax amounts, our identification strategy addresses only the latter channel. As such, our estimates cannot readily be translated into aggregate demand or aggregate ticket revenue effects.

# 5 Results

## 5.1 Tax Incidence

Table 3 presents the results from the estimation of Equation (12). All specifications include the full set of controls in $\tilde{\mathbf{X}}$. These are suppressed from Table 3 for brevity but can be found in Appendix Table A4. Additionally, Column 1 controls for carrier $\times$ quarter fixed effects, while Columns 2 and 3 further incorporate origin-destination city-pair $\times$ quarter fixed effects and represent our preferred specifications. We compute clustered standard errors at the O&D city-pair level across all regression specifications and weight observations by itinerary-level passenger volume in order to account for wide dispersion in itinerary popularity and high idiosyncratic volatility of passenger volume along low-volume routes (Goolsbee and Syverson, 2008).[32]

Large differences between Columns 1 and the others in estimated pass-through rates in both the pre- and post-FFAR periods highlight the importance of controlling for unobserved time-varying product characteristics which might otherwise yield a spurious association between ticket taxes and

[32] This weighting strategy is analogous to estimating ticket tax pass-through at the ticket level with appropriate clustering.

total fares. Based on the results in Column 2, ticket-tax pass-through in the pre-FFAR period is approximately 0.99, consistent with consumers having borne essentially all of the tax burden prior to 2012, either because of relatively low "true" elasticity of demand (high elasticity of supply) or because of a high degree of consumer inattention. Only this last possibility, however, can explain the sharp reduction in average pass-through rates following the adoption of tax-inclusive pricing. In the post-FFAR period, the ticket tax pass-through rate falls by 0.743 ($\alpha_2$), so that, on net, every dollar increase in unit taxes is associated with a 25 cent increase in total fares. Three-quarters of every dollar in ticket taxes are thus borne by the airlines in the post-FFAR period, in marked contrast to the pre-FFAR period when consumers bore the entire tax.

Column 3 of Table 3 introduces our measure of itinerary-specific non-tax charges. Due to the manner in which non-tax charges are levied (i.e. on a per-movement basis instead of per-passenger), these constitute a cost of airline operations much like any other, and their inclusion in advertised fares was consequently unaffected by FFAR. Thus, non-tax charges serve as a type of placebo control in that pass-through rates for these charges should have remained unchanged in the post-FFAR period and, furthermore, should be similar to unit tax pass-through rates once both are treated equally: namely, once both are required to be presented as part of a single tax-inclusive price post-FFAR.[33] The results show that pass-through in the pre-FFAR period for unit taxes is little changed from column (2) at 0.958 cents for every dollar of unit taxes. Non-tax charges, however, show a significantly lower pass-through rate in the pre-period (p-value = 0.065), which is consistent with their inclusion in posted prices precluding airlines from shifting these itinerary-specific costs fully onto consumers. Moreover, pass-through rates for non-tax charges are virtually unchanged post-FFAR. This is expected given that the rule change did not impact the presentation of these charges to consumers. Taken together, we cannot reject a null hypothesis of equal pass-through rates in the post-FFAR period of 0.247 and 0.373 for unit taxes and non-tax charges, respectively (p-value = 0.708), consistent with both sources of price variation being presented in

[33]Strictly speaking, given the differing margins at which non-tax charges and passenger ticket taxes are incurred, these may potentially be passed through to ticket prices at differing rates. We abstract from this distinction for purposes of testing for placebo effects and implicitly assume that airlines treat non-tax charges as though these were incurred on a per-passenger basis when setting average fares.

an equally-salient manner.

## 5.2 Passenger Demand and Tax-Exclusive Total Revenue

Table 4 has an identical structure to Table 3 but focuses on the post-FFAR effect of unit taxes on itinerary-level passenger volume (columns 1-2) and total revenue (column 3). As discussed in section 4, we present both ordinary least squares (OLS) and instrumental variable (IV) results for passenger volume. Recall that we instrument base fares using the number of itineraries offered by competing carriers servicing the same O&D airport pairs in order to focus on exogenous variation in base fares.

Column 1 of Table 4 presents the OLS estimates and are likely to suffer from endogeneity bias. As always, failing to account for the simultaneous determination of equilibrium prices and quantities should yield positively-biased OLS estimates of the price semi-elasticity of demand. Indeed, as shown in the previous section, ticket prices were themselves endogenously impacted by FFAR, with larger reductions in base and total fares arising along higher-taxed routes. As such, the IV estimates in column 2 reveal multiple important results. First, although the point estimates suggest the possibility of some heightened demand sensitivity with respect to base fares in the post-FFAR period, we cannot reject that changes in base fares affect demand similarly in both the pre- and post-FFAR periods. The same is true for non-tax charges. Unit taxes, however, show no statistically significant impact on demand in the pre-period but show a large negative impact in the post-period. Moreover, t-tests of the equality of estimated coefficients show that we cannot reject equality of the impact of base fares and non-tax charges on demand either pre- or post-FFAR (p-values of 0.311 and 0.483, respectively), whereas we can reject equality of each with unit taxes in the pre-FFAR period (p-values of 0.000 and 0.005, respectively). Post-FFAR, we cannot reject a test of equality of demand effects due to base fares, unit taxes, or non-tax charges (p-value = 0.126). Consumers' under-reaction to components of the total price that are not fully salient (i.e. unit taxes in the pre-FFAR period) serves as further evidence of the pronounced effects of limited attention. Adoption of FFAR, however, is associated with significant de-biasing, such that when base fares, unit taxes, and non-tax charges are all included in total fares in an equally salient manner, consumers respond to each equally—consistent with the standard theory of (attentive) consumer behavior.

The results from column 2 can also be interpreted as estimated elasticities, presented in the bottom half of the table. In order to convert our semi-elasticity estimates into directly-comparable price elasticities of demand, we evaluate each of our point estimates in relation to the average value of total fares (about $750). The bottom panel of Table 4 reports these calculations. An increase in base fares equal to 1 percent of total fares (roughly $7.50) in the pre-FFAR period thus implies a 3.23 percent reduction in demand. This elasticity increases slightly in absolute terms in the post-period but is statistically-indistinguishable from the pre-period. The elasticity of demand with respect to non-tax charges at -2.25 and -3.44 is statistically similar to that of base fares in both the pre- and post-FFAR periods, respectively. In contrast, the demand elasticity with respect to unit taxes is positive and statistically-insignificant in the pre-period but negative and significant in the post-period. Demand hence falls by 6.36 percent in response to an increase in unit taxes of an amount equal to one percent of total fares in the post-period. While larger than the elasticity of demand with respect to base fares, a 95 percent confidence interval around our estimate of the unit tax elasticity of demand spans a range of approximately -3.45 to -9.26, and we cannot reject that the post-FFAR base fare and unit tax elasticities are equal.[34]

Our estimated elasticities fall at the high end of the range of elasticity estimates for air travel reviewed in Gillen, Morrison and Stewart (2003) or InterVistas (2007), which combine studies based on domestic and international travel, the latter markets tending toward higher elasticities given the relative importance of leisure travel. Berry and Jia (2010) document a trend toward increasing elasticities between 1999 and 2006 and report a main estimate of 1.05 for the latter period

[34]Taken seriously, consumers could exhibit hyper-sensitivity to unit taxes for several reasons, especially in the short-run aftermath of the adoption of FFAR. While ticket taxes are now included in advertised prices, they are still enumerated before final purchase, thereby calling special attention to their magnitude. Moreover, consumers might have experienced initial shock at the shift in pricing norms, an effect to which particular carriers might have advertently or inadvertently drawn attention in their roll-out of FFAR pricing rules. Spirit Airlines, for instance, made an explicit point of alleging on their website that the new DOT rule was requiring airlines to "hide" taxes from consumers (i.e. by rolling these into a single total fare). A newly-attentive—or surprised—consumer might plausibly have exhibited tax aversion as a result, at least temporarily.

based on U.S. domestic flights only. It is worth noting, however, that elasticity estimates based on DOT ticket data from the pre-FFAR era will systematically understate consumer sensitivity to advertised (base) fares as a result of inattention to the unit tax portion of total fares reported in the DB1B.[35] Furthermore, it is also important to emphasize that the source of identifying variation in our analyses arise *within* O&D city market, such that our estimates of demand responses depend fundamentally upon patterns of consumer substitution across itineraries serving the same origin and destination. This is a much narrower source of identifying variation than in most studies of airline demand, and consumers may reasonably view itineraries within such narrowly-defined markets as more highly substitutable than itineraries serving the same general regions, origins, or destinations (separately).

A key parameter of interest with respect to tax salience is the degree of taxpayer inattention measured as the ratio of the estimated elasticity of demand with respect to taxes relative to the elasticity of demand with respect to tax-exclusive prices. As discussed in Section 4, the post-FFAR change in this ratio provides a direct measure of the change in consumer inattention resulting from the implementation of full-fare advertising. Using our IV estimates from column 2 and taking into account the degree of statistical imprecision surrounding our point estimates, we cannot refute full inattention in the pre-period and full de-biasing as a consequence of FFAR–assuming that consumers optimize fully when taxes are included in advertised fares.[36] By way of comparison, Chetty, Looney and Kroft (2009) document a degree of inattention of approximately 0.35 under sales tax-exclusive pricing, such that their experimental introduction of tax-inclusive pricing on grocery store shelves is associated with a change in inattention of 0.65. It is *a priori* ambiguous whether to expect more or less severe inattention to ticket taxes under tax-exclusive pricing given

[35] Interestingly, the *Wall Street Journal* reported a claim by Delta Airlines in December 2017 that for every dollar increase in ticket taxes (specifically, U.S. passenger facility charges), demand falls by one percent. Based on the typical average domestic fare of $300 quoted in the same article, this implies an elasticity of -3, precisely in line with our calculations (`https://www.wsj.com/article_email/airports-want-to-raise-ticket-fees-airlines-say-no-fight-ensues-1512729000-lMyQjAxMTI3NDAwODgwMjg5Wj/`).

[36] More precisely, $\theta_{Qtr_t<2012Q1} = \frac{\partial ln(Passengers)/\partial UnitTaxes}{\partial ln(Passengers)/\partial BaseFare} = \frac{0.304}{-0.438} = -0.69$, with a 95% confidence interval spanning the range $[-2.06, 0.67]$, and $\theta_{Qtr_t>2012Q1} = \frac{0.304-1.179}{-0.438-0.113} = 1.59$, with a confidence interval spanning the range $[0.90, 2.28]$.

the combination of larger financial stakes (i.e. more costly optimization errors) and fewer learning opportunities or experience to eradicate biases in the context of ticket taxes on international airfare, but our evidence suggests that the latter mechanism dominates.

As shown in Table 3, unit tax pass-through rates fell from approximately 1 to 0.25. For the average ticket sold post-FFAR along higher-taxed itineraries, this should constitute a significant loss in ticket revenue through reduced base fares. Moreover, the results from column 2 of Table 4 establish that increased ticket tax salience could lead to further possible revenue losses through reductions in passenger demand. Column 3 of Table 4 presents estimates of these combined price and quantity effects on itinerary-level ticket revenues exclusive of unit taxes and non-tax charges (measured in logs). Consistent with the prior results, unit taxes in the pre-FFAR period have no statistically-significant impact on revenues while non-tax charges have a significant negative impact (reflecting both incomplete pass-through of the latter charges, as well as their negative demand effects). Post-FFAR, however, a $10 increase in unit taxes is associated with a 4.8 percent reduction in ticket revenue.[37] For comparison, a simple back-of-the-envelope calculation of tax-exclusive revenue losses attributable to the product of price and quantity effects identified in Table 3 and Table 4, column 2, would instead imply a 5.7 percent reduction in ticket revenue for a tax increase of the same magnitude.

Applied to the full pre-FFAR (2011) distribution of within- market-by-quarter demeaned unit tax amounts, these estimates imply an aggregate post-FFAR reduction in within-market ticket revenue of just over $16 million across the 300 markets that we study. For comparison, after-tax revenues in our estimation sample totaled $144 million in 2011. Scaled up to a full 100 percent sample, this thus amounts to $160 million in revenue losses *coming strictly from within-market substitution toward lower-tax itineraries and reduced ticket tax pass-through* (i.e., without accounting for any potential aggregate demand effects). These represent relatively large losses in ticket revenue and lend strong justification for the U.S. airline industry's intense and persistent efforts to reverse FFAR through lobbying and public relations campaigns. It is important to note, however,

[37] i.e. $e^{(0.1*(0.195-0.682))}-1) = -0.048$.

that carriers may have compensated for lower base fares and ticket revenue through increased reliance on product unbundling and the use of less heavily regulated add-on fees, such as baggage and check-in fees, seat upgrades, in-flight meals and service, etc., whose costs to consumers we do not observe in the ticket data.[38] If airline markets were perfectly competitive, this would be the expected response due to carriers adjusting their menu of product offerings to re-align their (fee-inclusive) prices with marginal costs (Agarwal et al., 2015). Though responses may be more nuanced in an imperfectly competitive setting, our estimates of ticket revenue losses or reductions in unit tax pass-through rates should not, therefore, be interpreted as a pure transfer of surplus from airlines to consumers.[39]

## 5.3 Heterogeneity in Pass-through: Market Concentration and Capacity Utilization

In this section we consider the possibility of heterogeneous effects of FFAR on tax incidence as a function of market supply conditions, including market concentration and capacity utilization. As we discuss in Section 4.1, the basic theory of tax incidence—based on linear demand and fully-salient taxes—implies that taxes should fall relatively more heavily on firms in less competitive markets. More generally, however, pass-through rates in imperfectly-competitive markets depend not only on the relative elasticities of supply and demand, but also on the curvature of demand, with the result that full or over-shifting of taxes onto consumers are also possible. These predictions have not been tested for less than fully-salient taxes, let alone in environments where the degree of salience (and changes therein) may depend in part on the availability of competing product offerings in order for consumers to make informed comparisons.

[38] Indeed, the airline industry has likewise lobbied heavily—and thus far successfully—to prevent the DOT from requiring more prominent disclosure of add-on fees.

[39] Appendix A.4 characterizes the evolution of the largest U.S. carriers' sources of revenue from international and domestic operations on the basis of quarterly financial statement information compiled by the DOT. With the possible exception of United/Continental, it does not appear that the implementation of FFAR coincided with a sharp break in carriers' reliance on add-on fees. In the United/Continental case, the shift in reliance on add-on fees as a source of revenues more likely reflects the coincident timing of merger-related restructuring and opportunities afforded by the alignment of business practices at that time.

We compute a Herfindahl-Hirschman Index (HHI) of market concentration based on carrier revenue shares within origin-destination airport-pairs in the full DB1B sample—regardless of the availability of matching tax information, class of service, and outbound versus inbound, round-trip versus one-way status—and we divide this number by 10000 to obtain HHI values ranging from 0 (perfect competition) to 1 (monopoly). Mean and median HHI levels in our estimation sample are 5600 and 5000, respectively, such that what are typically considered "competitive" markets based on an adaptation of the classification introduced by Borenstein and Rose (1994) account for just under half of all observations, and monopolistic markets account for only approximately 5 percent of observations.[40,41] We allow for market concentration to affect pass-through rates by extending our basic empirical specification with an interaction of unit taxes and a cubic polynomial in HHI (pre- and post-). We depict the resulting partial effect estimates evaluated over the distribution of HHI deciles in Figure 4, which calls attention to several notable features. First, we find that we cannot reject complete pass-through at all levels of market concentration in the pre-FFAR period. Logically, if consumers do not react to changes in unit taxes due to their inattention, then market concentration is irrelevant to pass-through. Second, at higher levels of competition (lower levels of HHI), the post-FFAR interaction with HHI continues to show near complete pass-through of unit taxes, consistent with standard theoretical predictions with respect to marginal cost pricing in competitive markets. However, pass-through rates for unit taxes are shown to drop most sharply in more highly concentrated (i.e. "duopoly") markets following the adoption of tax-inclusive pric-

[40] Translation of Borenstein and Rose's (1994) definition of monopoly, duopoly, and competitive markets (originally based on carrier shares of the number of daily flights) into minimum threshold HHI values implies that markets with an HHI of less than 4050 are considered "competitive." Values of HHI falling between 4050 and 8100 (i.e. corresponding to the range of HHI values in a market in which two firms collectively hold a 90 percent market share yet where no single firm holds 90 percent individually: $2 * 45^2 = 4050 \leq HHI < 8100 = 90^2$) constitutes a "duopoly", and a "monopoly" is defined as having an HHI of at least 8100. Regressions involving these discretized categorizations of market concentration yield a similar pattern of results as those involving the continuous measure of HHI (available upon request).

[41] Independent of the usual caveats regarding the use of HHI as a measure of market competitiveness, we are unable to measure HHI precisely due to the fact that the DB1B data only include information on foreign carriers through their code-sharing agreements with U.S. reporting carriers. We may consequently under- or overstate the true degree of market concentration depending on the importance of direct competition from foreign carriers versus the treatment of code-share or alliance partners. Measured market concentration is predictably somewhat higher when we treat all members of the SkyTeam, Star, and OneWorld alliances as belonging to one of three "firms," respectively. We nevertheless obtain qualitatively similar results using a measure of HHI defined on the basis of airline alliances. See Brueckner (2003) for a discussion of airline competition with respect to alliances and code-sharing agreements.

ing, consistent with a combination of substantial de-biasing and standard tax incidence results under imperfect competition and linear demand. In these less competitive markets, pass-through is strictly less than one in the post-FFAR period, and even negative over part of the range (albeit not statistically different from zero) before rising slightly in the top HHI decile. One possibility in this context is that tax salience is lower and remains lower—despite the implementation of tax-inclusive pricing—in markets where fare comparisons are largely impossible due to the presence of a single dominant carrier in the market, thereby offsetting otherwise lower pass-through rates due to monopolists' price-setting behavior. As such, market concentration may play a dual role with respect to FFAR, in terms of both conventional cost pass-through effects as well as in terms of modulating intrinsic consumer attentiveness and tax saliency.

Figure 5 provides comparable evidence of heterogeneous pass-through rates as a function of (standardized) capacity utilization across O&D airport pairs within city markets. As airlines and airports bump into capacity constraints at high levels of capacity utilization (e.g. because of an inability to readily deploy larger aircraft types or acquire new landing slots in the short term), we expect this to be reflected in a lower elasticity of supply and lower rates of ticket tax pass-through. Consistent with this conjecture, pass-through rates in both the pre- and post-FFAR periods are indeed decreasing modestly in capacity utilization, albeit not significantly so in statistical terms. Moreover, the spread between pre- and post-FFAR pass-through rates at comparable rates of capacity utilization remains virtually unchanged over the capacity utilization distribution—despite estimation of complete interaction effects between unit taxes and a cubic polynomial in capacity utilization (pre- and post-). This suggests a relatively insignificant effect of this proxy for the elasticity of supply on pass-through rates or de-biasing once other market characteristics—including market concentration—are accounted for among our general set of controls.

# 6 Conclusion

We find that the switch from tax-exclusive to tax-inclusive pricing of airfares mandated by the DOT in 2012 had a significant impact on ticket tax incidence and consumer demand. Contrary to the standard presumptions of well-informed rational consumer behavior, this confirms that tax salience plays a prominent role in affecting market outcomes when consumers suffer from limited attention, even in cases involving relatively large purchases and high effective commodity tax rates. The implementation of FFAR is associated with a significant decline in unit tax pass-through from near-complete pass-through under the previous tax-exclusive pricing regime to a rate of roughly 25 cents on the dollar in the post-FFAR period—comparable to the rate of pass-through on the set of non-tax charges which were always subject to disclosure in advertised fares. Moreover, we estimate that pass-through of unit taxes onto consumers fell more in less competitive markets, consistent with the basic textbook theory of tax incidence under imperfect competition.

Accounting for these endogenous pricing responses—a novel feature of our quasi-experimental framework relative to the prior experimental literature on tax salience—we also show that a $10 increase in unit taxes (approximately equal to the average standard deviation of unit taxes within O&D city market) is associated with a 8.4% reduction in itinerary-level passenger volume. In sharp contrast to evidence from the pre-FFAR period, consumers in the post-FFAR period are thus equally sensitive to tax-driven changes in total fares as they are to changes in total fares resulting from changes in underlying base fares. Given the within-market nature of our identification strategy, we attribute this reduction in demand to cross-itinerary substitution as consumers seek out lower-taxed routes.

The combined impact of reduced ticket tax pass-through and reduced passenger demand (in relation to the portion of the tax still born by consumers) together imply that a $10 increase in unit taxes is furthermore associated with a 4.8% reduction in airline ticket revenue. While our within market-by-quarter identification strategy and data limitations do not allow us to calculate precisely the impact of FFAR on aggregate ticket revenues—let alone airline profits—these results point to a substantial transfer of surplus from airlines to consumers whose precise magnitude is subject to the aforementioned caveats about possible compensating adjustments in reliance on add-on fees. The airline industry's persistent and ongoing attempts to reverse FFAR serve as *prima facie* evidence of its negative effects on producer welfare due to increased tax incidence on airlines, as well as possible reductions in aggregate demand due to the perception of higher prices.

These findings emphasize the profound influence which disclosure rules may have in light of the prevalence of cognitive biases. This represents a potentially-fruitful avenue for promoting consumer welfare through regulation and tax policy design. However, this should be tempered by the possibility of fostering unintended consequences. Consideration of possible such consequences in the context of FFAR—such as through the increased use of add-on fees as a source of revenues or through extensive-margin itinerary entry and exit supply decisions—is left for future work.

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Table 1. Sample Tax and Fare Decomposition:
New York City (JFK) to Tel Aviv (TLV)

| | JFK-TLV<br>TLV-JFK<br>(1) | JFK-FCO-TLV<br>TLV-JFK<br>(2) | JFK-CDG-TLV<br>TLV-CDG-JFK<br>(3) |
|---|---|---|---|
| **Base Fare** | **$885.00** | **$885.00** | **$873.00** |
| Fare | 279.00 | 279.00 | 873.00 |
| *(of which non-tax charges)*[a] | 16.86 | 22.86 | 39.67 |
| Fuel surcharge (YQ or YR) | 606.00 | 606.00 | 0.00 |
| **Total Ticket Taxes** | **$88.96** | **$112.26** | **$195.36** |
| US Intl Departure and Arrival Tax (US) | 35.00 | 35.00 | 35.00 |
| US Sep. 11 Security Fee (AY) | 5.60 | 5.60 | 5.60 |
| US Passenger Facility Charge (XF) | 4.50 | 4.50 | 4.50 |
| USDA APHIS Fee (XA) | 5.00 | 5.00 | 5.00 |
| US Immigration Fee (XY) | 7.00 | 7.00 | 7.00 |
| US Customs Fee (YC) | 5.50 | 5.50 | 5.50 |
| Israel Departure Tax (IL) | 26.36 | 26.36 | 26.36 |
| Israeli Security and Insurance Surcharge (AP)[b] | | | 16.00 |
| Italy Passenger Service Charge Departure (MJ) | | 1.10 | |
| Italy Council City Tax (HB) | | 9.10 | |
| Italy Security Charge (VT) | | 3.10 | |
| Italy Embarkation (IT) | | 10.00 | |
| French Intl Passenger Service Charge (QX) | | | 52.20 |
| French Airport Tax (FR) | | | 38.20 |
| **TOTAL FARE** | **$ 973.96** | **$ 997.26** | **$ 1,068.36** |

[a] Aircraft-specific non-tax charges are based on 2014Q2 levels (in current U.S. dollars) and include various airport fees, including take-off and landing charges; parking and terminal fees; noise and environmental charges; navigation charges; etc. Charges are allocated on a per-passenger basis assuming 100 percent seating capacity utilization.
[b] AP applies only to flights operated by the Israeli national airline, EL AL.
Source: ITA Software and RDC.

Table 2. Quarterly Ticket and Itinerary Characteristics: 2009Q4-2014Q2

| | Mean | Median | Std. Dev. |
|---|---|---|---|
| Average Ticket Characteristics (\$00s): | | | |
| $TotalFare_{cit}$ | 7.50 | 6.07 | 3.67 |
| $BaseFare_{cit}$ | 6.19 | 4.91 | 3.48 |
| Observations | | 1088155 | |
| Itinerary Characteristics (Unweighted): | | | |
| $Passengers_{cit}$ | 44.03 | 16.00 | 95.63 |
| $Itineraries_{c-j_t}$ | 29.94 | 21.00 | 30.54 |
| Itinerary Characteristics (Passenger-Weighted): | | | |
| $UnitTaxes_{cit}(\$00s)$ | 1.08 | 0.98 | 0.45 |
| $NonTaxCharges_{cit}(\$00s)$ | 0.23 | 0.18 | 0.19 |
| $Distance_i$ | 5.10 | 3.74 | 3.28 |
| $Layovers_i$ | 0.79 | 0.00 | 0.96 |
| $HHI_{jt}$ | 0.56 | 0.50 | 0.24 |
| $Load_{cit}$ | 85.84 | 87.33 | 7.09 |
| $LnOriginVolume_{c j o_t}$ | 11.79 | 12.17 | 1.42 |
| Observations (itinerary-quarters) | | 24,712 | |

Observations include only round-trip flights with a U.S. origin and exclude all business, first-class, and award travel. Data from 2012Q1 are omitted. Distance is measured in thousands of miles. See Table A3 for variable definitions.

Source: DB1B and RDC.

Table 3. Ticket Tax Pass-Through

| $Y = TotalFare_{cit}$ | (1) | (2) | (3) |
|---|---|---|---|
| $UnitTaxes_{cit}$ | 0.768*** | 0.992*** | 0.958*** |
| | (0.100) | (0.312) | (0.307) |
| $UnitTaxes_{cit} \times I[Qtr_t > 2012Q1]$ | 0.700*** | -0.743* | -0.711* |
| | (0.134) | (0.418) | (0.413) |
| $NonTaxCharges_{cit}$ | - | - | 0.351*** |
| | - | - | (0.127) |
| $NonTaxCharges_{cit} \times I[Qtr_t > 2012Q1]$ | - | - | 0.022 |
| | - | - | (0.186) |
| *Controls:* | | | |
| $Layovers_i$ | x | x | x |
| $Distance_i$ *(cubic)* | x | x | x |
| $HHI_{jt}$ *(cubic)* | x | x | x |
| $LnOriginVolume_{cjo_{kt}}$ *(cubic)* | x | x | x |
| $Load_{cit}$ *(cubic)* | x | x | x |
| *Fixed Effects:* | | | |
| Carrier × Qtr ($\eta_{ct}$) | x | x | x |
| O&D City × Qtr ($\nu_{kt}$) | | x | x |
| Observations | 25,175 | 24,712 | 24,712 |
| R-squared | 0.854 | 0.964 | 0.964 |

Standard errors clustered by origin-destination airport-pair appear in parentheses. Observations are weighted by passenger volume.
*** p<0.01, ** p<0.05, and * p<0.1.
Source: DB1B and RDC.

Table 4. Itinerary-level Passenger Volume and Tax-Exclusive Ticket Revenue

| $Y =$ | $ln(Passengers)_{cit}$ (1-OLS) | $ln(Passengers)_{cit}$ (2-IV) | $ln(Revenue)_{cit}$ (3-OLS) |
|---|---|---|---|
| (a) $BaseFare_{cit}$ | -0.008 | -0.438** | - |
| | (0.011) | (0.180) | - |
| (b) $BaseFare_{cit} \times I[Qtr_t > 2012Q1]$ | -0.067*** | -0.113 | - |
| | (0.015) | (0.202) | - |
| (c) $UnitTaxes_{cit}$ | 0.289** | 0.304 | 0.195 |
| | (0.121) | (0.218) | (0.119) |
| (d) $UnitTaxes_{cit} \times I[Qtr_t > 2012Q1]$ | -0.791*** | -1.179*** | -0.682*** |
| | (0.198) | (0.350) | (0.195) |
| (e) $NonTaxCharges_{cit}$ | -0.017 | -0.303** | -0.169* |
| | (0.092) | (0.134) | (0.087) |
| (f) $NonTaxCharges_{cit} \times I[Qtr_t > 2012Q1]$ | -0.154 | -0.163 | -0.135 |
| | (0.128) | (0.161) | (0.122) |
| *Elasticity of Demand w.r.t.:* | | | |
| Base fares: | | | |
| Pre-FFAR | | -3.23** | |
| | | (1.31) | |
| Post-FFAR | | -4.05*** | |
| | | (0.88) | |
| Unit taxes: | | | |
| Pre-FFAR | | 2.31 | |
| | | (1.67) | |
| Post-FFAR | | -6.35*** | |
| | | (1.48) | |
| Non-tax charges: | | | |
| Pre-FFAR | | -2.25** | |
| | | (0.98) | |
| Post-FFAR | | -3.44*** | |
| | | (0.86) | |
| *Controls:* | | | |
| $Layovers_i$ | x | x | x |
| $Distance_i$ (cubic) | x | x | x |
| $HHI_{jt}$ (cubic) | x | x | x |
| $LnOriginVolume_{c_jO_t}$ (cubic) | x | x | x |
| $Load_{cit}$ (cubic) | x | x | x |
| *Fixed Effects:* | | | |
| Carrier × Qtr ($\eta_{ct}$) | x | x | x |
| O&D City × Qtr ($\nu_{kt}$) | x | x | x |
| Observations | 24,712 | 24,712 | 24,712 |
| R-squared | 0.836 | 0.780 | 0.866 |
| Kleibergen-Paap F-Stat | | 15.27 | |

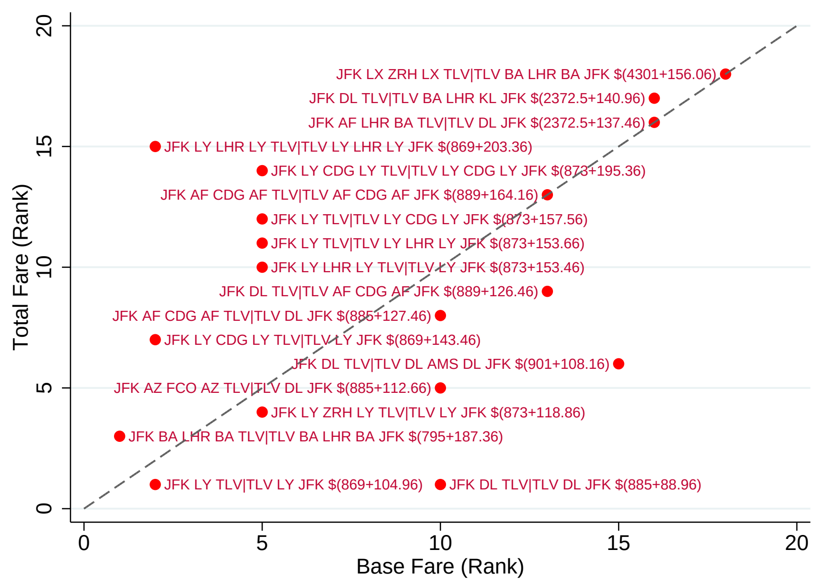
All elasticities evaluated for a 1% change in base fares equal to $7.50. This is equivalent to a 6.9% change in unit taxes and a 32.6% change for non-tax charges evaluated from their respective means. Standard errors clustered by origin-destination airport-pair appear in parentheses. Observations are weighted by passenger volume.

P-values of tests of equality of estimated coefficients from column (2): (a)=(c): 0.000; (a)=(e): 0.311; (c)=(e): 0.005; (a)+(b)=(c)+(d)=(e)+(f): 0.126.

*** $p<0.01$, ** $p<0.05$, and * $p<0.1$.

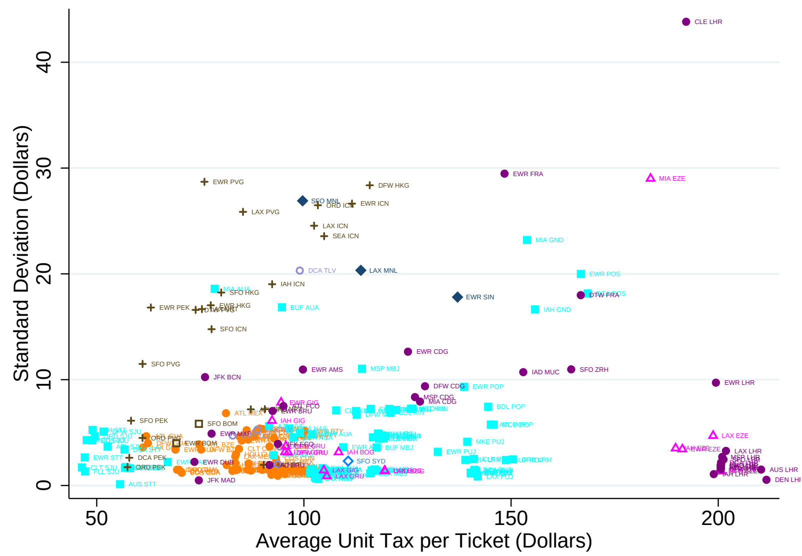
Source: DBIB and RDC.

Figure 1. Tax-Inclusive Versus Tax-Exclusive Fare Rankings:
New York City (JFK) to Tel Aviv (TLV)

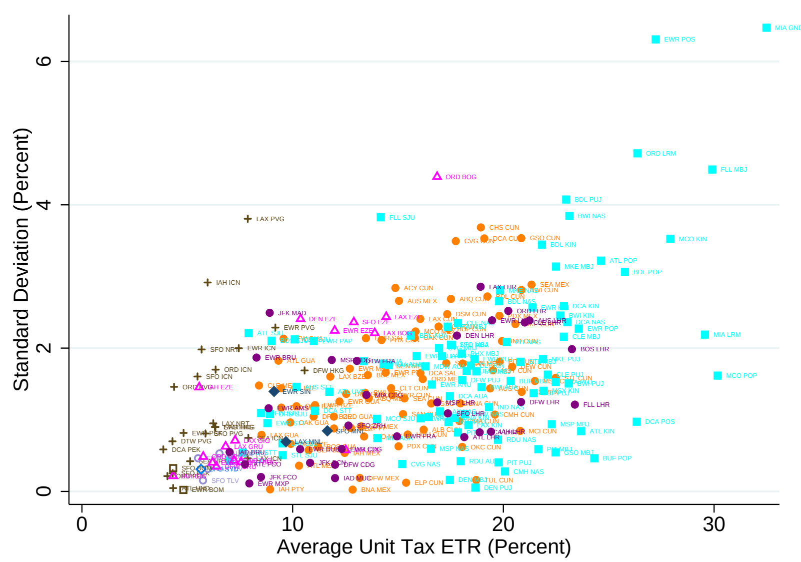



Dollar amounts in parentheses alongside each itinerary represent base fares + unit taxes. Fare amounts are drawn exclusively from online fare searches performed between December 30, 2014 and January 25, 2015 (non-DB1B).

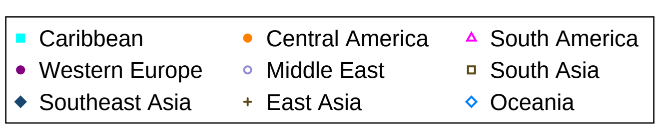
Figure 2. Variation in Unit Taxes Across and Within Origin-Destination City Markets (2011Q4)




(a)



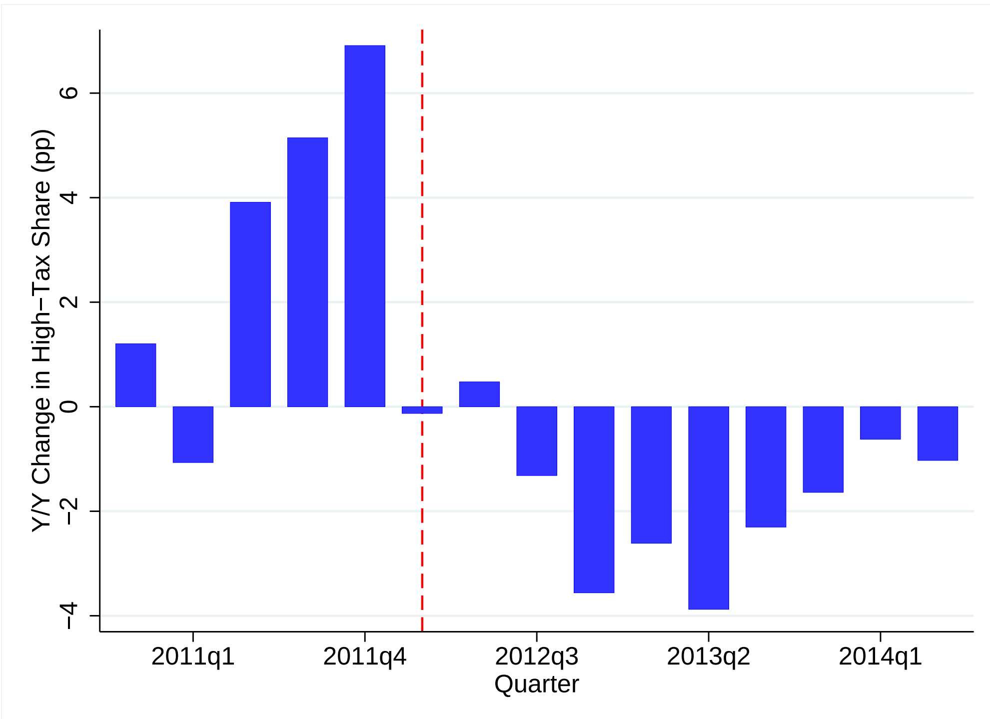

(b)




Airport labels refer to the largest single origin-destination airport-pair by passenger volume within each origin-destination city market. Effective tax rates (ETR) are computed as the ratio of unit taxes paid to total fares. Each point in the figure is computed from at least two unique routes with different unit taxes. Average tax amounts and ETRs are all measured on a passenger-weighted basis within origin-destination city market pairs.

Source: DB1B and RDC.

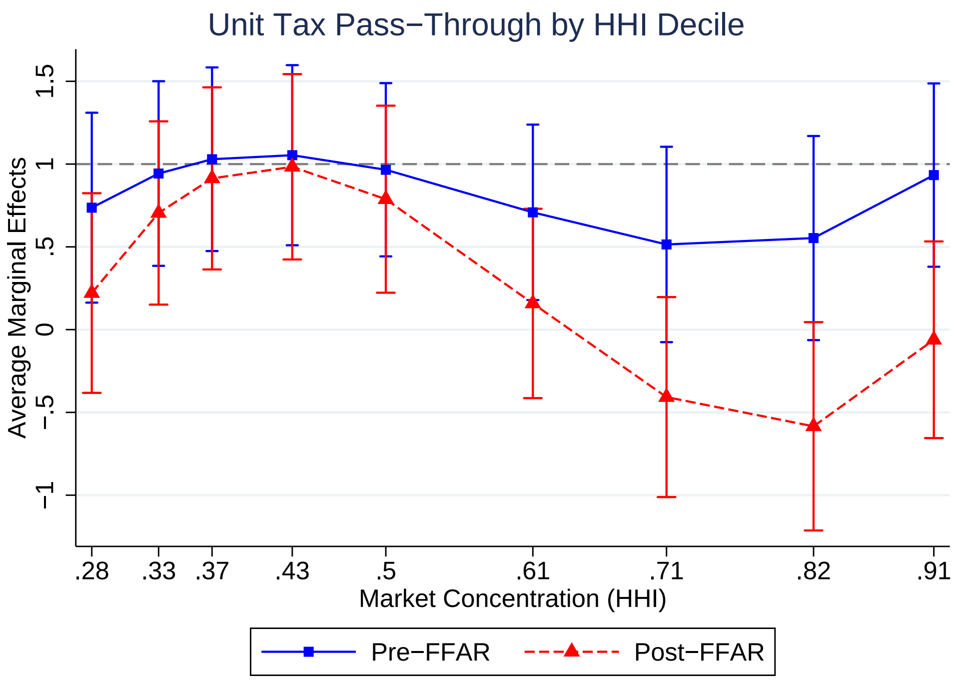
Figure 3. Four-Quarter Changes in High-Tax Route Volume Shares




Routes are categorized as high- and low-tax relative to the top and bottom quartile tax amounts within origin-destination city market pair, respectively, and are based on a balanced panel of ever-available route offerings. Only origin-destination city markets featuring at least one high-tax and one low-tax route are included.

Source: DB1B and RDC.

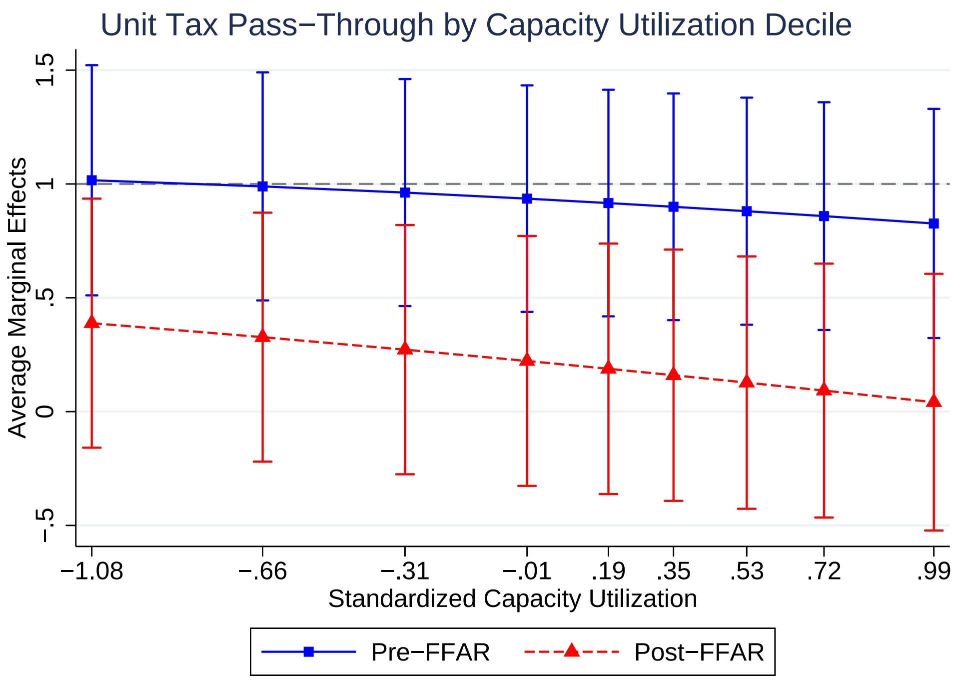
Figure 4




Average marginal effect estimates are based on a model fitted with pre- and post-FFAR unit taxes and airport charges interacted with a cubic polynomial in HHI. Whisker bars represent 90 percent confidence intervals.

Source: DB1B and RDC.

Figure 5




Average marginal effect estimates are based on a model fitted with pre- and post-FFAR unit taxes and airport charges interacted with a cubic polynomial in HHI. Whisker bars represent 90 percent confidence intervals.

Source: DB1B and RDC.

# A Appendix - For Online Publication

## A.1 Data

### A.1.1 Data Construction

The data for our analysis consist of two main components: (1) the restricted-use (international) portion of the DOT's Origin and Destination Survey (DB1B) data, featuring ticket-level itinerary characteristics, total fares paid, and passenger counts for a 10 percent sample of all tickets redeemed by U.S. reporting carriers on a quarterly basis, and (2) detailed historical data on tax and non-tax airport charges from RDC Aviation, measured on an airport-route-aircraft-specific basis. The combined data span the period 2009Q4 (the earliest quarter of broad data availability from RDC Aviation) through 2014Q2.

In line with other applications of the DB1B data (see, e.g., Brueckner (2003) for a careful description), we apply multiple sample restrictions to ensure a relatively homogeneous product sample. A first, non-standard, restriction that we impose, however, is to *exclude* all domestic itineraries due to limited variation in unit taxes, and we focus exclusively on international itineraries that originate in the U.S. en route to a foreign destination (or the reverse).[42] Beyond that, we exclude at the outset all one-way or multi-leg itineraries (i.e. itineraries involving a sequence of destinations which the DOT distinguishes from layovers using flags for directional breaks); itineraries involving at least one first-class or business-class segment (accounting for at least 10 percent of miles flown); group tickets featuring 9 or more passengers, and all tickets flagged by the DOT as involving implausibly high prices per mile flown. This latter restriction appears targeted at fares in excess of $0.90 per mile (not inflation adjusted), albeit with unspecified exceptions, and covers approximately 1-1.5% of ticketed itineraries. We extend this restriction to exclude all fares—without exception—that exceed $1 per mile (0.4% of the remaining sample). At the opposite end of the

[42]Based on reporting requirements, flights operated by foreign carriers appear in the sample only insofar as these form part of a longer itinerary which includes at least one segment operated by a U.S. carrier (e.g., as part of a codeshare agreement or alliance affiliation). These are treated in the same manner with respect to ticket taxation and full fare disclosure requirements as flights operated entirely by U.S. carriers.

distribution, we exclude all tickets with fares of less than $0.02 per mile or *base* fares of less than $0.01 per mile (or $50) as likely award travel.[43] Depending on quarter, this exclusion eliminates approximately 7-10% of ticketed itineraries from our sample. Among the remaining set of round-trip coach-class non-award tickets, we further exclude ticketed itineraries that fall outside of the 5$^{th}$-95$^{th}$ percentile of the fare distribution within itinerary-quarter to limit the potential influence of promotional offers or last-minute purchases.

Multiple steps are required to match the resulting DB1B sample with historical data on airport-level tax and non-tax charges from RDC Aviation in order to decompose total fare amounts in the DB1B into base fares, ticket taxes, and non-tax charges. Airport-specific tax amounts are commonly dependent on flight distance or route (with differing levels of tax for transatlantic versus intra-EU or domestic flight segments, for instance), or whether passengers are exiting the airport versus catching a connecting flight. Taxes may also differ on rare occasion according to operating airline. Airport-specific non-tax charges—such as runway fees, emissions and noise charges, etc.—likewise vary along multiple dimensions, but—with the exception of navigation and (international versus domestic) terminal charges—do not depend on route. Instead, non-tax charges vary primarily according to aircraft maximum take-off weight (MTOW), seating capacity and class configuration, and engine type of arriving and departing aircraft. Where possible (i.e. for all flight segments involving a U.S. airport), we utilize data from the DOT's Form 41 T-100 Segment database (domestic and international) to identify model types, seating capacity, and load factors for aircraft operated by U.S. and foreign air carriers along specific flight segments in a given quarter. A passenger traveling on the outbound leg of a round-trip flight Philadelphia to Paris on Delta Airlines (i.e. PHL DL CDG) in 2014Q2 would be identified, for example, as having flown on a 171-seat Boeing 757-200. In the case where airlines use multiple aircraft types in a given quarter

[43]Carriers are not required to distinguish award versus non-award tickets for reporting purposes. Dollar-valued total fare thresholds are commonly used elsewhere in the literature to make this distinction, but these ignore the fact that consumers remain responsible for paying certain ticket taxes on award travel. Ideally, we would prefer to exploit exogenously-flagged award tickets for purposes of conducting sensitivity analyses, but we remain concerned that many low dollars-per-mile fares may represent erroneous entries, and we do not have the ability—outside of U.S. ticket taxes—to identify which taxes apply to award travel and which do not. A large number of exact $0 fares is indicative of misreporting as all international award tickets remain subject to non-zero taxes. The distribution of total fares per mile reaches a local near-zero minimum density at $0.02 per mile, hence our choice of threshold.

to service the same segment, we use information for the most-heavily used aircraft based on passenger volume. The combined quarterly airport, route, airline, aircraft model, and seating capacity information is then fed into RDC Aviation's query system to extract the per-passenger tax and non-tax charges applied to the departing aircraft at PHL and the arriving aircraft at CDG. The corresponding inbound flight segment—which could in principle involve a different aircraft—triggers additional departure charges at CDG and arrival charges at PHL.

In cases where we cannot use the T-100 database to match flight segments to aircraft, such as for flight segments between foreign airports, we scraped this information through FlightAware's Flight Finder API in November 2016. This procedure yields aircraft tail numbers and model types for recent and upcoming flights, which can in turn be matched to the DOT's Form 41, Schedule B-43 annual aircraft inventory for aircraft owned by U.S. carriers to determine the relevant seating capacity of the aircraft. We assume for this purpose that airlines' selection of aircraft to service particular flight segments is largely fixed over time. Absent valid tail number information (U.S. carriers only), we defer to RDC Aviation's airline-specific fleet information to determine seating capacity. Where neither the T-100 database nor FlightAware's Flight Finder yield any specific matching aircraft, we use information either from adjacent quarters or for the most common model of aircraft utilized over the same or similar routes in the same quarter.

Each round-trip itinerary in the DB1B requires data for at least two sets of arriving and departing charges, one at each endpoint of the passenger's journey. The addition of a single layover in either direction adds two additional flight segments and thus two further sets of charges. In a typical case, a single query for airport charges for a particular airport-route-aircraft-airline combination yields multiple applicable charges and corresponding charge amounts (converted to nominal U.S. dollars at prevailing quarter-average bilateral exchange rates). Charge amounts are classified by RDC Aviation as being either "per-movement" or "per-passenger" and fall broadly into ten categories: air navigation, aircraft security, government, infrastructure, noise, parking, passenger, passenger security, runway, or terminal charges. Charges are further distinguished by their applicability to arriving versus departing aircraft and terminal versus connecting passengers. Altogether, we utilize data for nearly 320000 charge amounts which we classify as passenger-specific tax amounts or non-tax charges before stringing these together for a sequence of flight segments into total itinerary-level taxes and charges for itineraries appearing in the DB1B.

Regrettably, the RDC data are not reliably coded in this manner, and are not linked exactly to specific international airport tax codes as defined by the International Air Transport Association (IATA). In order to make use of the RDC data, we therefore construct a concordance of ticket and airport tax codes with their corresponding names in a representative sample of flight segments by pulling these details from fare searches using ITA Software. We link the IATA and RDC data based on the description and dollar amount to named per-passenger charges in the data from RDC Aviation. Where applicable, we also consult the underlying government source documents to confirm our name- and amount-matching procedure. As a representative example, Table A1 lists the set of taxes levied by the French airport authority for a round-trip flight PHL DL CDG using the precise names and IATA tax codes given by ITA Software, alongside the set of matching charge elements from RDC which forms the basis for our ticket tax concordance. We are thereby able to pass the list of charges from the RDC database (e.g., 16 charge elements for transatlantic flights arriving in and departing from CDG as of 2014Q2) through our ticket-tax concordance to come up with a complete historical record of tax amounts by IATA tax code, and we confirm that the remaining charges in the RDC database for which we do not have a matching tax represent per-movement non-tax charges (such as parking and landing fees, etc.). Table A2 provides an illustration of the latter types of fees, as applied to the same PHL DL CDG flight. Otherwise, we treat charges that are levied on a per-passenger basis without matching our tax concordance as miscellaneous ticket taxes.[44]

Out of the 253 unique tax codes represented in our original pull of over 30000 scraped fare searches, we are thus able to use our ticket tax concordance to construct complete historical records

[44] We strive to avoid failed matches due to minor string mismatches in the naming of charges over time. Nevertheless, some such mismatches are largely inevitable. Failed matches can also reflect more substantive changes in applicable taxes over time, such that current IATA tax codes and descriptions may not capture ticket taxes that have been replaced or eliminated.

for 94 foreign tax codes from the RDC data with a high degree of precision.[45] We are furthermore able to construct complete histories of the six applicable U.S. ticket taxes (International Departure and Arrival Taxes (US), September 11$^{\text{th}}$ Security Fees (AY), Passenger Facility Charges (XF), APHIS Fees (XA), Immigration Fees (XY), and Customs Fees (YC)) from various sources, including the Federal Aviation Administration, Department of Homeland Security, Department of Agriculture, and Customs and Border Patrol.[46] This allows us to directly identify applicable tax amounts for all itineraries involving these 94 foreign and 6 domestic ticket tax codes based on our scraped fare search results (subject to caveats about variation in amounts owed for specific airport or ticket taxes based on route or airline), whereas without known tax amounts by tax code, we instead compute total tax amounts from miscellaneous airport-level taxes by adding these up across itinerary flight segments. We apply a similar procedure to sum non-tax charges (by airport-route-aircraft-airline) into a single itinerary-specific total amount and allocate these to passenger fares assuming 100% capacity utilization.

Due to the complexity of the aforementioned procedure for constructing a historical record of itinerary-specific ticket tax amounts, this inevitably requires us to impose one further important restriction on our sample. Namely, we limit our ticket tax queries to the set of routes flown by no fewer than 9 passengers in a single quarter over the period 2012Q4-2013Q3 (or 36 passengers over the full four quarters) in the DB1B (i.e. implying an average of at least 1 passenger per day in the full 100% ticket sample). This is intended to mitigate undue influence from large idiosyncratic changes in passenger volume (measured in logs) along very low-volume itineraries. Likewise, we exclude all observations from itineraries involving relatively low-volume ticketing carriers (i.e. below the 1$^{\text{st}}$ percentile of the distribution of carrier volume in the year 2011) out of concern that many of these carriers—including many foreign and charter operators—may not have been subject

[45] Of the remaining ticket tax codes, 30 represent presumptive ad valorem taxes—typically only applicable to in-bound flights—which were already required to be included in advertised fares prior to FFAR and thus do not figure in the calculation of applicable unit taxes. We distinguish ad valorem taxes from unit taxes by running separate regressions of each tax code on scraped base fares plus a scrape date indicator. All taxes featuring a statistically significant effect of base fares in excess of 0.5 percent and a regression R-squared of at least 0.5 are treated as as ad valorem.

[46] We are also grateful to Joakim Karlsson and the MIT Airline Ticket Tax Project for sharing data on airport-specific passenger facility charges at an earlier stage in this project.

to FFAR.

As described in the next section, we nevertheless compute certain key control variables prior to applying these last sample restrictions using data from the full DB1B without regard to our ability to calculate matching ticket tax information.

### A.1.2 Variable Definitions

Brief descriptions of the variables used in our analyses are presented in Table A3. HHI ($HHI$) and the number of total or competing itineraries within O&D airport pair (*Itineraries*) are each calculated using the full DB1B sample, whereas the remaining variables are all calculated exclusively within our sample of tax- and charge-matched itineraries.

## A.2 OTA Advertising Practices

As an illustration, Figure A1 shows a set of screenshots drawn from the Internet Archive's Wayback Machine capturing Expedia.com's fare advertising practices at the time of FFAR implementation. Importantly, in the period preceding the implementation of FFAR up through January 27, 2012, Expedia's featured flights page consistently included a small-print notice indicating "(+) Taxes and Fees Additional" with an accompanying explanation appearing at the bottom of the page (panel (a)).[47] No screen captures are available for January 28 or 29, but this notice had disappeared by January 30, 2012 (panel (b)) and screen captures after January 30, 2012 confirm its permanent removal. These screenshots are representative of the shift in industry advertising practices due to FFAR. Regrettably for our purposes, the Internet Archive only records static pages and links, such that dynamically-generated fare search result pages cannot be retrieved.

[47] Expedia's delay in compliance—one day beyond the statutory deadline of January 26—is again indicative of the industry's reluctance to come up with quick technical fixes to comply with FFAR.

## A.3 Extended Results

Tables A4 and A5 display the full set of coefficient estimates from estimation of our main empirical specifications, and replicate the results shown in Tables 3 and 4, respectively. First stage IV results corresponding to the specification shown in column 2 of Tables 4 and A5 are reported in Table A6.

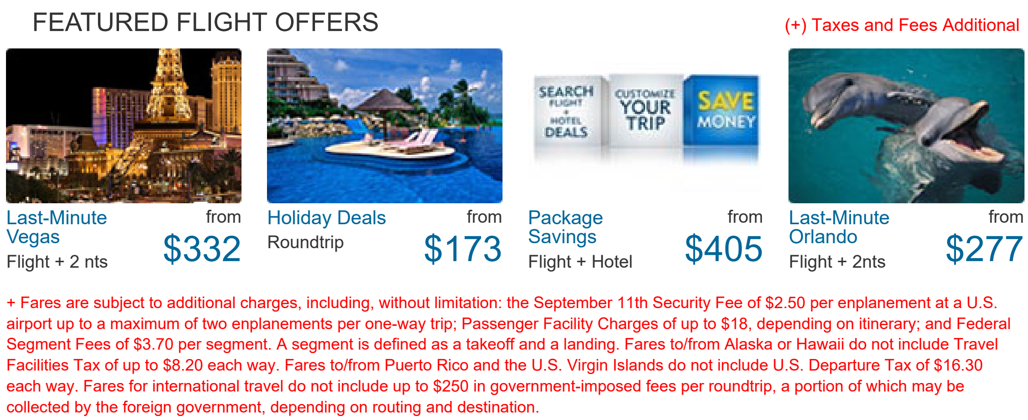
Figure A2 plots quarterly pass-through rates from equation (12) estimated as an event study, whereby quarterly unit tax and non-tax charge pass-through rates are estimated via incorporation of a full set of quarterly interaction terms. Data from 2012Q1 are omitted for consistency with the main specifications in the body of the paper. The main message of this figure may be that our quarterly estimates suffer from low power and are subject to large standard errors. Only in rare instances can we reject pass-through rates of either 1 *or* 0, especially for unit taxes. Pass-through rates for non-tax charges are generally more precisely estimated. This pattern reflects our narrow identification strategy, which is based on relatively modest within-market $\times$ quarter variation in unit taxes and the crude mapping of FFAR to passengers' quarter of travel. Though smaller in magnitude, non-tax charges exhibit greater within-market variation due to the fact that they are *aircraft*- and route-specific, whereas unit taxes are generally only route-specific (and with very rare exceptions, operating carrier). Statistical imprecision notwithstanding, the remaining key message from Figure A2 is that our point estimates of unit tax pass-through are close to unity for most quarters prior to 2012, and these lie above the pass-through rate for non-tax charges for the corresponding period in all but one quarter pre-FFAR. Post-FFAR, unit tax pass-through rates appear to shift downward, as evidenced by point estimates near or below 0.5 in virtually every quarter. Moreover, these estimates are in many cases very similar to the point estimates for non-tax charges, especially over the period 2012Q4-2013Q4, 2012Q4 being the first quarter that FFAR would have affected virtually all passengers identified in the DB1B sample of *redeemed* flight coupons. Subsequent divergence between pass-through rates for non-tax charges and unit taxes—with rates on the former exceeding the latter in the last 2 or 3 quarters of our sample period—are harder to explain except as a possible short-run over-correction.

## A.4 Add-On Fees

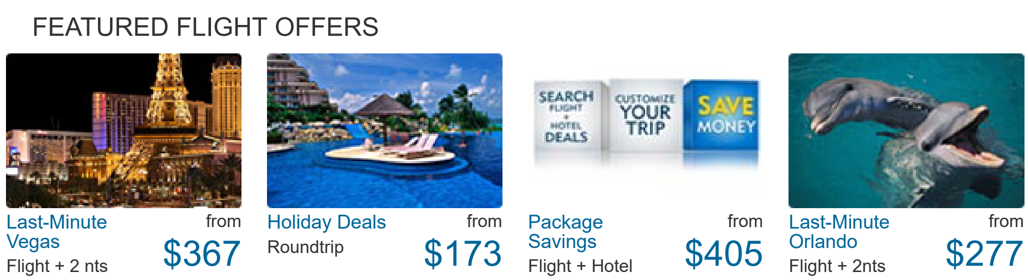
Detailed data on airline charges and fees are relatively scarce. Nevertheless, U.S. air carriers' quarterly financial statements provide a rough breakdown of sources of revenue from domestic and international operations. Of particular relevance to understanding the proliferation of carrier-imposed fees are baggage fees, cancellation and change-of-ticket fees, ticketing and check-in fees, fees for seat assignments and upgrades, and charges for in-flight food and beverages, entertainment, Wi-Fi, pillows and blankets, etc. Only the first two longest-established of these fees are reported separately on Form 41, Schedule P-1.2. More broadly, Schedule P-1.2 classifies revenues into: transport revenues from scheduled passengers, mail, freight, baggage fees, revenue from charter operations, change/cancellation fees, miscellaneous operating revenues, and transport-related revenues. Fees for seat assignments and upgrades or ticketing fees are included in general transport revenues along with base fares, while in-flight sales are included in transport-related revenues, which also incorporate revenue from code-share operations (flown by the partner airline), fuel sales, rental revenue, and revenue from maintenance performed for other carriers. Miscellaneous operating revenues includes pet transport fees (in the hold) and compensation for collection of passenger facility charges.

Figure A3 plots the evolution of six sources of revenue as a share of total revenue from international operations for the eight largest carriers by international revenue. The only notable break in reliance on baggage and cancellation fees around the implementation of FFAR occurs in 2012Q1 for the newly-combined United/Continental in their first period of joint financial reporting. Previously, neither constituent carrier levied baggage fees for international travel to any significant degree. Baggage fees for domestic travel on the "new United," meanwhile, decreased significantly as a share of total revenue (Figure A4) in the post-FFAR period. These apparent trend breaks appear to coincide with merger consummation, but it cannot be ruled out that these changes were implemented in reaction to reduced revenues from ticket sales on high-tax international routes.

Figure A1. Archived Screen Captures of Expedia.com
Advertising Before and After Implementation of FFAR



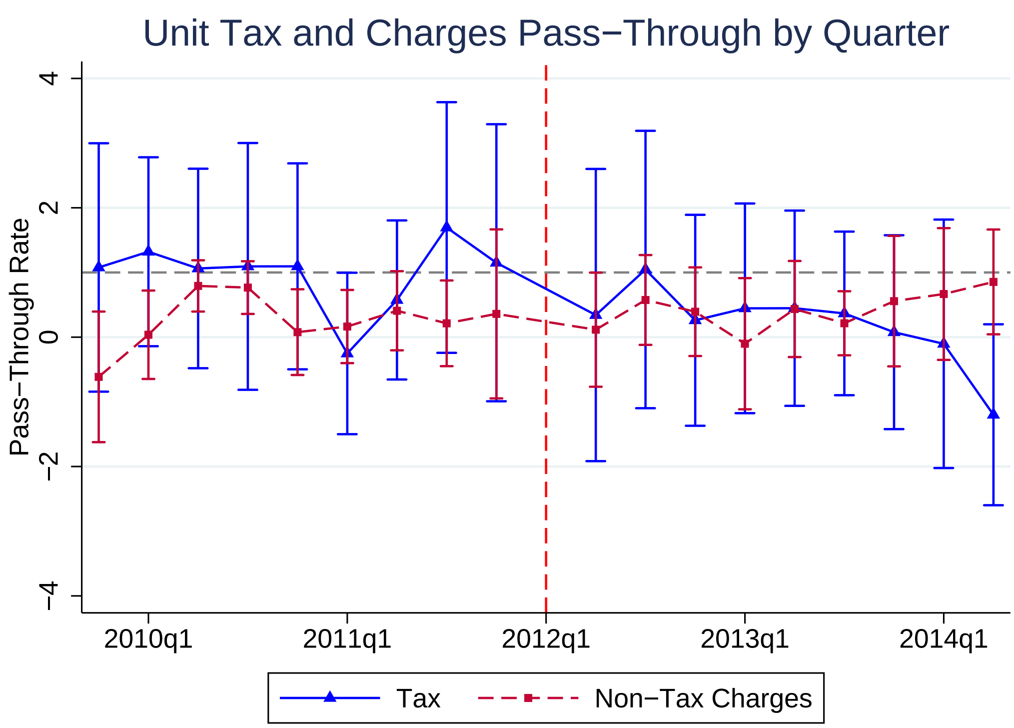

(a) Jan. 27, 2012 (Source: `https://web.archive.org/web/20120127042318/http://www.expedia.com/Flights`)




(b) Jan. 30, 2012 (Source: `https://web.archive.org/web/20120130050747/http://www.expedia.com/Flights`)

Red text coloration and positioning of detailed disclaimer immediately below featured fares added for authors' emphasis only.

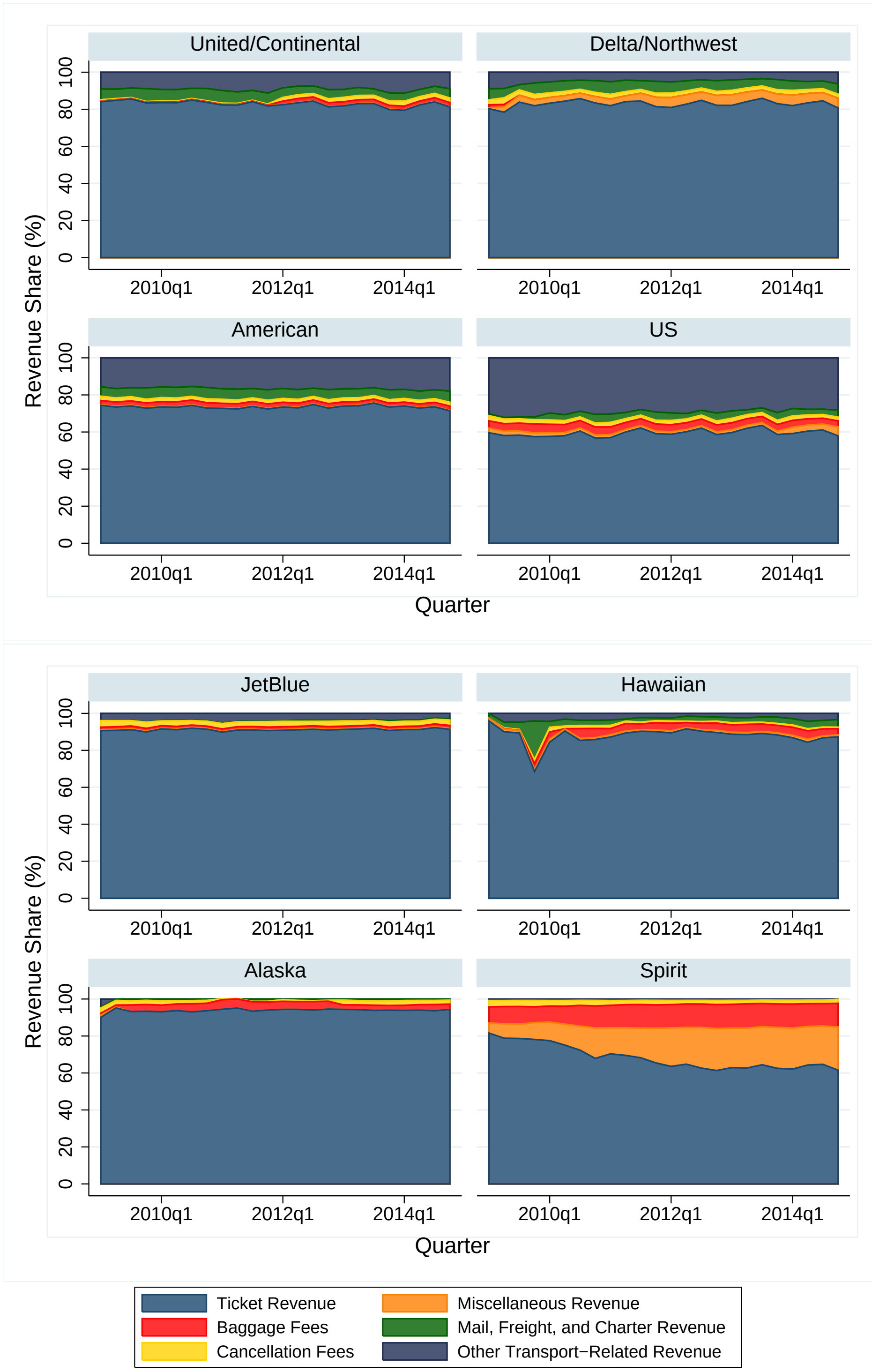
Figure A2




Whisker bars represent 95 percent confidence intervals.

Source: DB1B amd RDC.

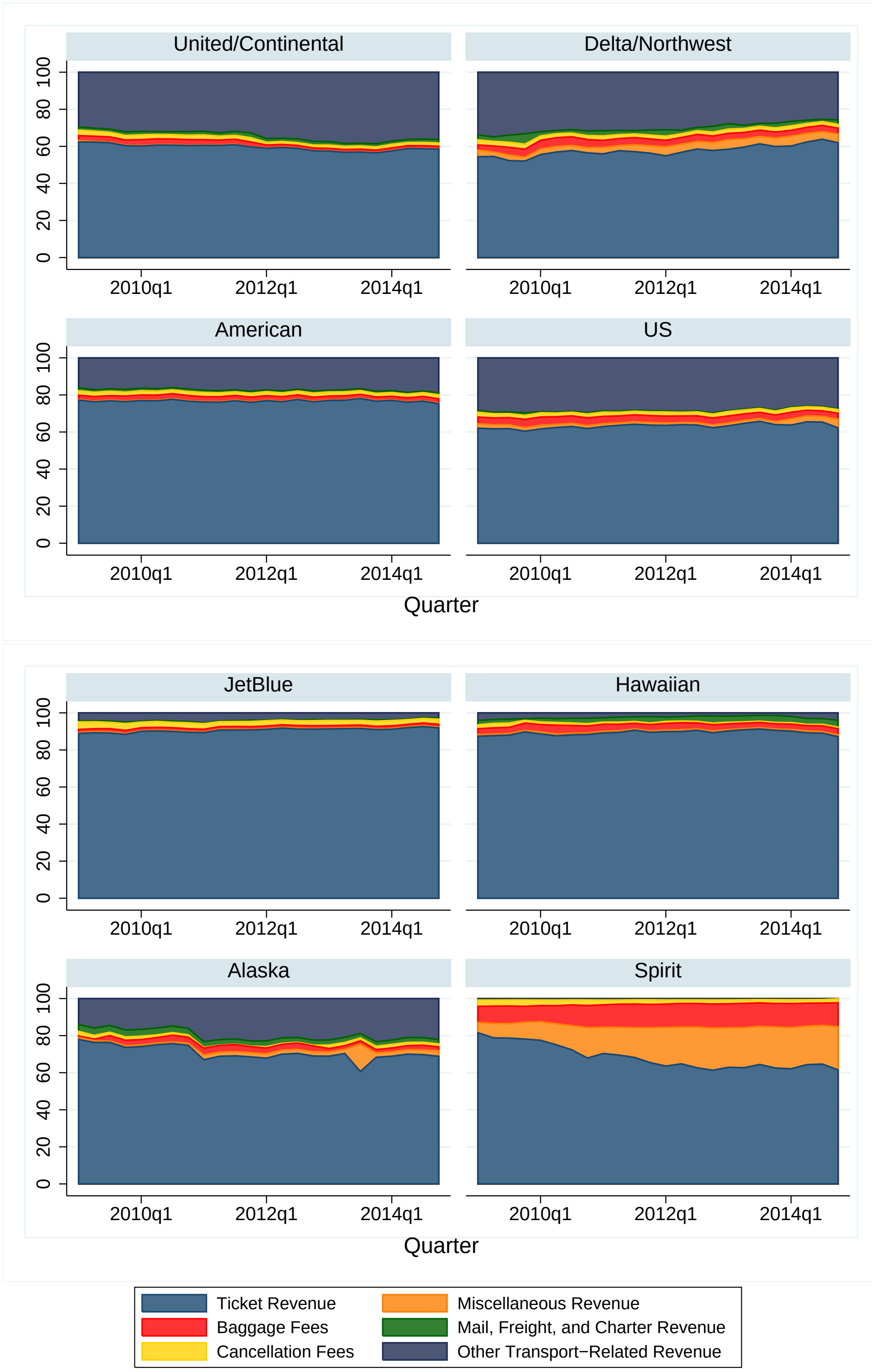
Figure A3. Carrier Revenue Sources from International Operations




Delta/Northwest and United/Continental began reporting combined financial statements in 2010Q1 and 2012Q1, respectively. Revenues from merged carriers are combined for the entire sample.

Source: DOT Form 41 Air Carrier Financial Statements, Sch. P-1.2.

Figure A4. Carrier Revenue Sources from Domestic Operations




Delta/Northwest and United/Continental began reporting combined financial statements in 2010Q1 and 2012Q1, respectively. Revenues from merged carriers are combined for the entire sample.

Source: DOT Form 41 Air Carrier Financial Statements, Sch. P-1.2.

Table A1. Sample Tax and Charge Concordance: French Portion of PHL DL CDG

| Tax Description (IATA Code) | RDC Charge Element | RDC Item Detail |
|---|---|---|
| French Airport Tax (FR) | Airport Tax | Direct Passengers |
| | National Surcharge | Per Passenger |
| France Civil Aviation Tax Domestic And International (FR) | Civil Aviation Tax | Per departing passenger to other states |
| France Passenger Service Charge International (QX) | Passenger Fee | Per departing passenger, international |
| | PRM Fee | Per departing passenger |
| | Check-In Counters (Supplemental Rate) | Per passenger, other international |
| | Computer Check-in and boarding (Crews) | Per departing passenger |
| French Air Passenger Solidarity Tax (IZ) | Solidarity Tax | Economy passengers to other states |

Source: ITA Software and RDC.

Table A2. Sample Non-Tax Charges: French Portion of PHL DL CDG (Aircraft-Specific)

| RDC Charge Element | RDC Item Detail |
|---|---|
| Terminal Charges | Departing flights |
| Tax on Air Transport Noise Pollution | Acoustic Group 5a, Departure 06:00-18:00 |
| Noise Level Coefficient | Acoustic Group 5a, Departure 06:00-22:00 |
| Fixed Power Supply (Landing) | Category 1, other international, 400 Hz |
| Fixed Power Supply (Take-Off) | Category 1, other international, 400 Hz |
| Aircraft Parking Fee | Base charge, pier-side stands |
| Aircraft Parking Fee | Supplemental charge, pier-side stands 07:00-23:00 |
| Aircraft Landing Fees | MTOW over 40 tonnes |
| De-icing Fees - Base Fee Per Landing | Class 4 aircraft |

Source: RDC.

Table A3. Variable Definitions

| Variable Name | Description | Unit of Observation | Source |
|---|---|---|---|
| $TotalFare_{cit}$ | Average total fare per ticket | Itinerary-Qtr | DB1B |
| $BaseFare_{cit}$ | Total fare net of ad valorem and unit taxes (and, depending on specification, non-tax charges) | Itinerary-Qtr | DB1B, RDC |
| $UnitTaxes_{cit}$ | Sum of all specific (unit) taxes levied on a per-passenger basis, aggregated over all arriving and departing flight segments. | Itinerary-Qtr | RDC |
| $NonTaxCharges_{cit}$ | Sum of all airport charges levied on a per-movement basis, aggregated over all arriving and departing flight segments. | Itinerary-Qtr | RDC |
| $ln(Passengers)_{cit}$ | Natural log of passenger volume | Itinerary-Qtr | DB1B |
| $ln(Revenue)_{cit}$ | Natural log of ticket revenue net of unit taxes (and, depending on specification, non-tax charges) | Itinerary-Qtr | DB1B, RDC |
| $Distance_i$ | Total flight distance (in thousands of miles) | Route | DB1B |
| $Layovers_i$ | Number of connecting flights | Route | DB1B |
| $HHI_{jt}$ | Herfindahl-Hirschman Index of market concentration based on ticketing carrier revenue shares in full DB1B sample (scaled to $[0,1]$ interval) | O&D-Qtr | DB1B |
| $Load_{cit}$ | Percent of available seats sold on the U.S.-foreign flight segment of the ticketed itinerary (normalized by O&D city pair mean and std. dev.) | Itinerary-Qtr | T100 |
| $LnOriginVolume_{cjo_t}$ | Natural log of number of passengers transported by ticketing carrier at U.S. airport of origin for all domestic and international flights | Carrier-Origin-Qtr | T100 |
| $Itineraries_{jt}$ | Number of available itineraries in full DB1B sample | O&D-Qtr | DB1B |
| $Itineraries_{c-jt}$ | Number of available itineraries excluding ticketing carrier $c$'s own route offerings (including alliance or code-share operations) in full DB1B sample | Carrier-O&D-Qtr | DB1B |

Dollar-denominated figures are measured in hundreds of current dollars. O&D refers to origin-destination airport pairs.

## Table A4. Ticket Tax Pass-Through

| $Y = TotalFare_{cit}$ | (1) | (2) | (3) |
|---|---|---|---|
| $UnitTaxes_{cit}$ | 0.768*** | 0.992*** | 0.958*** |
| | (0.100) | (0.312) | (0.307) |
| $UnitTaxes_{cit} \times I[Qtr_t > 2012Q1]$ | 0.700*** | -0.743* | -0.711* |
| | (0.134) | (0.418) | (0.413) |
| $NonTaxCharges_{cit}$ | - | - | 0.351*** |
| | - | - | (0.127) |
| $NonTaxCharges_{cit} \times I[Qtr_t > 2012Q1]$ | - | - | 0.022 |
| | - | - | (0.186) |
| $Distance_i$ | 29.647*** | 33.994* | 31.512* |
| | (7.990) | (17.998) | (17.865) |
| $Distance_i^2$ | 10.782*** | -6.785** | -6.417** |
| | (1.115) | (2.810) | (2.790) |
| $Distance_i^3$ | -0.517*** | 0.216** | 0.205* |
| | (0.045) | (0.108) | (0.107) |
| $I[Layovers = 1]_i$ | -71.686*** | -21.894*** | -21.943*** |
| | (5.500) | (4.107) | (4.099) |
| $I[Layovers = 2]_i$ | -109.258*** | -33.280*** | -33.943*** |
| | (7.220) | (5.991) | (5.929) |
| $I[Layovers = 4]_i$ | -107.537* | -115.872*** | -115.678*** |
| | (61.591) | (17.567) | (17.575) |
| $HHI_{jt}$ | 51.533 | 661.766*** | 687.970*** |
| | (170.581) | (210.405) | (208.671) |
| $HHI_{jt}^2$ | 424.729 | -1,062.927*** | -1,102.260*** |
| | (319.866) | (411.793) | (408.013) |
| $HHI_{jt}^3$ | -448.029** | 542.313** | 557.449** |
| | (179.686) | (235.436) | (233.122) |
| $LnOriginVolume_{cjo_t}$ | 339.867*** | 185.596*** | 182.505*** |
| | (36.657) | (23.988) | (23.771) |
| $LnOriginVolume_{cjo_t}^2$ | -39.894*** | -21.971*** | -21.687*** |
| | (3.961) | (2.617) | (2.591) |
| $LnOriginVolume_{cjo_t}^3$ | 1.437*** | 0.824*** | 0.813*** |
| | (0.136) | (0.091) | (0.090) |
| $Load_{cit}$ | -5.142*** | 4.082*** | 3.895*** |
| | (1.760) | (1.287) | (1.274) |
| $Load_{cit}^2$ | -1.528*** | 0.085 | 0.058 |
| | (0.454) | (0.364) | (0.364) |
| $Load_{cit}^3$ | 0.039 | -0.086*** | -0.084*** |
| | (0.034) | (0.028) | (0.028) |
| *Fixed Effects:* | | | |
| Carrier × Qtr ($\eta_{ct}$) | x | x | x |
| O&D City × Qtr ($\nu_{kt}$) | | x | x |
| Observations | 25,175 | 24,712 | 24,712 |
| R-squared | 0.854 | 0.964 | 0.964 |

Standard errors clustered by origin-destination airport-pair appear in parentheses. Observations are weighted by passenger volume. *** p<0.01, ** p<0.05, and * p<0.1.

Source: DB1B and RDC.

Table A5. Itinerary-Level Passenger Volume and Tax-Exclusive Ticket Revenue

| $Y =$ | $ln(Passengers)_{cit}$ (1) | (2) | $ln(Revenue)_{cit}$ (3) |
|---|---|---|---|
| $BaseFare_{cit}$ | -0.008 | -0.438** | - |
| | (0.011) | (0.180) | - |
| $BaseFare_{cit} \times I[Qtr_t > 2012Q1]$ | -0.067*** | -0.113 | - |
| | (0.015) | (0.202) | - |
| $UnitTaxes_{cit}$ | 0.289** | 0.304 | 0.195 |
| | (0.121) | (0.218) | (0.119) |
| $UnitTaxes_{cit} \times I[Qtr_t > 2012Q1]$ | -0.791*** | -1.179*** | -0.682*** |
| | (0.198) | (0.350) | (0.195) |
| $NonTaxCharges_{cit}$ | -0.017 | -0.303** | -0.169* |
| | (0.092) | (0.134) | (0.087) |
| $NonTaxCharges_{cit} \times I[Qtr_t > 2012Q1]$ | -0.154 | -0.163 | -0.135 |
| | (0.128) | (0.161) | (0.122) |
| $Distance_i$ | -0.348*** | -0.206 | -0.387*** |
| | (0.097) | (0.133) | (0.096) |
| $Distance_i^2$ | -0.031** | -0.059*** | -0.030** |
| | (0.014) | (0.021) | (0.014) |
| $Distance_i^3$ | 0.001*** | 0.002*** | 0.001*** |
| | (0.001) | (0.001) | (0.001) |
| $I[Layovers = 1]_i$ | -2.483*** | -2.586*** | -2.526*** |
| | (0.033) | (0.045) | (0.033) |
| $I[Layovers = 2]_i$ | -1.927*** | -2.084*** | -1.978*** |
| | (0.043) | (0.065) | (0.044) |
| $I[Layovers = 4]_i$ | -1.510*** | -2.009*** | -1.701*** |
| | (0.092) | (0.236) | (0.092) |
| $HHI_{jt}$ | -1.579 | 1.580 | -0.621 |
| | (1.152) | (1.638) | (1.198) |
| $HHI_{jt}^2$ | 2.037 | -3.046 | 0.556 |
| | (2.060) | (3.013) | (2.173) |
| $HHI_{jt}^3$ | -0.957 | 1.621 | -0.201 |
| | (1.155) | (1.700) | (1.234) |
| $LnOriginVolume_{c_j o_t}$ | -1.794*** | -0.961*** | -1.525*** |
| | (0.204) | (0.323) | (0.205) |
| $LnOriginVolume_{c_j o_t}^2$ | 0.211*** | 0.112*** | 0.178*** |
| | (0.022) | (0.037) | (0.022) |
| $LnOriginVolume_{c_j o_t}^3$ | -0.007*** | -0.004*** | -0.006*** |
| | (0.001) | (0.001) | (0.001) |
| $Load_{cit}$ | 0.013 | 0.031*** | 0.020** |
| | (0.008) | (0.011) | (0.008) |
| $Load_{cit}^2$ | -0.054*** | -0.054*** | -0.053*** |
| | (0.006) | (0.006) | (0.006) |
| $Load_{cit}^3$ | -0.000 | -0.001 | -0.000 |
| | (0.001) | (0.001) | (0.001) |
| *Fixed Effects:* | | | |
| Carrier × Qtr ($\eta_{ct}$) | x | x | x |
| O&D City × Qtr ($\nu_{kt}$) | x | x | x |
| Observations | 24,712 | 24,712 | 24,712 |
| R-squared | 0.836 | 0.780 | 0.866 |
| Kleibergen-Paap F-Stat | | 15.27 | |

Standard errors clustered by origin-destination airport-pair appear in parentheses. Observations are weighted by passenger volume.
*** p<0.01, ** p<0.05, and * p<0.1.
Source: DB1B and RDC.

Table A6. Itinerary-Level Passenger Volume - IV First Stages

| $Y =$ | $BaseFare_{cit}$ (1) | $BaseFare_{cit} \times I[Qtr_t > 2012Q1]$ (2) |
|---|---|---|
| $Itineraries_{c-jt}$ | -0.006*** | -0.000 |
| | (0.001) | (0.000) |
| $Itineraries_{c-jt} \times I[Qtr_t > 2012Q1]$ | -0.002 | -0.009*** |
| | (0.002) | (0.001) |
| $UnitTaxes_{cit}$ | -0.079 | 0.793*** |
| | (0.306) | (0.115) |
| $UnitTaxes_{cit} \times I[Qtr_t > 2012Q1]$ | -0.761* | -1.970*** |
| | (0.418) | (0.312) |
| $NonTaxCharges_{cit}$ | -0.549*** | -0.127*** |
| | (0.127) | (0.035) |
| $NonTaxCharges_{cit} \times I[Qtr_t > 2012Q1]$ | -0.018 | -0.394*** |
| | (0.187) | (0.141) |
| $Distance_i$ | 0.317* | 0.161 |
| | (0.179) | (0.165) |
| $Distance_i^2$ | -0.062** | -0.027 |
| | (0.028) | (0.026) |
| $Distance_i^3$ | 0.002* | 0.000 |
| | (0.001) | (0.001) |
| $I[Layovers = 1]_i$ | -0.219*** | -0.195*** |
| | (0.041) | (0.034) |
| $I[Layovers = 2]_i$ | -0.393*** | -0.308*** |
| | (0.058) | (0.051) |
| $I[Layovers = 4]_i$ | -1.181*** | -0.068 |
| | (0.176) | (0.152) |
| $HHI_{jt}$ | 4.388** | 3.027* |
| | (2.003) | (1.675) |
| $HHI_{jt}^2$ | -7.408* | -5.804* |
| | (3.939) | (3.302) |
| $HHI_{jt}^3$ | 3.756* | 3.180* |
| | (2.263) | (1.901) |
| $LnOriginVolume_{cjo_t}$ | 1.328*** | 0.662*** |
| | (0.246) | (0.190) |
| $LnOriginVolume_{cjo_t}^2$ | -0.159*** | -0.081*** |
| | (0.027) | (0.021) |
| $LnOriginVolume_{cjo_t}^3$ | 0.006*** | 0.003*** |
| | (0.001) | (0.001) |
| $Load_{cit}$ | 0.042*** | 0.030*** |
| | (0.012) | (0.010) |
| $Load_{cit}^2$ | 0.001 | 0.003 |
| | (0.004) | (0.003) |
| $Load_{cit}^3$ | -0.001*** | -0.001*** |
| | (0.000) | (0.000) |
| *Fixed Effects:* | | |
| Carrier × Qtr ($\eta_{ct}$) | x | x |
| O&D City × Qtr ($\nu_{kt}$) | x | x |
| Observations | 24,712 | 24,712 |
| R-squared | 0.960 | 0.984 |

Standard errors clustered by origin-destination airport-pair appear in parentheses. Observations are weighted by passenger volume. *** p<0.01, ** p<0.05, and * p<0.1.

Source: DB1B and RDC.