The Impact of Post 9/11 Airport Security Measures on the Demand for Air Travel*

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Abstract

We examine the impact of post-9/11 airport security measures on air travel in the U.S. Using five years of data on passenger volume, we evaluate the effects of the implementation of baggage screening and the federalization of passenger screening on the demand for air travel. These two congressionally mandated measures are the most visible changes in airport security following the 9/11 attacks. Exploiting the phased introduction of security measures across airports, we find that baggage screening reduced passenger volume by about five percent on all flights, and by about eight percent on flights departing from the nations fifty busiest airports. In contrast, federalizing passenger screening had little effect on passenger volume. We provide evidence that the reduction in demand was an unintended consequence of baggage screening and not the result of contemporaneous price changes, airport-specific shocks, or other factors. Moreover, this decline in air travel has substantial welfare implications. "Back-of-the-envelope" calculations indicate that the airline industry lost about $1.1 billion, a tenth of the projected revenue lost because of 9/11 itself. Similar calculations show that the substitution of driving for flying by those seeking to avoid security inconvenience likely lead to over 100 road fatalities.

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1 Introduction

In response to the terrorist attacks of September 11, 2001, the federal government enacted new legislation to increase air passenger safety. On November 19, 2001, President Bush signed into law the Aviation and Transportation Security Act (ATSA). This act established a new Transportation Security Administration (TSA), which consolidated security efforts inside the Department of Transportation (DOT). In addition, the ATSA mandated several important changes in civil aviation security procedures. The two primary changes in airport security visible to passengers were the federalization of passenger security screening at all U.S. commercial airports by November 19, 2002,[1] and the requirement to begin screening all checked baggage by December 31, 2002. To implement these mandates, the TSA established 158 Federal Security Director positions charged with overseeing security operations at all 429 commercial airports in the U.S.[2]

While these new security regulations were enacted to ensure passenger safety and restore confidence in the U.S. aviation system, they have made traveling less convenient. The overall effect of the new regulations on passenger demand is unclear. On one hand, greater confidence in the safety of air travel should spur demand. On the other hand, by requiring additional time and effort on the part of passengers, the inconvenience of security procedures may reduce demand for air travel. We examine the data in an effort to find the net effect.

Our identification strategy exploits variation in the timing of security implemen-

[1] Five airports, San Francisco (SFO), Kansas City (MCI), Tupelo (TUP), Rochester (ROC), and Jackson Hole (JAC), were included in a pilot program in which private security screeners operated under the supervision of TSA screeners. These private screeners were required to go through all TSA training, background checks, etc. We include these in our sample and treat them as airports with TSA screeners. Excluding them from the sample does not change our results.

[2] The affected airports included those in the U.S. territories of Guam, Puerto Rico, and the U.S. Virgin Islands.

tation to estimate reduced-form models of its effect on demand. We control for unobserved time trends and airline industry conditions by including fixed effects for each carrier-segment and each time period.[3] To confirm that we are correctly attributing changes in demand to security measures instead of unobserved airport conditions, we explicitly compare a "treatment" group of originating passengers, who are affected by the new airport security measures, with a "control" group of connecting passengers, who are not affected. Passengers and their bags are not screened on connecting flights and thus transfer passengers provide a near counterfactual—individuals flying the same segment, on the same carrier from the same airport at the same time who do not pass through security. In addition, we estimate a separate equation for return travel to discover if security implementation at destination airports in round-trip travel influences our results. Finally, we examine whether demand changes are a response to contemporaneous price changes rather than to security measures.

We use data from two sources. Data on domestic passenger volume from 1999 to 2003 comes from the Department of Transportation's Data Bank 1B (DB1B) of the Origin and Destination (O&D) survey. We use TSA press releases to establish the timing of airports' adoption of the security operations.

Our results indicate that baggage screening reduced originating passenger volume from all airports by five percent, and reduced originating passenger volume at the nation's fifty busiest airports by eight percent. At the same time, we find no evidence that baggage screening reduced connecting passenger volume from the same airports, on the same flights. In addition, we observe larger declines in passengers flying shorter trips, for which passengers are more likely to substitute driving for flying following the implementation of the new security procedures. Furthermore, we find that contemporaneous price changes cannot explain our results. Prices remain stable

[3] A segment is direct service from an originating airport to a destination airport.

or drop slightly following the implementation of baggage screening.

In contrast to baggage screening, federalizing passenger screening had little impact on passenger volume. The effect of was slightly positive in most of our models, but statistically significant in none.

These results suggest that regulatory efforts to enhance airport security, in response to the terrorist attacks of 9/11, had the unintended consequence of reducing the convenience of air travel, which in turn caused a decline in the demand for air travel. Moreover, this decline has substantial implications for welfare. "Back-of-the-envelope" calculations indicate that the airline industry lost about $1.1 billion in revenues due to the reduction in demand, a tenth of the projected revenue lost because of 9/11 itself. Similar calculations show that the substitution of driving for flying by those seeking to avoid security inconvenience likely lead to over 100 road fatalities. These unintended consequences must be weighed relative to the intended enhancements to passenger safety and confidence in order to evaluate the effectiveness of these regulatory responses.

The rest of the paper proceeds as follows. In section 2, we provide more details about security changes since 9/11. Section 3 lays out the competing hypotheses for the effect of security variables on air travel demand. Section 4 discusses the data, section 5 details our identification strategy, section 6 discusses our results, 7 discuss the implications of our findings, and section 8 summarizes our findings.

2 Changes in Airport Security since September 2001

Following the terrorist attacks of September 11, 2001, air travelers experienced many changes in airport security procedures. For example, airlines instructed passengers to arrive at airports as much as two hours before takeoff for domestic flights. After passing through security checkpoints, passengers were randomly selected for additional screening, including hand-searching of their carry-on bags, in the boarding area. Following an incident in December 2001, in which a passenger attempted to light a bomb in his shoe while in flight, security screeners asked passengers to remove their shoes when passing through checkpoints.

In this paper, we focus on two particular changes in airline security: the federalization of passenger screening operations, and the requirement that airports screen all checked baggage for explosives. These two changes are the most visible federal regulatory responses to the 9/11 attacks, related to improving airline security.

2.1 Federalization of passenger screening operations

TSA officially took over responsibility for airport security in February 2002. Initially, TSA retained private security screeners. However, over a period of nearly seven months, starting at Baltimore-Washington International Airport (BWI) on April 30, 2002, and concluding on November 19, 2002, TSA employees began to conduct passenger-screening operations at all U.S. commercial airports.

TSA made three important changes in an effort to improve the efficiency of security screening operations. First, at least initially, TSA increased staffing to help reduce waiting time in security lines. Prior to 9/11, there were about 16,200 private security screeners employed at U.S. airports, nearly all of whom were screening passengers. By the end of 2002, TSA had hired 56,000 screeners for both passenger and baggage screening (TSA, 2002). Roughly 55 percent of screeners were for passengers, with the remaining 45 percent screening checked baggage. Second, TSA increased the compensation of screeners, offering higher wages and better benefits. Prior to 9/11, airport screeners earned an average hourly wage of $7.00 (Seidenstat, 2004), often with no benefits. TSA more than doubled the average wage rate, and all TSA employees receive benefits. Perhaps as a result, turnover among security screeners plummeted. From May 1998 through April 1999, the average turnover rate at 19 large airports was 126% (Coughlin, Cohen, and Khan 2004). In February 2004, a GAO report found that TSA's overall attrition rate was about 14 percent, with attrition rates ranging from 15 to 36 percent at eight of the busiest airports (General Accounting Office 2003). Third, TSA increased training for screeners. For example, prior to 9/11, x-ray machine operators at private security firms averaged about twelve hours of training (Seidenstat, 2004), while TSA requires more than a hundred hours of training for all of its passenger and baggage screeners (General Accounting Office 2003).

Despite these changes, reports of resource allocation problems have plagued TSA's passenger screening operations. Initially, TSA allocated screeners based on airport passenger volumes and screening lanes. According to the House Subcommittee on Aviation Security, this resulted in "'thousands standing around' at major connecting airports, where most passengers do not pass through screening, and shortages at origin and destination airports" (Subcommittee on Aviation 2004). Responding to concerns about imbalances and overstaffing, TSA reduced its screener workforce by more than 6,000, to 45,300 screeners by January 2004 (Subcommittee on Aviation 2004). However, the workforce reductions, combined with recent difficulties in hiring additional screeners (General Accounting Office 2003), have resulted in several major airports being understaffed, and in reports of long security lines, flight delays, and passengers missing flights.

2.2 Baggage screening procedures

Unlike passenger screening, no general system for screening checked baggage was in place prior to 9/11, and only five percent of checked bags were screened (Transportation Security Administration 2002). The TSA introduced baggage screening in two stages. Beginning on January 16, 2002, all airlines had to either adopt positive bag matching, in which they matched each piece of checked luggage to a passenger on board a flight, or to screen checked baggage for explosives using one of four methods: explosion detection systems (EDS), explosion trace detection (ETD) machines, bomb-sniffing dogs, or manual searching of bags. EDS machines are about the size of a SUV, process 150-200 bags per hour, and generate false positive identifications of explosives in almost 30 percent of bags (Butler and Poole 2004). Bags that are flagged as containing explosives must then be searched by hand, which takes additional time and recently has prompted many complaints of theft or destruction of passengers' property (De Lollis 2003). ETD machines are much smaller, much more labor-intensive, and only about half as fast as EDS machines (Butler and Poole 2004). Where ETD machines are used, a screener takes a swab of each bag and places the swab in the machine for analysis. Congress required TSA to install EDS machines at all U.S. commercial airports by the end of 2002. However, airports that were unable to meet this deadline were allowed to use alternative screening methods, including ETD machines, hand searches, bomb-sniffing dogs, and bag matching.[4]

[4] A relatively small number of airports, about 30 to 40, were given an additional year to deploy EDS machines (Seidenstat 2004). However, these airports were required to use one of the alternative methods for screening baggage. For security reasons, TSA will not disclose the exact number of airports, nor which airports were granted the extra year.

Indeed, many airports were unable to meet the deadline for deploying EDS. However, by January 1, 2003, more than 90% of all checked bags were being screened electronically, using either ETD machines or EDS (Transportation Security Administration 2002). The remaining checked bags were screened using either dogs or hand searches, or matched to passenger lists.

TSA has configured the baggage screening process in three different ways. In most airports, passengers first check-in at the ticket counter, and then take their baggage to a screening area, where it is screened using either ETD or EDS machines. In the majority of remaining airports, passengers first have their baggage screened and then proceed to the ticket counter to check-in. In each of these cases, if the electronic screening technology indicates the presence of explosives or other prohibited items, then additional screening is done. In some cases, the bag is opened, in front of the passenger, and manually searched. With either system, the baggage screening process requires additional time and effort on the part of passengers. Finally, a small number of airports (currently, eight) have installed in-line EDS, which imposes no additional time or inconvenience on passengers. With in-line EDS, passengers simply hand their checked baggage to airline agents at the ticket counter. Screening is done out of the passengers' view, while the passengers are able to proceed directly to the passenger screening area. However, setting up an in-line system requires substantial, additional up-front costs to insert the baggage screening machines into the airport's existing infrastructure rather than place them in airport lobbies, the location used in the other two security configurations.

As of January 2004, TSA had deployed more than 1,100 EDS machines and more than 7,200 ETD machines in airports around the country (Subcommittee on Aviation 2004). However, "there may be 15-30 airports that are chronically unable to screen 100 percent of checked bags electronically" due to staffing shortages and mechanical failures (Subcommittee on Aviation 2004).

In the next section, we discuss the possible impact of these measures.

3 The Effects of Security Regulations

Generally, the effects of airport security measures on the demand for air travel are ambiguous. On the one hand, tighter security measures make traveling less convenient. Since 9/11, the best example of increased inconvenience is the need for passengers to arrive at airports as much as two hours prior to scheduled departures. Similarly, the random hand-searches of passengers and their carry-on baggage, the prohibitions regarding various seemingly non-dangerous items such as nail clippers, and the overall greater scrutiny all reduce the convenience of air travel. Survey data support the claim that increased security has made flying less convenient; 63 percent of travelers said that airport security "is becoming more of a hassle" (Woodyard and De Lollis 2003). Airlines claim that the increased inconvenience caused by security measures has cost them billions in lost ticket revenues, as business travelers opt to stay home (Sharkey 2002).

On the other hand, passengers value increased security, especially following the 9/11 attacks. Several surveys conducted since 9/11 have found that passengers are willing to accept some additional inconvenience and/or higher prices in order to feel more secure (Travelocity 2002; University of Nebraska at Omaha 2003). Moreover, these surveys support TSA claims that the security measures implemented since 9/11 increase passengers' confidence in the safety of air travel (Compart 2004; University of Nebraska at Omaha 2003). Increased confidence in airline security may result in increased demand for air travel.

Looking specifically at baggage screening, the ex ante effects are ambiguous. To the extent that passengers feel safer knowing that bags are being screened for explosives, we would expect baggage screening to increase demand for air travel. However, by requiring additional time and effort on the part of passengers, baggage screening reduces convenience. Additionally, as noted above, baggage screening has led to an increased number of complaints by travelers of items stolen from or damaged in their checked baggage (De Lollis 2003).

It seems likely that baggage screening will increase inconvenience more at large airports than at small airports. At larger airports, congestion in baggage screening areas is likely to be greater and waiting times are likely to be longer. Moreover, there have been widespread reports that baggage-screening capacity has not been able to keep up with the flow of baggage at many large airports. Airline industry analysts cite baggage screening bottlenecks as a leading cause of the sharp increase in the rate of mishandled and late arriving baggage in recent years. (Higgins 2005). In sum, we would expect baggage screening to have a more negative impact on passenger volume at large airports.

Predictions of the impact of TSA passenger screening is also ambiguous ex ante. However, there are some factors that suggest that TSA passenger screening has a more positive (less negative) impact on the demand for air travel. In particular, passenger screening was already conducted at all airports, and TSA passenger screeners simply replaced existing private screeners.[5] Moreover, by enhancing screener quality and increasing staffing levels, TSA may have reduced the inconvenience of screening. In

[5]One additional complicating factor in predicting the impact of the federalization of passenger screening is that private security firms were aware, in advance, of the date when TSA screeners would replace them. Recognizing that their contracts were facing imminent cancellation, we would not expect private firms to invest in efficiency improvements near the end of their tenure. Instead, it seems likely that there would be a shortage of security staff, demoralized and unmotivated employees, and reduced monitoring of employees in the weeks before the handover. As a result, we might expect to find positive benefits from TSA screening simply because of the deterioration of security procedures prior to the TSA takeover.

addition, there is some evidence that federalizing airport security may have increased travelers' confidence in that security. A Zogby poll, conducted in April 2004 found that 59 percent of respondents feel safer with federal security screeners, rather than private ones (American Federation of Government Employees 2004). More generally, as noted above, results of several surveys indicate that travelers feel safer as a result of TSA's more stringent security procedures (Compart 2004; University of Nebraska at Omaha 2003). On the other hand, these more rigorous procedures increase time and inconvenience of passing through passenger security checkpoints (Seidenstat 2004).

Summarizing, both baggage and passenger screening by TSA have ex ante ambiguous effects on consumer convenience, confidence, and therefore on consumer demand for air travel. However, baggage screening is more likely to have a negative effect on demand for air travel because TSA passenger screeners simply replaced private screeners. In addition, we would expect that baggage screening will reduce passenger volume more at big airports, where the inconvenience of baggage screening will be greater.

4 Data

We use quarterly data on passenger volume and ticket prices from the U.S. Department of Transportation's (DOT) Data Bank 1B (DB1B) of the Origin and Destination (O&D) survey. This survey consists of a 10 percent random sample of tickets sold by airlines for flights originating and terminating in the U.S. and includes the full itinerary for each trip, the price of the ticket, as well as the carrier.

We consider the time period from 1999 to 2003, placing the triggering event for our study, the terrorist attacks of 9/11, at about the midpoint of our data. Although we could have included data prior to 1999, earlier observations are unlikely to provide additional useful information for assessing the impact of security changes since 9/11.

We conduct the demand analysis at the carrier-segment level. A segment refers to direct service from an originating airport to a destination airport.[6] For example, a passenger who flies round-trip from LaGuardia (LGA) to Los Angeles (LAX) with a connection in Chicago O'Hare (ORD), would fly four segments: (1) LGA-ORD; (2) ORD-LAX; (3) LAX-ORD; and (4) ORD-LGA. However, consistent with other studies of airline industry pricing, we estimate price models at the carrier-route level, where a route refers to the originating and destination airport for each leg of the trip. Referring to the earlier example, the roundtrip from LGA to LAX (with a plane change in ORD) would comprise two routes: LGA-LAX and LAX-LGA. We estimate the passenger models at the carrier-segment rather than carrier-route levels to allow us to distinguish between connecting and originating passengers, an important aspect of our identification strategy, which we discuss below.[7]

We use TSA announcements of the date that TSA employees began screening checked baggage and began screening passengers at each airport to create indicator variables for security changes. In the case of passenger screening, we believe that the TSA announcements provide a precise indication of when each airport switched to federal screening. However, for the baggage screening variable, there is some uncertainty.

On November 19, 2002, the date on which it met the Congressional mandate to have TSA passenger screening in all 429 U.S. commercial airports, TSA provided a final progress report. This report lists the date that TSA began screening passengers and checked baggage at each airport. However, at that point, there were more than

[6] Direct service refers to travel on one airplane, with or without stops. Therefore, non-stop service between two airports is direct service, as is travel from airport i to airport k, with a stop at airport j, as long as a passenger does not change planes at airport j.

[7] Our results are consistent, though the point estimates are smaller, if we estimate the passenger models at the carrier-route level rather than the carrier-segment level.

150 airports that had not yet begun screening baggage. Because, in most cases TSA did not issue additional announcements, we do not know the exact date at which these airports began screening baggage. However, we do know that, with a small number of exceptions, all airports were screening baggage by the end of December 2002. We assume that these remaining airports began screening baggage on January 1, 2003. Stories in the print and electronic media, written at that time, indicate that the vast majority of remaining airports did not begin screening until the very last days of December 2002, or the first day of 2003 (www.cnn.com 2002; www.cnnfyi.com 2002). To illustrate the spread of TSA security changes, Table 1 provides the date that each of the fifty busiest airports (using 2003 enplanements data from the DOT T-100 dataset) first began using TSA security screening and first began screening checked baggage.

—Insert table 1 here—

To estimate the effect of airport security measures on demand, we must assign the implementation date to a quarter to be consistent with the data frequency of the O&D survey. We assume that TSA began screening baggage in a quarter if the date of the announcement falls during the first half of the quarter; if the announcement falls during the last half of the quarter, screening is assumed to commence in the subsequent quarter.[8]

[8]We chose this assignment scheme because it seems to best fit the distribution of announcement dates. The announcement dates fall into three categories. (1) There are twelve airports with announcement dates during the third quarter of 2002. Of these twelve, only one airport introduced baggage screeners during the first half of the quarter. Of the remaining eleven, eight are among the 50 busiest airports, and seven of these eight introduced baggage screeners during late September 2002, the very end of the quarter. (2) The majority of remaining 272 airports reported dates during the first half of the fourth quarter of 2002, with another group of 140 airports (3) just meeting the end-of-2002 deadline. Therefore, our assignment scheme group categories (1) and (2) together, which seems sensible given the proximity of their dates, and our identifying variation is between them and airports in category (3). We considered several alternative assignment schemes. The results we report below are generally robust to these alternatives.

While these two security measures, the federalization of passenger screening and the screening of all checked baggage, are the two most notable regulatory changes in airport security since 9/11, they only account for only a portion of the changes potentially causing inconvenience. For example, the requirement that passengers arrive at the airport at least 90 minutes (in many cases longer) prior to departure has greatly increased the cost of travel. We do not have any time-varying data on the implementation of these other changes and therefore, are, unable to estimate their impact. As a result, our estimates should be considered a lower bound on the total effect of changes in security procedures brought on by 9/11.

5 Identification Strategy and Estimation

To estimate the effect of the security measures on demand for air travel, one would ideally compare passenger volume on flights with the new security procedures to the counterfactual: passenger volume on the same flights without those procedures. Although such a comparison is impossible, we exploit certain features of the airline industry to construct a very close counterfactual. Our identification comes from two factors: (1) TSA's phased introduction of security measures across different airports, which created a quasi-natural experiment and (2) the fact that only originating passengers, but not connecting passengers, should be affected by the security measures.

Empirically, we first estimate a difference-in-difference model that exploits TSA's phased introduction of the new procedures by comparing the change in the volume of originating passengers on carrier-segments departing from airports that adopt new security procedures to the change in originating passenger volume on carrier-segments departing from airports that did not adopt the new security measures during this time period. In this method, year fixed effects account for any national change in passenger volume that may have occurred at the same time as security adoption, and carrier-segment fixed effects for any time-invariant differences between airports, carriers, and or segments. If adoption of security measures is randomly assigned, this method will produce unbiased estimates of the effect of security measures.

To illustrate our approach, consider Atlanta's Hartsfield International Airport (ATL) and John F. Kennedy Airport in New York (JFK) from the third to fourth quarter of 2002. JFK adopted baggage screening during the fourth quarter of 2002, while ATL did not. To assess the impact of baggage screening on flights departing from JFK, the difference-in-difference estimator calculates the following:[9]

$$(OPV_{JFK,4Q2002} - OPV_{JFK,3Q2002}) - (OPV_{ATL,4Q2002} - OPV_{ATL,3Q2002}) \qquad (1)$$

where $OPV_{airport,quarter}$ is the originating passenger volume on carrier i's flights on segment s from the respective airports during each quarter.

A concern with this method is that we cannot separate changes in passenger volume due to security measures from changes due to airport-specific demand shocks occurring at the same time. For example, if JFK improved passenger amenities, added a runway, or made other alterations during the fourth quarter of 2002, our difference-in-difference method could falsely attribute the effect of those changes to the implementation of baggage screening.

To consider whether these factors are biasing our results, we examine changes in the demand of a "control" group of passengers unaffected by security measures, but influenced by any airport-specific shocks occurring at the same airport, at the

[9] To be more precise, the difference-in-difference estimator subtracts the average passenger volume for all quarters before the introduction of the new security measure from the average passenger volume for all quarters after the introduction. Because the effect is identified only during the period where the treatment group has implemented the new security measure and the control group has not, we only include this period in describing the estimator.

same time. Fortunately, the airline industry's hub and spoke system creates a natural control group. Passengers connecting (primarily at large hub airports) do not undergo security when changing planes. However, these passengers are affected by many unobserved changes in airport attributes.[10]

Because security measures would not affect connecting passengers, any observed relationship between security measures and connecting passenger volume would indicate a correlation between security adoption and airport demand shocks. However, the absence of a relationship between airport security measures and connecting passenger volume would allow us to exclude unobserved airport shocks as an alternative explanation for any observed relationship between security measures and originating passenger volume.

To separate changes in passenger volume due to security measures from changes due to airport-specific demand shocks, we estimate the same difference-in-difference in expression (1) for the control group of connecting passengers:

$$(CPV_{JFK,4Q2002} - CPV_{JFK,3Q2002}) - (CPV_{ATL,4Q2002} - CPV_{ATL,3Q2002}) \qquad (2)$$

where $CPV_{airport,quarter}$ is connecting passenger volume on carrier i's flights on segment s from the respective airports during each quarter.

To use this method to dismiss demand shocks as a factor, we must assume that connecting passengers provide an effective control group. However, connecting passengers must go through security at the feeder cities from which they originate their travel. To the extent that the introduction of security measures at these feeder airports is correlated with security at the hub airports, the control group of connecting

[10] Connecting passengers, of course, are not affected by changes at airports outside of the secure area. We cannot test for simultaneity between security measures and airport changes such as the addition of new parking or improvements in ground transportation to city centers.

passengers becomes more similar to the treatment group of originating passengers. This potential contamination of the control group creates a conservative bias that understates the difference in the changes in demand of the two groups.[11]

A related concern is the effect of security conditions at the destination airport. Our identification assumes that passengers' travel decisions are based on the security procedures at their originating airport, about which they have the most information, but one could argue that round-trip travelers also consider the security procedures at the destination airport, which they must pass through on their return. To confirm that destination airport security procedures do not influence our demand estimates, we repeat the analysis with only the population of return travelers.

Finally, we are concerned that price changes correlated with security changes could affect our results. For example, airlines might lower prices to restore passenger volume lost because of the greater inconvenience of travel. Alternatively, if better security increases demand, airlines might raise fares, thus mitigating the positive security effect. To examine these possibilities, we test for the relationship between security arrangements and airfares.

Thus, our empirical approach uses the difference-in-difference identification shown

[11]To see this, consider two extremes: (1) the timing of feeder cities' security adoption is perfectly correlated with that of the connecting cities, or (2) the timing of feeder cities security changes has no correlation at all with that of the connecting cities. In case (1), the implementation of security measures at the connecting airport would coincide with their implementation at the originating airport. In this situation, one would expect our supposed "control" group passengers' demand to fall in tandem with that of the treatment group, an occurrence that would obscure our findings. In case (2), our control group would be comprised of many passengers who have traveled without passing through the new security procedures. In either extreme case, and anywhere in between, our control group of connecting passengers contains some passengers who are affected by the new security measures.

in expression 1 by estimating the following reduced form, fixed-effects models:

$$\begin{aligned}\ln PASSENGERS_{isq} =& \alpha_1 BAGGAGE\_SCREENING_{isq} + \\ & \beta_1 PASSENGER\_SCREENING_{isq} + \\ & QUARTER_q + CARRIER\_SEGMENT_{is} + \epsilon_{isq}\end{aligned} \tag{3}$$

$$\begin{aligned}\ln PRICE_{irq} =& \alpha_2 BAGGAGE\_SCREENING_{irq} + \\ & \beta_2 PASSENGER\_SCREENING_{irq} + \\ & QUARTER_q + CARRIER\_ROUTE_{ir} + \epsilon_{irq}\end{aligned} \tag{4}$$

$PASSENGERS\_SCREENING_{isq}$ is the number of passengers (originating or connecting) flying on airline i, on segment s, during quarter q. $PRICE_{irq}$ is the average price paid by passengers flying on airline i, on route r, during quarter q.[12] $BAGGAGE\_SCREENING_{isq}$ ($BAGGAGE\_SCREENINGirq$) is an indicator of whether TSA began screening checked baggage at the originating airport for passengers flying on airline i, serving segment s (route r), during quarter q. Similarly, $PASSENGER\_SCREENING_{isq}$ ($PASSENGER\_SCREENING_{irq}$) indicates whether TSA had taken over the passenger screening function at the originating airport. In each model, the next two terms are the chronological quarter, e.g., Q1 2002, and carrier-segment (-route) fixed effects. The quarter fixed effects control for changes in the airline industry during the study period. For example, these fixed effects control for changes in economic conditions, weather, technology, industry-wide labor relations, congestion, attitudes toward flying, seasonal demand, as well as many of the other changes in security procedures that were implemented simultaneously at

[12] As noted above, in the price model, we define a route by the originating and destination airports for the outbound portion of the trip.

most or all airports, including arriving early to the airport, having to remove footwear, etc. The carrier-segment (-route) fixed effects control for systematic differences in demand (price) across airlines' segments (routes).[13]

One might expect correlation in the ϵ_{isq} (ϵ_{irq}) error terms belonging to carrier-segments (carrier-routes) departing from the same airport, which can lead to severe bias in estimating standard errors for difference-in-difference models (Bertrand, Duflo, and Mullainathan 2001). To correct for this correlation, we estimate standard errors clustered at the originating airport in all of our regressions.

Table 2 displays descriptive statistics for each of our two outcome variables. When looking at the number of passengers, it is important to recall that the O&D survey is a ten percent sample of tickets, which suggests that the actual mean number of originating (connecting) passengers on a carrier-segment during a quarter was about 3,749 (2,985). This number averages a distribution highly skewed by a very small number of high-traffic carrier-segments; the median number of originating passengers on a carrier-segment is only 220 (140 for the connecting passengers).

The observations with very few passengers are an artifact of the dataset construction. The O&D dataset is a random sample of passenger tickets and reports the ticket itinerary by "coupon," the industry term for each sheet in a paper ticket that may be exchanged for a boarding pass. A ticket coupon is issued for each travel segment and most segments are non-stop. However, if a passenger remains on the *same* airplane for multiple legs of travel, only one coupon is issued. Many carriers will fly the same aircraft on a sequence of flights, with majority of passengers remaining on the plane for only one "hop." Nonetheless, it is possible for a passenger to travel across country one coupon, making five stops along the way, and this direct travel appears

[13] Recall that we use segments for the demand analysis, but full origin to final destination routes for the price analysis.

as a segment in our data. In practice, such an itinerary is traveled very infrequently because most passengers would prefer to make a single connection at a hub airport.

The combination of the low volume of passengers on these segments and the O&D's ten percent sampling rule can lower the precision of our estimates. To minimize the noise due to sampling in low volume carrier-segments, we repeat all of our analyses dropping the carrier-segments in the bottom 25% percentile by volume, a cut-off that corresponds to about 15 sampled passengers (true value of 150). In most cases, this sample selection, which we refer to as the restricted sample, lowers the magnitude of our standard errors but has little effect on the estimated coefficients.

We also note that there are many more observations on prices than on passengers. This difference is because there are many more routes than segments; segments comprise only direct service between two airports, while routes comprise all trips made, including multi-flight trips. Since prices are measured at the carrier-route level, there are more price observations.

Figures 1 and 2 show the trends in each of the outcome variables during the five-year period included in the sample. Surprisingly, the average number of originating passengers flying on a carrier-segment increases during the five-year period. This increase is because airlines eliminated more than 9,000 segments during this time; there were 36,731 carrier-segments in 1999 and 27,320 in 2003.

The impact of the 9/11 terrorist attacks is clear; passenger volumes and fares both plummeted following September 2001. Because of the drastic effect of the attacks, we exclude the third quarter of 2001 from all of our regressions.[14]

—Insert table 2, figure 1, and figure 2 here—

[14] We also tried excluding the fourth quarter of 2001, rather than the third. Our results do not change.

6 Results

6.1 Effects of Security on Demand

To examine the impact of the new security measures on the number of passengers traveling by air, we first estimate difference-in-difference models which assess whether the introduction of TSA passenger screening or baggage screening affected demand in our treatment group: originating passengers. The results of these baseline models are reported in table 3.

—Insert table 3 here—

The difference-in-difference analysis shows that baggage screening is associated with about a five percent decline in originating passenger volume, an effect which is statistically significant ($p<.07$ for the full sample and $p<0.01$ for the restricted sample), while TSA passenger screening has no effect on originating passenger volume. We also examine the impact of these security procedures only at the fifty busiest airports in the U.S. In each year, these airports comprise more than 80 percent of total passenger volume. As expected, at these larger airports we find that the negative effect of baggage screening is greater. Baggage screening reduces the number of originating passengers traveling from large airports by about eight percent compared to the five percent effect for all airports (ten percent compared to eight percent for the restricted sample). Again, TSA passenger screening has no effect on originating passenger volume. It appears that baggage screening makes travel less attractive, while TSA passenger screening either has no effect on travelers, or that any increased inconvenience resulting from TSA screening is offset by enhanced efficiency and greater public confidence in the security of the aviation system.

In the difference-in-difference models, the fixed effects control for many unobserved factors that might be correlated with baggage or security screening and passenger volume. However, as we discuss above, this identification strategy does not control for unobserved, airport-specific demand shocks that occur at the same time and at the same airport that the observed changes in security occur. For example, TSA may have purposely introduced baggage screening at airports during periods of low traffic so as to minimize inconvenience while procedures were learned. In this case, the negative effect of baggage would be endogenous.

To ensure that unobserved airport-specific demand shocks are not biasing our estimates, we examine the impact of security procedures on connecting passenger volume flying on the same carrier, leaving from the same airport, for the same destination, during the same quarter. These connecting passengers provide a natural control group because passengers do not pass through security when changing planes, and they have their baggage screened only at the originating airport.

The results for the sample of connecting passengers are reported in table 4. Neither baggage screening nor TSA passenger screening has any impact on connecting passenger volume on connecting flights. These results provide strong evidence that the changes in security procedures are indeed causing the changes in originating passenger volume. It does not appear that unobserved airport demand shocks are biasing our estimates.[15]

—Insert table 4 here—

As a further check of airport shocks as an alternative explanation, we estimate the effect of security measures on originating passengers while conditioning on connecting

[15] We also estimated the difference-in-difference-in-difference models jointly by pooling the originating and connecting passenger samples, and interacting the security variables with an indicator for observations from the originating passenger sample. The results for the baggage screening are consistent with, but stronger, than what we describe above

passenger volume. Here, we use connecting passengers to control for any unobserved airport-specific shocks. As with our baseline results, the negative effect of baggage screening is greater at the top 50 airports than at all airports, but the effect is not significant for either using the full sample. Using the restricted sample, baggage screening has a negative and significant effect of about six percent for all airports and nine percent for the top 50 airports. The effects of passenger screening are insignificant in all models. These results provide further evidence that the negative effect of baggage screening is not biased by unobserved airport-specific factors.

Another concern is that passengers flying round-trip may consider the security procedures at destination airports, from which they will depart later, when choosing whether and where to fly. To consider this possibility, we estimate our model once again, this time including only passengers on the first flight of their return trip.

The results for the returning passengers are reported in table 6. As with the connecting passengers, we find that neither baggage screening nor TSA passenger screening has any effect on returning passengers in any of our models.[16] These results suggest that security procedures at airports other than the originating airport have little impact on travel, and that baggage screening at the originating airport is driving the estimates we report above.[17] This finding is consistent with the reasonable assumption that passengers are the most familiar with the security at their hometown airport.

—Insert table 6 here—

[16] An alternative approach to removing possible bias from destination airport security is to use a sample of only one-way passengers. Doing so yields results similar to those for round-trip passengers, suggesting that destination airport security has little effect on demand.

[17] In a further attempt to isolate the impact of baggage screening at the originating airport, we also tried excluding flights to airports that had implemented baggage screening. The effect of baggage screening on demand is stronger in this analysis: baggage screening reduces originating passenger volume by seven percent at all airports and by ten percent at the fifty busiest airports.

Finding that baggage screening reduces airline passenger volume raises the question of what the discouraged passengers do instead: Do they travel less, or do they substitute a different mode of transportation for flying? To shed light on this question, we restrict our sample to trips of less than 500 miles (roundtrips of less than 1000 miles), with the expectation that passengers are more likely to substitute travel by car, bus, or train for flying on shorter trips.[18] The results are reported in table 7.

—Insert table 7 here—

The salient finding is for short trips from the top 50 airports, the sample of itineraries and airports for which substitutes are the most accessible and security inconvenience is likely the greatest. The number of originating passengers on trips of 500 miles or less falls by about 16 percent on flights departing the fifty largest airports with baggage screening. Due to the reduced sample size, the baggage screening coefficient has a much larger standard error than in the estimation for all trips and is significant only in the restricted sample. Nonetheless, the more negative coefficient supports the notion that travelers are substituting other forms of transportation for flying on shorter routes.[19]

Taken together, the above results suggest that the introduction of baggage screening at U.S. airports created inconvenience that reduced demand for air travel by about five percent, with even greater reductions in demand for flights originating at large airports and shorter flights. On the other hand, the federalization of passenger screening had little effect on passenger volume, except on shorter routes where it appears that travelers who had substituted driving for flying following 9/11 switched back to flying again.

[18] That is, we exclude all observations for passengers flying on *routes* that are under 500 miles

[19] In Blalock, Kadiyali, and Simon (2005), we find that road fatalities increased following September 2001, and provide evidence that travelers substituting driving for flying provided the primary mechanism for this result.

6.2 Effects of Price on Demand

While the above results provide evidence that security procedures affect the demand for air travel, and in particular, that baggage screening may increase the inconvenience of such travel, there are possible alternative explanations for the negative impact of baggage screening on the volume of airline travelers.

An alternative demand-side explanation is that by increasing passengers' confidence levels, the security procedures actually raised the demand for air travel. If airlines boosted prices in response to an upward shift in demand, then we might observe a price-induced decline in air travel from airports that screen baggage.

An alternative supply-side explanation is that airlines incurred higher security costs after TSA began managing airport security. Prior to 9/11, airlines and airports paid directly for most security costs. Instead, TSA now assesses each airline a monthly security fee based on the amount it paid for passenger screening in 2000 (Seidenstat 2004). In addition, Congress passed a new excise tax, the security service tax, of $2.50 for each enplanement on flights originating at domestic airports.[20] If airlines pass these fees and taxes on to passengers in the form of higher ticket prices, then this would provide an alternative explanation for the negative relationship between baggage screening and passenger volume. We think the taxes and fees are unlikely to affect our results, however. Our identification exploits time-series variation in the implementation of security measures, whereas the TSA fees and the excise tax were applied to all flights and airports simultaneously. So, whatever their effect, the fees and taxes did not selectively affect some airports and not others and therefore should not influence our findings.

To consider each of these alternative explanations, we examine the impact of the

[20] There is a $5 limit in each direction, i.e., a $10 limit for round trips.

security variables on airline prices. As noted above, we examine prices at the carrier-route level, where a route refers to the originating airport and destination airport for each direction of a trip. The results are presented in table 8.

—Insert table 8 here—

The results show that baggage screening had a very modest 1.5% negative effect on airline prices (no effect when we only look at the 50 busiest airports), providing no support for the hypothesis that higher prices introduced a negative bias in the estimated relationship between security measures and passenger volume.

7 Implications for Welfare and Transportation Safety

Taken together, we believe the results above provide convincing evidence that the introduction of baggage screening reduced the demand for air travel. This finding has implications for both welfare and transportation safety. All else being equal, welfare is reduced because trips not taken because of airport security represent a reduction in consumer surplus. Further, on the producer side, empty seats on airplanes impose a large cost in terms of reduced profit and jobs in the airline industry. Transportation safety is also compromised if the inconvenience of airport security prompts some travelers to substitute less-safe road transportation for air travel. To quantify some of these implications, we estimate "back of the envelope" calculations for the effect of baggage screening on airline industry revenues and highway fatalities.

To measure the reduction in airline revenues, we multiply the demand reductions estimated above by the average ticket price. Using the number of 4th quarter 2002 passengers as a base, the 5.4 percent decline in demand we estimate in our first regression indicates a realized reduction of 2.8 million trips. At the average ticket price in our data of $404, the lost revenue to the airline industry is approximately $1.1 billion dollars for 4th quarter of 2002. In comparison, the Air Transport Association estimates that the lost revenue from the 9/11 attacks in the 4th quarter of 2001 were about $10.1 billion (General Accounting Office 2001). Because the airline industry is characterized by high fixed cost and low marginal costs, most of this lost revenue translates to lost profits in the short run. Compared to the total airline industry revenue of approximately $80 billion, our very rough estimate shows the effect of lost revenue due to security inconvenience to be far from trivial. Of course, one must also consider the cost of baggage screening itself, which totaled $1.5 billion in 2003 Subcommittee on Aviation 2004. More generally, the total cost of TSA operations in its first two years (2002 and 2003) was about $11.5 billion dollars (Seidenstat 2004).

If the inconvenience of security discourages travelers from flying, some might choose to travel by automobile instead. Consistent with our finding that the negative effect of baggage screening is greatest for trips of less than 500 miles, we expect this substitution would be especially likely on short trips, for which driving is most feasible. Because air transportation is safer than road transportation, the increase in driving could lead to more traveler fatalities. In fact, we show in a separate paper that the substitution of road for air transportation following 9/11 led to an increase in driving fatalities (Blalock, Kadiyali, and Simon 2005). As part of that analysis, we estimated the reduced-form relationship between air passenger volume and driving deaths. We controlled for time trends, weather patterns, economics conditions, and unobserved highways conditions using commercial vehicle fatalities as a control group. We found that a decrease of one million enplanements leads to an increase of fifteen driving fatalities. Applying that relationship to the estimated reduction in originating passenger volume due to baggage screening, we estimate that in the 4th quarter of 2002 approximately 116 individuals died in automobile accidents which resulted from travelers substituting driving for flying in response to inconvenience associated with baggage screening.[21]

Although both our revenue and fatalities estimates are very rough approximations, the numbers are of an order of magnitude that warrant attention. These costs must be weighted against the difficult-to-measure benefits of better security.

8 Conclusion

This paper assesses the impact of post-9/11 airport security measures on demand for air travel. We find that the introduction of baggage screening at U.S. airports reduced originating passenger volume at all airports by about five percent, with an effect of eight percent at the nations fifty busiest airports. In contrast, baggage screening had no effect on connecting passengers, who do not need to have their baggage screened. This provides support for the view that the negative relationship between baggage screening and passenger volume is not driven by unobservable airport demand shocks. In addition, we find evidence that security measures reduced demand by even more on shorter flights. Moreover, we find no evidence that contemporaneous price changes can explain these results. Prices remained stable or fell slightly following the introduction of baggage screening. While baggage screening reduced originating passenger volume, the federalization of passenger screening had little effect on passenger volume.

Proponents of federalized passenger screening may point to the absence of a decline in demand following the introduction of TSA passenger screening, which is more stringent than what it replaced, as an indication of the success of federalization. We

[21] To calculate the number of fatalities we multiply the estimated number of trips not taken due to baggage screening, 2.8 million, by the number of enplanements associated with each trip (2.7). This then gives us the total reduction in enplanements associated with baggage screening. Finally, we multiply this figure by the number of additional fatalities resulting from a decrease of one million enplanements, 15, to arrive at our figure of 116 additional fatalities.

do not believe this is a correct inference, however. The TSA increased staffing levels, wages, and training, but one should not necessarily conclude that federalization of the workforce improved efficiency and service quality. Indeed, a report conducted for TSA finds that at five airports, private screeners working under TSA guidelines provided service as good as or better than that provided by TSA screeners at other airports (Transportation Security Administration 2004). Moreover, in December 2004, Nevada's Elko regional airport became the first airport to exploit an opt-out rule and return to private security screeners (Donnelly 2004). It is expected that many more airports will do the same in 2005 (Donnelly 2004).

Although we find evidence that baggage screening has reduced the demand for air travel, we recognize that any assessment of the net benefits of this procedure must balance this loss in consumer welfare against the difficult-to-measure increase in the security of air travel. Nonetheless, we believe that it is important to identify these unintended consequences of regulatory efforts to enhance security against the threats of terrorism. In addition to the lost consumer welfare, rough estimates for the 4th quarter of 2002 alone suggest that baggage screening cost the airlines over a billion dollars in lost revenue and substitution from air to road travel resulted in about 116 driving fatalities. Our findings are consistent with the argument presented in Mueller (2004) that the greatest cost of terrorism may be the unintended consequence of responses to attacks rather than the attacks themselves.

Finally, it is important to note some limitations in our analysis. First, our measures of when airports first introduced TSA passenger and baggage screening contain some error, with more error likely in the baggage screening measure. While our results are fairly robust to alternative specifications of these variables, this nonetheless poses a concern. In addition, our ability to precisely estimate the impact of these security changes on the demand for air travel is hampered by the fact that the O&D

survey is quarterly. This poses a challenge given the short time span during which baggage screening was introduced throughout U.S. commercial airports. In particular, the short span prevents us from measuring the persistence of the demand decline. We would expect demand to slowly return to pre-intervention levels as the TSA and airports invest in infrastructure to minimize the inconvenience of baggage screening. However, absent a counterfactual of airports without baggage screening, we cannot measure a fall in demand beyond the first quarter of 2003.

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A Tables

Table 1: **TSA announcement dates for baggage screening and passenger screening at the 50 busiest U.S. airports.** * indicates that the date was not announced and that baggage screening began sometime after November 19, 2002, but before January 1, 2003.

Airport	TSA Passenger Screeners	TSA Baggage Screeners
Atlanta (ATL)	9/17/2002	1/1/2003*
Chicago OHare (ORD)	8/6/2002	9/17/2002
Dallas-Fort Worth (DFW)	9/4/2002	9/10/2002
Los Angeles (LAX)	10/8/2002	10/29/2002
Phoenix (PHX)	9/24/2002	1/1/2003*
Denver (DEN)	9/10/2002	1/1/2003*
Las Vegas (LAS)	9/17/2002	1/1/2003*
Minneapolis-St. Paul (MSP)	9/10/2002	1/1/2003*
Detroit (DTW)	8/27/2002	10/29/2002
Houston Intercontinental (IAH)	9/17/2002	10/16/2002
Orlando (MCO)	7/30/2002	9/30/2002
Seattle (SEA)	9/17/2002	10/1/2002
San Francisco (SFO)	11/19/2002	1/1/2003*
Newark (EWR)	8/13/2002	10/29/2002
Charlotte (CLT)	9/4/2002	1/1/2003*
New York Laguardia (LGA)	8/6/2002	9/24/2002
Philadelphia (PHL)	9/10/2002	1/1/2003*
St. Louis (STL)	9/17/2002	1/1/2003*
Cincinnati (CVG)	9/4/2002	1/1/2003*
Baltimore-Washington (BWI)	4/30/2002	10/21/2002
Boston (BOS)	8/6/2002	9/24/2002
Salt Lake City (SLC)	9/17/2002	10/1/2002
Chicago Midway (MDW)	9/4/2002	9/17/2002
New York JFK (JFK)	7/9/2002	10/29/2002
Fort Lauderdale (FLL)	9/10/2002	1/1/2003*
Tampa (TPA)	8/6/2002	1/1/2003*
San Diego (SAN)	10/16/2002	1/1/2003*
Honolulu (HNL)	10/1/2002	1/1/2003*
Miami (MIA)	10/1/2002	9/24/2002
Pittsburgh (PIT)	8/27/2002	1/1/2003*
Washington National (DCA)	9/17/2002	9/24/2002
Oakland (OAK)	10/8/2002	1/1/2003*
Washington Dulles (IAD)	10/8/2002	1/1/2003*
Portland, OR (PDX)	10/8/2002	10/22/2002
Memphis (MEM)	10/1/2002	1/1/2003*
Kansas City (MCI)	11/19/2002	1/1/2003*
San Jose (SJC)	10/1/2002	1/1/2003*

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Airport	TSA Passenger Screeners	TSA Baggage Screeners
Cleveland (CLE)	8/6/2002	1/1/2003*
New Orleans (MSY)	10/16/2002	1/1/2003*
Nashville (BNA)	8/27/2002	1/1/2003*
Sacramento (SMF)	10/1/2002	1/1/2003*
Orange County, CA (SNA)	10/17/2002	1/1/2003*
Houston Hobby (HOU)	9/4/2002	1/1/2003*
Raleigh-Durham (RDU)	8/13/2002	1/1/2003*
SJU (San Juan, Puerto Rico)	10/1/2002	1/1/2003*
Indianapolis (IND)	9/17/2002	1/1/2003*
Austin (AUS)	9/4/2002	1/1/2003*
Albuquerque (ABQ)	10/8/2002	1/1/2003*
San Antonio (SAT)	9/10/2002	1/1/2003*
Ontario, CA (ONT)	10/8/2002	1/1/2003*

Table 2: **Descriptive statistics for passenger volume and ticket price.** The unit of observation for passengers is the carrier-segment-quarter. The unit of observation for prices are carrier-route-segments. Because the O&D Survey uses a 10% sampling frame, passenger volume should be multiplied by 10 to refect the true number of travelers. All models exclude the third quarter of 2001.

Variable	Mean	Std. Dev	No. Observations
Originating passengers	374.91	(851.58)	293,489
Connecting passengers	298.46	(819.54)	261,268
Ticket price ($)	408.04	(242.10)	2,851,804

Table 3: **The effect of security measures on originating passenger volume.** Carrier-segments below the 25th percentile are removed in some models as indicated. Carrier-segment and year-quarter fixed effects are included but not reported. The third quarter of 2001 is excluded.

	all airports		top 50 airports	
TSA baggage screening	−0.054*	−0.082***	−0.0822***	−0.1082***
	(0.030)	(0.027)	(0.040)	(0.036)
TSA passenger screening	0.022	0.000	0.005	−0.007
	(0.032)	(0.031)	0.036	0.037
Adj. R^2	0.893	0.922	0.860	0.912
Carrier-segments below 25th percentile	Y	N	Y	N
No. carrier-segment observations	278,777	204,966	177,109	134,715

* Significant at 0.10; ** Significant at 0.05; *** Significant at 0.01

Table 4: **The effect of security measures on connecting passenger volume.** Carrier-segments below the 25th percentile are removed in some models as indicated. Carrier-segment and year-quarter fixed effects are included but not reported. The third quarter of 2001 is excluded.

	all airports		top 50 airports	
TSA baggage screening	−0.028	−0.021	−0.016	−0.016
	(0.048)	(0.040)	(0.067)	(0.055)
TSA passenger screening	−0.036	0.004	−0.049	−0.009
	(0.050)	(0.045)	(0.060)	(0.054)
Adj. R^2	0.908	0.923	0.100	0.920
Carrier-segments below 25th percentile	Y	N	Y	N
No. carrier-segment observations	248,228	172,004	177,854	125,499

* Significant at 0.10; ** Significant at 0.05; *** Significant at 0.01

Table 5: **The effect of security measures on originating passenger volume, conditional on connecting passenger volume.** Carrier-segments below the 25th percentile are removed in some models as indicated. Carrier-segment and year-quarter fixed effects are included but not reported. The third quarter of 2001 is excluded.

Dep. variable: passengers	all airports		top 50 airports	
TSA baggage screening	−0.031	−0.056*	−0.065	−0.090**
	(0.038)	(0.030)	(0.051)	(0.040)
TSA passenger screening	0.031	0.010	0.029	0.013
	(0.036)	(0.045)	(0.060)	(0.054)
log(connecting passengers)	0.579***	0.465***	0.617***	0.500***
	(0.017)	(0.035)	(0.044)	(0.043)
Adj. R^2	0.943	0.943	0.932	0.942
Carrier-segments below 25th percentile	Y	N	Y	N
No. carrier-segment observations	186,838	167,584	127,904	114,806

* Significant at 0.10; ** Significant at 0.05; *** Significant at 0.01

Table 6: **The effect of security measures on returning passenger volume.** Carrier-segments below the 25th percentile are removed in some models as indicated. Carrier-segment and year-quarter fixed effects are included but not reported. The third quarter of 2001 is excluded.

Dep. variable: passengers	all airports		top 50 airports	
TSA baggage screening	−0.036	−0.031	−0.028	−0.023
	(0.032)	(0.034)	(0.048)	(0.035)
TSA passenger screening	0.022	0.028	−0.035	0.021
	(0.034)	(0.035)	(0.050)	(0.039)
Adj. R^2	0.891	0.916	0.909	0.917
Carrier-segments below 25th percentile	Y	N	Y	N
No. carrier-segment observations	274,876	195,639	248,228	130,681

* Significant at 0.10; ** Significant at 0.05; *** Significant at 0.01

Table 7: **The effect of security measures on originating passenger volume for passengers travelling less than 500 miles.** Carrier-segments below the 25th percentile are removed in some models as indicated. Carrier-segment and year-quarter fixed effects are included but not reported. The third quarter of 2001 is excluded.

Dep. variable: passengers	all airports		top 50 airports	
TSA baggage screening	−0.061	−0.074	−0.164	−0.174*
	(0.073)	(0.065)	(0.116)	(0.102)
TSA passenger screening	0.080	0.034	0.066	0.043
	(0.053)	(0.044)	(0.060)	(0.050)
Adj. R^2	0.921	0.926	0.924	0.932
Carrier-segments below 25th percentile	Y	N	Y	N
No. carrier-segment observations	79,112	58,186	44,306	33,138

* Significant at 0.10; ** Significant at 0.05; *** Significant at 0.01

Table 8: **The effect of security measures on ticket prices.** Carrier-route and year-quarter fixed effects are included but not reported. The third quarter of 2001 is excluded.

Dep. variable: ticket prices ($)	all airports	top 50 airports
TSA baggage screening	−0.015**	0.003
	(0.006)	(0.09)
TSA passenger screening	−0.000	−0.012
	(0.007)	(0.008)
Adj. R^2	0.321	0.396
Carrier-routes below 25th percentile	Y	Y
No. carrier-route observations	3,046,728	1,110,068

* Significant at 0.10; ** Significant at 0.05; *** Significant at 0.01

B Figures

Figure 1: Passenger volume over time. Quarter 1 is 1Q 1995 and 9/11 is in quarter 11, 3Q 2001.

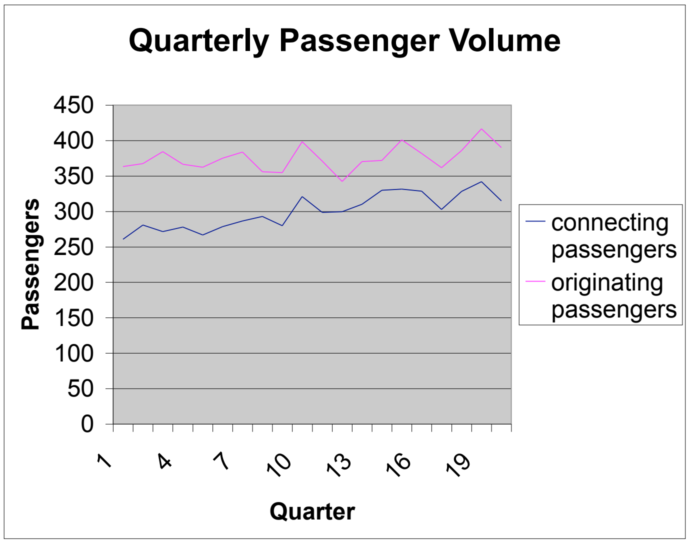

Figure 2: Ticket prices over time (in dollars). Quarter 1 is 1Q 1995 and 9/11 is in quarter 11, 3Q 2001.