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Abstract

Airport policy involves decisions about not only the sizes of airports but how many airports should serve a given area. I test the arguments for airport consolidation by estimating the effect of the number of airports on total local traffic using US data and a historical instrument for the number of airports. Cities that are randomly allocated a larger number of airports are found to host more air traffic and flights to more destinations. Furthermore, the effect is largely due to a greater number of transit passengers, so cities with multiple airports are more likely to be chosen as airline hubs.

Keywords: Airport infrastructure; Air travel; Transportation policy

JEL classification: H54, R41, R42

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1 Introduction

Public debates about airport policy often concern questions of whether to expand or replace existing airports. An important aspect of such decisions is whether to construct or continue to operate secondary airports, which in some cases are the main airports serving their cities before the new facilities are built. In practice it is common that when a major new airport is constructed, the city's former main airport is closed down, as occurred in Denver, Colorado and Austin, Texas in the 1990s.[1] Similarly, some of the proposals for a new Thames Estuary airport for London involve closing Heathrow Airport.[2] However, London and many other large cities including Tokyo, New York, Washington, Paris, and Moscow currently have two or more major airports. Should airport operations be consolidated at a single facility? Or is it better to operate several airports, especially if these airports have already been built?

Airport consolidation is motivated by implicit beliefs about the scale economies in airport operations and the resulting advantages in terms of the air services offered. Lower operating costs for a given level of services could be captured in higher profits or lower ticket prices, but should also lead to more flights being operated by the airlines. The scale economies arise because the same runways, terminal facilities, and ground transportation infrastructure can be used by many aircraft and passengers. In addition, concentrating operations at a single airport makes it easier for passengers to transfer between flights.

However, while there are advantages of operating a larger-scale airport, the costs of congestion also increase with airport size. Indeed as the safe operation of air traffic requires a minimum separation between any two aircraft, there is a maximum frequency at which flights can take off or land at an airport, so there must be a level of traffic beyond which the costs of congestion exceed the benefits of concentration. As the scale economies and congestion costs are difficult to measure,

[1] When Denver International Airport was opened in 1995 it replaced Stapleton International Airport, which was then closed down and redeveloped for residential and retail use (Goetz, 2013). Austin–Bergstrom International Airport replaced Robert Mueller Municipal Airport as the main airport in Austin, Texas in 1999, after which the site of the former airport was redeveloped as the mixed-use Mueller Community.

[2] The proposed plans for London include expanding Heathrow or one of the other airports that currently serve London or building a new airport in the Thames Estuary and either closing or continue to operate Heathrow (Gourlay and Gadher, 2008). A further example is the new airport planned for Mexico City, which is to replace the existing Mexico City International Airport (Luhnow, 2014).

particularly for a proposed airport that is not yet in operation, it is not clear a priori whether having a city served by a single airport or multiple airports leads to a greater provision of air services.

In this paper I aim to answer the question of whether consolidating the airports that serve a city leads to more or less air services being provided. I do this by estimating the effect of the number of airports in a metropolitan area on the frequency of passenger flights and the range of destinations, using US data. As the number of airports may be influenced by the local demand for air travel or other local factors that also influence air traffic, causality cannot be established by simply comparing the numbers of airports and flights by metropolitan area. To identify the effect I use the instrumental-variables method, which simulates an experiment by estimating the treatment variable using an instrument that explains part of the variation in the treatment variable but is otherwise unrelated to the outcome variable. The instrument I use is the number of major airports in each metropolitan area in the 1944 National Airport Plan, a document authored by the Civil Aeronautics Administration that included a survey of existing airports and specified which airports could be constructed using federal funds in the following years.

The main finding is a positive causal effect of the number of airports in a metropolitan area on the overall level of traffic at the metropolitan area's airports. The effect is mostly due to a difference in the number of transit passengers, as metropolitan areas that are randomly allocated a larger number of airports have significantly more passengers who transfer between flights without leaving the airport but do not have significantly more origin or destination passengers. This suggests that metropolitan areas with multiple airports are more likely to be used as airline hubs. There is no evidence of an effect of the number of airports on ticket prices, the composition of flights, or flight delays.

The results can be used to inform debates about the design of airport policy. They predict how air traffic – and therefore the possibilities for travel to or from the local area – will adjust when new airports are opened or existing airports are closed. Having an additional airport will tend to increase the air services offered to local residents and workers, allowing them to travel more easily and local firms to interact with firms in other places.

This paper contributes to the existing literature on the economics of airport infrastructure in two broad ways. Firstly, it complements the research that estimates the production functions of airports from financial and operations data, notably Bazargan and Vasigh (2003), Pels, Nijkamp and Rietveld (2003), Martín and Voltes-Dorta (2008), Oum, Yan and Yu (2008), and Martín and Voltes-Dorta (2011). These studies regress the output of the airport in terms of traffic or revenue on factors of production such as runway capacities, raw materials, and labour costs to generate relative measures of airports' productivity levels. Of particular relevance to this paper is the work of Martín and Voltes-Dorta (2008) and Martín and Voltes-Dorta (2011), who study the relative efficiency of single- and multi-airport systems with data from several countries. They find evidence of unexploited returns to scale in airport operations, with larger airports having lower costs per flight than smaller airports and potential benefits of expansion for even the largest airports. These results imply that airport consolidation would decrease operating costs. In contrast, Bazargan and Vasigh (2003) studied the operational efficiency of US airports and found smaller airports to be more efficient, in terms of the costs per unit of air services produced, than larger airports. This suggests a possible cost advantage for having a city served by multiple airports.

This paper addresses the same question in a different way: rather than estimating the factors for the output of an airport and asking how the outcomes would differ if there were a different set of airports, it does not assess the factors but directly measures the outcomes that arise with different sets of airports. It can be important to understand the roles of the underlying factors in determining output. However, the approach used here has the advantage of allowing a quasi-experiment, with feasibly exogenous variation in the numbers of airports explained by the instruments, which yields more credible estimates of the causal effects. It would be difficult to do the equivalent for each of an airport's factors of production. Without such a technique there is a risk of reverse causality or bias from unobserved variables, meaning that the results inferred by comparing actual single- and multiple-airport systems may not apply to a counterfactual situation in which there is a change in the number of airports serving a city.

Secondly, this paper can be used to inform work that estimates the economic benefits of airport infrastructure. A growing body of literature addresses the fundamental question of how airport infrastructure affects local employment and productivity using US data. Brueckner (2003) and

Green (2007) were the first to apply modern econometric techniques, using instrumental variables and finding positive effects of airport size on local employment growth. Sheard (2014), McGraw (2014), and Sheard (2015) also applied instrumental variables and found positive effects on local employment and productivity and on employment in particular industries. Blonigen and Cristea (2015) and Bilotkach (2015) identified the effects of airports on the local economy by exploiting time-series variation and also found positive effects.

These studies mostly leave aside the question of how the composition of airports affects the costs and benefits of air services by simply aggregating the airports within each metropolitan area. This approach is not unreasonable as Brueckner, Lee and Singer (2014) showed that the relevant level for defining air-travel markets is the city rather than the airport, so travellers readily substitute between local airports. However, it may ignore some important detail. The current paper adds depth to this research by studying how the composition of airports affects the costs of operation and thereby the amount of air services that airlines provide for a given level of demand. The findings may be considered alongside the results of the studies that measure the effects of the aggregate amount of infrastructure, or the ideas may be integrated into future studies to account for the composition of local airports in a meaningful way.

Though the empirical evidence presented in this paper can be used to inform policy decisions about airport infrastructure, it has some limitations that should be considered when applying the results to policy design. Firstly, the results were derived using US data and may not apply to other countries where the operation of air travel is substantially different. Secondly, the instrumental-variables technique generates feasibly exogenous variation in the number of airports, given the controls, but represents a specific source of variation and there is no guarantee that the outcomes will match the results presented here. Thirdly, the approach measures the effects on overall outcomes rather than detailing the individual mechanisms, which may make it more difficult to predict the outcomes from certain policy decisions. And finally, the analysis is limited in how much it can differentiate between the effects of different combinations of airport sizes. This means that caution should be taken when interpreting the results, but also represents a potential topic for further research.

The remainder of this paper is organised as follows. Section 2 describes the theoretical basis for the empirical analysis. Section 3 describes the data and Section 4 describes the method used for the empirical analysis. Section 5 presents the results of the empirical analysis. Section 6 presents concluding remarks.

2 Conceptual framework

The arguments for airport consolidation can be grouped into two broad categories. On the one hand, there are perceived economies of scale in operating an airport, which are borne by either the airport operators or the airlines. On the other hand, having activities consolidated at one airport are thought to make it less costly for travellers to access or use the airport, because larger airports tend for example to have better infrastructure links or present more possibilities of transferring between flights.

The potential benefits of airport consolidation would be reflected in the level of air traffic at a city's airports. This is illustrated in Figure 1, which plots the demand for and supply of air trips in a city. For clarity only two airports are shown in the illustration, though the ideas can naturally be extended to three or more airports. The quantity of trips is denoted q and the price of a trip is denoted p. The demand and supply curves are labelled D and S, respectively, with subscripts indicating the number of airports in the city. The demand curves are downward-sloping because higher ticket prices will lead to fewer trips being made by air. The supply curves are upward-sloping because of increasing marginal costs of operation, which mean that more services will be provided if the price that can be charged for a ticket is higher. For the sake of argument, the baseline case in Figure 1 is the one in which there are two airports and the relative positions of the demand and supply curves reflect benefits of consolidation for both air-travel providers and passengers.

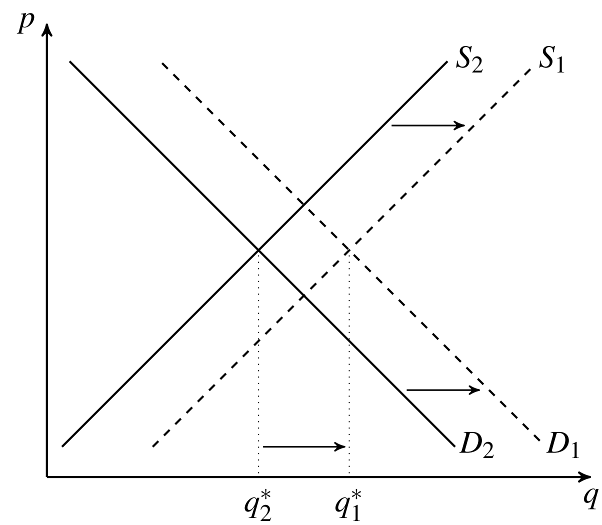

Figure 1: Demand for and supply of air trips in a city. If there are two airports in the city, then the equilibrium level of traffic q_2^* is determined by the intersection of demand D_2 and supply S_2. If there is only one airport in the city, then the equilibrium level of traffic q_1^* is determined by the intersection of demand D_1 and supply S_1. By comparing the positions of the curves it is evident that lower costs of air travel for either providers or customers leads to an increase in the equilibrium level of air traffic.

To see how the potential benefits of airport consolidation would affect local air traffic, begin by observing the situation in which there are two airports. The equilibrium level of traffic q_2^* is determined by the intersection of the demand curve D_2 and the supply curve S_2.

Now consider what would happen if operations are consolidated at a single airport. If indeed there are efficiency gains for the airport operators or airlines because of increasing returns to scale, then the per-flight costs of operation will be lower if there is only one airport. This will be reflected in an outward shift in the supply curve, illustrated as a shift to S_1 in Figure 1, as the airlines can provide more services for a given ticket price. For a given level of demand, this leads to a decrease in the equilibrium price and an increase in the equilibrium level of traffic.

If the benefits of consolidation accrue to the passengers, for example if the single airport is on average more convenient to use or access than the two smaller airports, then the demand for trips at a given ticket price will increase. This is reflected in Figure 1 by an outward shift in the demand curve from D_2 to D_1. For a given level of supply, this shift results in a higher equilibrium ticket price and again an increase in the equilibrium level of traffic.

It is therefore obvious from Figure 1 that an increase in efficiency from airport consolidation, whether borne by the providers or customers of air travel, will result in a higher level of traffic.

That is, if either demand or supply shifts out to reflect lower costs, then the new equilibrium level of traffic q_1^* will be higher than in the baseline case with two airports. If, on the other hand, it was less costly to have operations split between two airports, then the overall level of traffic would be higher if there were two airports. The direction of the shift and what it implies about the relative costs is essentially what is being tested in this paper: by measuring the causal effect of the number of airports on the level of traffic, I test whether it is more efficient to operate a smaller or a larger number of airports. The effect on ticket prices is ambiguous and will depend on how much the efficiency gains accrue to the providers or the customers.

The relationship between the number of airports and the costs of operation will depend on a trade-off between the scale economies and congestion costs at each facility. Figure 2 shows a stylised representation of the overall costs of operating either one or two airports in a city. The horizontal axis represents the total level of air traffic in the city and the vertical axis represents the average, per-flight costs of operation. Average cost curves for scenarios with one or two airports are shown in the plot.

The scale economies are captured by a substantial fixed cost of operating the airport: an amount that is paid whatever the level of traffic. This generates an average cost curve that is decreasing for low levels of traffic at each airport. The costs of congestion are trivial for low levels of traffic but increase rapidly as an airport becomes more congested, hence the increasing average cost for higher levels of traffic. The total capacity of each airport is $\bar{q}$, which defines the absolute limit for the amount of traffic at a single airport. Connections between flights are facilitated to some degree by having traffic concentrated at a smaller number of airports. This feature is represented in Figure 2 by a somewhat lower cost of operating a single airport of a given size than of operating two airports that are each of that size.

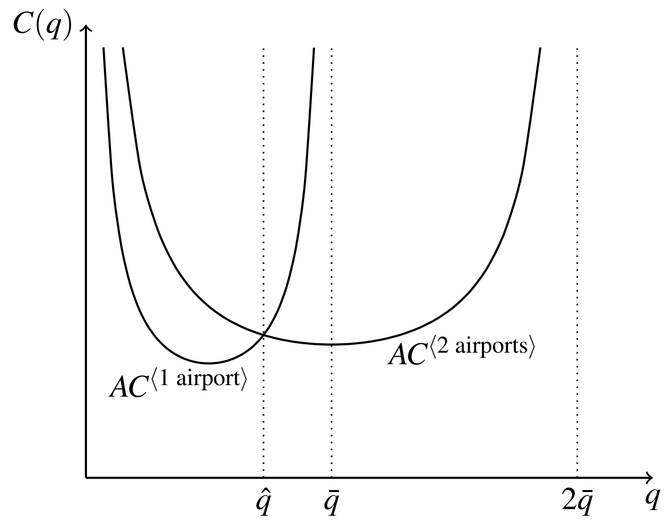

Figure 2: Average operating costs per flight as a function of the overall number of flights that depart from a city. The solid lines in the plot represent scenarios in which the city is served by one or two airports. The average cost is decreasing for low levels of traffic due to economies of scale, but increasing for high levels of traffic due to congestion costs. For levels of traffic below $\hat{q}$ it is less costly to operate one airport and for levels of traffic above $\hat{q}$ it is less costly to operate two airports.

Given the combination of factors represented in Figure 2, the costs of operation may be lower for either one or two airports depending on the level of traffic. For levels of traffic up to the threshold $\hat{q}$ the costs of operation are lower for a single airport, whereas for levels of traffic above $\hat{q}$ the costs of operation are lower if there are two airports.

As explained above, a lower cost of operating each flight will lead to more traffic.[3] Figure 2 shows that the cost of operating flights may be increasing or decreasing in the number of airports, depending on the level of traffic q. A larger number of airports may therefore result in either more or less air services being provided. Whether air services would be increased or decreased in response to additional airports being opened is essentially a question of how the current and anticipated levels of traffic compare to $\hat{q}$.

The theory sketched out here does not generate a prediction about whether the current allocation of airports and level of traffic is such that scale economies or congestion costs predominate. Rather, to answer this question I turn to the data.

[3]The number of airports in operation will naturally be affected by the demand for traffic. For example, an additional airport may be opened if those already serving a city are excessively congested. However, due to the costs of construction and the difficulty of acquiring land – the same factors that allow the instrument to explain the current distribution of airports – the number of airports does not always adjust to achieve the lowest possible operating costs.

3 Data

The empirical analysis in this paper uses data from the United States of America, aggregated by Core Based Statistical Area (CBSA).[4] The sample includes the airports that had at least 10,000 departing passengers in 2010, the Federal Aviation Administration definition of a *Primary Airport*. The sample is limited to the contiguous United States and to the CBSAs with at least one Primary Airport. This leaves 287 CBSAs in the sample. The main variables in the dataset are summarised in Table 1.

	Mean	Std. dev.	Minimum	Maximum
Land area (square miles)	7,966	6,606	366	45,759
1940 population	293,383	865,617	3,663	11,950,188
2010 population	812,414	1,768,433	21,100	18,897,109
Number of existing category-5 airports in 1944 NAP	0.6	1.1	0	9
Number of proposed category-5 airports in 1944 NAP	0.7	1.3	0	10
Number of commercial airports in 2010	1.1	0.5	1	5
Number of departing flights in 2010	29,867	75,876	235	576,213
Number of departing passengers in 2010	2,431,174	6,979,748	10,197	53,578,997
Number of originating passengers in 2010	143,608	356,116	0	2,804,362
Number of transit passengers in 2010	54,442	228,026	0	2,246,306
Number of daily destinations in 2010	14.8	30.2	0	167
Number of daily destinations for main carrier in 2010	6.7	14.4	0	93

Note: 287 observations of each variable, aggregated by CBSA; the originating and transit passengers are from a 10% sample of all tickets and therefore do not sum to the total number of departing passengers

Table 1: Summary statistics for the main variables in the dataset, which are aggregated by CBSA.

The estimation relates the number of airports in a CBSA to various measures of air traffic in 2010, which are summarised in Table 1. The numbers of departing flights, departing passengers, and destination airports flown to at least daily are from the T-100 segment data published by the Bureau of Transportation Statistics. The numbers of passengers who begin their trips or transfer at an airport are from the DB1B coupon data.[5] The data on the fares are from the DB1B market data and the information about flight delays is from the BTS On-Time Performance data.[6]

The estimation also uses various sets of CBSA-level control variables. These include population

[4]The CBSAs are collections of counties that are defined as metropolitan areas by the Office of Management and Budget.

[5]As the DB1B data are a 10% sample of tickets while the T-100 data include all tickets, the numbers of originating and transit passengers from the DB1B data sum to roughly one tenth of the total numbers of passengers from the T-100 data.

[6]Some of the delays recorded in the data are negative, indicating that the aircraft departed or arrived before the scheduled time. The delays for these flights are rounded up to zero before the CBSA-level data are aggregated.

sizes and other demographic variables from the decennial United States Census, employment figures from the County Business Patterns, climate data from the National Oceanic and Atmospheric Administration, and land-area and elevation data from the United States Geological Survey. The land area and the 1940 and 2010 populations of the CBSAs are summarised in Table 1.

The instruments used in the estimation are from the 1944 National Airport Plan of the Civil Aeronautics Administration (1944) (henceforth the "Plan"). The Plan reflected the existing airports in 1944 and largely determined which airports were constructed or expanded in subsequent decades, as inclusion in the Plan was a prerequisite for federal funding. The Plan specified the category for each existing and proposed airport. The instrument is the count of the category-5 airports, which were the largest facilities in terms of land area and physical infrastructure and were intended to be able to handle the largest contemporary aircraft.[7]

4 Empirical analysis

The relationship I estimate is the following:

$$a_m = \alpha_2 + \beta_2 n_m + \gamma_2 X_m + \varepsilon_{2,m} \tag{1}$$

The variable a_m is a measure of air traffic in metropolitan area m in 2010, α_2 is a constant term, n_m is the number of airports in m in 2010, X_m is a set of physical geography, climate, and demographic variables that are intended to capture demand and supply factors other than the number of airports, and $\varepsilon_{2,m}$ is an error term. The coefficient of interest in (1) is β_2. The obvious problem with estimating β_2 is that the number of airports may be partly determined by the level of traffic, or it may be correlated with some unobserved factor that influences the level of traffic. To address these problems I use two-stage least squares (TSLS) and instrument for n_m using the number of category-5 airports in the Plan.

The main estimation equation (1) is the second-stage equation in the system. The first-stage equation, in which the instrument $n_m^{\langle 1944 \rangle}$ is used to generate a notional set of values of the number

[7] More details of the 1944 National Airport Plan and the framework for federal airport funding are explained in Sheard (2014).

of airports, is the following:

$$n_m = \alpha_1 + \beta_1 n_m^{\langle 1944 \rangle} + \gamma_1 X_m + \varepsilon_{1,m} \tag{2}$$

For the instrument to be valid, two conditions must hold. The first of these is the relevance condition, which requires that the instrument explain a substantial amount of variation in the current number of airports, conditional on the controls. Formally, this condition requires that $\beta_1 \neq 0$. The category-5 airports were the largest facilities specified in the Plan and the most likely to become major commercial airports. They had long runways with high weight-bearing capacities, which were more likely to be suitable for airlines in later years. Moreover, the large areas of land suitable for airports became much scarcer in the decades following World War II, so the more sites set aside in the Plan, the more commercial airports a metropolitan area is likely to have today.[8] Furthermore, Redding, Sturm and Wolf (2011) showed that airport operations can be highly persistent, even in spite of changes in underlying factors. The relevance condition is empirically testable and is shown below to be satisfied.

The second condition that must hold for the instrument to be valid is the orthogonality condition, also known as the exogeneity condition or exclusion restriction. It requires that the instrument only be related to the level of traffic through the number of airports, conditional on the controls, so that $Cov\left(n_m^{\langle 1944 \rangle}, \varepsilon_{2,m}\right) = 0$. This is feasible because of the criteria used for the Plan. The Plan included all existing airports in 1944, which had either been built by local governments before the air network was planned at the federal level or were military airfields. Neither motivation is related to the current demand for or operation of air traffic. Most of the category-5 airports in the Plan were relatively large existing facilities in 1944.

The criteria stated in the Plan for selecting the locations and sizes of airports included the local population, the airport's importance in the air network of the time, and the residences of returning airmen from World War II who could make use of their training by working as commercial pilots.

[8] As an example, the Boston and Seattle metropolitan areas are similar in terms of population, land area, and coastal location. Logan International Airport was the only category-5 airport in Boston in the Plan and it remains the only Primary Airport in Boston, whereas Seattle had five category-5 airports in the Plan and has three Primary Airports today.

The 1944 population is related to the current population, so I control for population in both 1940 and 2010, as well as population growth in the decades preceding 1940 – a reasonable proxy for anticipated population growth after 1944. The other criteria have little relationship to the current operation of air travel.[9] The planning for the air network in 1944 was tailored to the aircraft then in use and included provisions for refuelling stops, even on relatively short routes. It is therefore plausible that the orthogonality condition holds.

The robustness checks presented below address a number of potential concerns about the validity of the instrument. The primary concern is that the number of airports in the Plan may be correlated with current air traffic through channels other than the current number of airports because certain metropolitan areas are simply more advantageous for air traffic, for example the local climate. The controls are intended to capture such factors. However, the robustness checks go further by controlling for the overall number or value of proposed airports in the Plan, which should reflect the overall amount of air traffic that is anticipated for each metropolitan area. Other potential concerns include the importance of regional-level factors such as market access and climate, which are addressed by using state fixed effects.

5 Results

The results from the estimation of the system of equations (1) and (2) using the log number of departing flights as the measure of air traffic are presented in Table 2. Panel A presents the ordinary least squares (OLS) results, which use only the main estimation equation (1), and Panel B presents the TSLS results. I run Kleibergen-Paap *rk* Wald tests for weak instruments and display the resulting F-statistics at the bottom of Panel B. I also run Hausman tests on the difference between the OLS and TSLS coefficients and display the p-values from these tests at the bottom of Panel B.[10]

The columns in Table 2 use different sets of CBSA-level controls. Column 2 adds a control for the population of each CBSA in 2010, the main factor for the demand for air travel.[11] Column

[9] In any case, the results are similar if only the *existing* category-5 airports in 1944 are used as the instrument.

[10] As there is only one instrument it is not possible to run the standard statistical tests for overidentification.

[11] In the robustness checks, an alternative specification is run that treats the 2010 population as an endogenous variable and instruments for it using the 1940 population.

3 adds log land area, log mean county size, a binary variable for coastal location, the mean and standard deviation of land elevation, average wind speed, and heating and cooling degree days. Column 4 adds fixed effects for the nine Census Divisions.[12] Column 5 adds the populations in 1910, 1920, 1930, and 1940. Column 6 adds controls for education and income levels contemporary to the Plan. Column 7 adds controls for the age, education, and income levels in 2010. Column 8 adds controls for the local employment shares of the manufacturing and service industries in 2010. Due to the large number of control variables Table 2 displays only the coefficients for the number of airports and the CBSA population in 2010. The full results are displayed in Appendix B.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A. OLS estimation. Dependent variable: Log number of departing flights in 2010.								
num_airports $_{2010}$	1.68^a	0.37^a	0.22^c	0.23^c	0.24^c	0.26^b	0.27^b	0.29^b
	(0.19)	(0.12)	(0.13)	(0.13)	(0.12)	(0.12)	(0.13)	(0.13)
$\ln(pop_{2010})$		0.98^a	1.05^a	1.08^a	1.36^a	1.37^a	1.05^a	0.90^a
		(0.04)	(0.07)	(0.07)	(0.12)	(0.12)	(0.15)	(0.15)
R^2	0.22	0.73	0.77	0.77	0.79	0.80	0.81	0.82
Panel B. TSLS estimation. Dependent variable: Log number of departing flights in 2010.								
num_airports $_{2010}$	2.71^a	0.61^b	0.63^b	0.67^b	0.76^a	0.75^a	0.75^a	0.71^a
	(0.46)	(0.29)	(0.29)	(0.29)	(0.27)	(0.26)	(0.25)	(0.24)
$\ln(pop_{2010})$		0.94^a	0.99^a	1.01^a	1.31^a	1.34^a	1.00^a	0.85^a
		(0.06)	(0.08)	(0.09)	(0.12)	(0.12)	(0.15)	(0.15)
First-stage F-statistic	39.27	37.71	35.78	33.77	34.59	35.68	34.38	34.47
Hausman test p-value	0.00	0.25	0.06	0.04	0.01	0.02	0.02	0.02
Physical geography, climate			Y	Y	Y	Y	Y	Y
Census divisions				Y	Y	Y	Y	Y
$\{\ln(pop_t)\}_{t\in\{1910,\ldots,1940\}}$					Y	Y	Y	Y
1940 education; 1950 income						Y	Y	Y
2010 age, education, income							Y	Y
2010 man. and serv. shares								Y

Note: 287 observations for each regression; robust standard errors in parentheses; a, b, c denote significance at 1%, 5%, 10%

Table 2: Relationship between the number of airports and the number of flights in 2010.

The OLS results in Table 2 show a positive correlation between the number of airports in a CBSA and the level of traffic. The OLS coefficient is positive throughout and, with the inclusion of the controls, significant at the 5% level. The TSLS coefficients are positive and significant for all sets of controls, indicating a positive causal effect of the number of airports on the level of traffic.

[12]The results are similar when state fixed effects are used. These controls and the climate variables assuage an obvious concern about the estimation: that airports may have been built before 1944 or included in the Plan because they were in locations with better weather for aviation or market access, factors that would also contribute to a_m.

The F-statistics from the Kleibergen-Paap *rk* Wald tests indicate that the instrument clearly satisfies the relevance condition.[13] The p-values from the Hausman tests indicate that the hypothesis that the OLS and TSLS coefficients on n_m are the same is rejected in most specifications. This suggests that, as far as the instruments are thought to be credible, there is a bias in the OLS estimation that necessitates the use of the instruments.

The TSLS coefficient of 0.71 implies that being randomly allocated one additional airport leads to roughly twice the level of air traffic.[14] This is a sizeable effect, which could be explained by a high level of congestion at large airports. The result appears to contrast with those of Martín and Voltes-Dorta (2008) and Martín and Voltes-Dorta (2011), who find that larger airports produce air services at lower per-unit costs and infer that airport consolidation would lower overall operating costs. All else being equal, lower operating costs would make more flights profitable for airlines to offer, leading to higher traffic. However, there are at least three reasons why these results may in fact be consistent. The first is that the demand for air travel may depend on the number and locations of airports. Thus a single airport may have lower operating costs, but if local residents and workers must travel further to access it then there may be fewer trips made by air. The second is that the costs of constructing an airport are not necessarily reflected in the current demand for and supply of air traffic, as these would be sunk costs, even though the costs of maintenance would be captured. The third is that competition between the airports in metropolitan areas with multiple airports may lead to higher traffic in spite of the higher costs.

The TSLS coefficients on the number of airports are larger than the OLS coefficients, as is common in studies that use instruments for transportation infrastructure (Duranton and Turner, 2012; Sheard, 2014; Blonigen and Cristea, 2015). One possible explanation, as noted by Duranton and Turner (2012), is reverse causality. Here this explanation would apply if the level of air traffic negatively affects the actual number of airports. This could occur if either CBSAs that experi-

[13]As a rule of thumb, an F-statistic of more than 10 is sufficient to indicate that the instrument is relevant. The F-statistics displayed in Table 2 clearly exceed this threshold. The first-stage results are displayed in full in Appendix A.

[14]In the main estimation equation (1), having one additional airport would be represented by $\triangle n_m = 1$. If $\beta_2 = 0.71$, then $\triangle n_m = 1$ means that the value of the right-hand side increases by $\beta_2 \triangle n_m = 0.71$. The value of a_m, the variable on the left-hand side, thus increases by 0.71. As a_m is the natural log of the level of traffic, the proportional change in the level of traffic is $e^{0.71} \approx 2.03$.

ence increases in air traffic tend to respond by consolidating their air traffic, or if places that have experienced declines in air traffic have airports built as a type of stimulus.

The coefficients on the log 2010 population in Table 2 indicate that, adjusting for the number of airports, air traffic in a metropolitan area tends to increase in proportion to the population.

Table 3 estimates the relationships between the number of airports and alternative measures of air traffic including the number of passengers, the numbers of destinations, and the concentration of air traffic by airline. This is done by estimating (1) and (2), but with each of these alternative measures as the dependent variable a_m. Each regression uses the full set of controls as in Column 8 of Table 2. The numbers of passengers and destinations are all in logs. The OLS and TSLS results are in separate panels.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Number of passengers			Number of destinations		HHI (airline) at CBSA level		HHI (airline) at mean apt in CBSA	
	All	Origin	Transit	All	Main airl.	Flights	Pass.	Flights	Pass.
Panel A. OLS estimation.									
num_airports $_{2010}$	0.13	−0.08	0.08	0.14	0.29^b	0.08^b	0.06^b	0.15^a	0.12^a
	(0.14)	(0.15)	(0.23)	(0.12)	(0.13)	(0.03)	(0.03)	(0.03)	(0.03)
ln(*pop* $_{2010}$)	1.33^a	1.28^a	1.20^a	0.89^a	0.62^a	-0.20^a	-0.18^a	-0.19^a	-0.17^a
	(0.18)	(0.20)	(0.28)	(0.13)	(0.12)	(0.04)	(0.04)	(0.04)	(0.04)
R^2	0.85	0.83	0.83	0.83	0.76	0.60	0.52	0.58	0.50
Panel B. TSLS estimation.									
num_airports $_{2010}$	0.61^b	0.38	0.76^b	0.33^c	0.51^b	0.08	0.08	0.14^b	0.14^b
	(0.27)	(0.28)	(0.36)	(0.18)	(0.21)	(0.06)	(0.06)	(0.07)	(0.07)
ln(*pop* $_{2010}$)	1.27^a	1.23^a	1.11^a	0.86^a	0.59^a	-0.20^a	-0.18^a	-0.19^a	-0.17^a
	(0.17)	(0.19)	(0.26)	(0.12)	(0.12)	(0.03)	(0.04)	(0.03)	(0.04)
First-stage F-statistic	34.47	33.94	33.58	33.78	33.78	34.47	34.47	34.47	34.47
Hausman test p-value	0.03	0.03	0.02	0.21	0.19	0.95	0.74	0.89	0.80
Number of observations	287	282	279	281	281	287	287	287	287

Note: robust standard errors in parentheses; a, b, c denote significance at 1%, 5%, 10%; each regression uses the full set of geographic, climate, and demographic controls; the dependent variables in the first five columns are in logs

Table 3: Relationships between the number of airports and the number of passengers, the number of destinations, and the concentration of traffic by airline.

The TSLS coefficients in Table 3 are instructive about how the number of airports affects CBSA-level air traffic. The effect on the number of passengers in Column 1 is positive and similar in magnitude to the effect on the number of flights. However, there is no significant effect on the number of passengers who originate their trips in the CBSA (in Column 2), but a significant and relatively large effect on the number of passengers who pass through in transit (in Column 3).

Though the difference between these coefficients is not itself significant, their relative magnitudes and levels of significance suggest that the greater amount of air traffic in CBSAs with more airports is due largely to a greater number of transit passengers. This is not surprising as on average the demand for transit stops should be more elastic than the demand for trip originations, because using an alternative airport to start a trip would normally be more of an inconvenience than stopping at a different airport en route. Therefore, if having an additional airport reduces the cost of operating flights in a CBSA, then the resulting increase in air traffic would be due disproportionately to transit passengers.

The numbers of transit passengers are related to the 'hub' status of the airports. Airlines naturally offer more tickets with transfers through their own designated hubs than through airports they do not use as hubs. This means that airports at which greater numbers of passengers transfer are relatively likely to be hub airports. The positive and significant coefficient on the number of airports in Column 3 of Table 3 therefore suggests that CBSAs that are randomly allocated a larger number of airports are more likely to be used as hubs, with more connecting flights routed through them. The transit passengers who do not actually leave the airport may provide little direct benefit to the metropolitan area, but local residents and businesses can benefit from the greater availability of flights.

The results for the number of destinations support the idea that the number of airports positively affects the likelihood of a metropolitan area being used as a hub. Column 4 estimates the effect on the log number of daily destinations for any carrier and Column 5 estimates the effect on the log number of daily destinations for only the carrier that operates the most flights from the CBSA. The effects of airport size on both measures of the number of destinations are positive. However, the effect on the main carrier is somewhat larger, again suggesting that a CBSA with more airports is more likely to host hub operations.

The positive effect of the number of airports on the number of destinations could also be driven by the competition between airports and the airlines that operate at the airports. That is, if there is more than one airport in a metropolitan area, then each may attempt to gain market share and indeed market power by offering flights to exclusive destinations. The opposite may also be true, as airlines based at different airports could compete over flights to the same destination whereas a single, larger airport used as a hub by a major airline could offer flights to many additional destinations.[15] Though it would be difficult to isolate the effect of competition from the costs of operation in the data, the overall effect of the number of airports on the number of destinations is positive.

Columns 6 to 9 of Table 3 measure the effects on two types of Herfindahl–Hirschman Index (HHI) of air traffic by airline in each CBSA in 2010. The HHI is a measure of the concentration of an activity, defined as $H = \sum_i s_i^2$ where s_i is the proportion of the activity in category i. The HHI indices in Columns 6 and 7 represent the degree of concentration of traffic by airline in each CBSA, with traffic measured as the numbers of flights and passengers. The HHI indices in Columns 8 and 9 are calculated on the traffic by airline at each airport, then taking the mean for each CBSA weighting the airports by their shares of CBSA-level traffic.

The TSLS results in Columns 6 and 7 show no significant effect of the number of airports on the HHI indices of airline concentration, though the OLS results indicate a positive correlation. Given the evidence presented above that a CBSA having more airports makes it more likely to have hub activities, the lack of an effect on CBSA-level airline concentration demands explanation. It could simply be that the coefficients on the number of airports are not significant because of measurement error or the particular functional form of the HHI. Or the lack of an effect suggests that the airlines concentrate their activities at different airports within the same CBSA.

The idea that having a larger number of airports in a CBSA leads airlines to concentrate at different airports is supported by the TSLS results in Columns 8 and 9, which exhibit a positive effect on concentration at the 'average' airport in a CBSA. In combination, the findings in Columns 6 through 9 suggest that having a greater number of airports causes airlines to concentrate their traffic at different airports in a CBSA but not necessarily to become more concentrated in the CBSAs with more airports. The controls for the log population in 2010 indicate that the degree of concentration is generally decreasing in the size of the metropolitan area.

Table 4 tests the effects of the number of airports in a CBSA on a number of other outcome

[15] An example would be Hartsfield–Jackson Atlanta International Airport in Atlanta, Georgia, which is the largest hub for Delta Air Lines and the only airport in the Atlanta-Sandy Springs-Marietta, GA CBSA in the data. The Atlanta-Sandy Springs-Marietta CBSA had 164 daily destinations in 2010, the second most of any CBSA in the US.

variables, namely the mean distances flown, mean fares, and mean flight delays.

	(1)	(2)	(3)	(4)	(5)	(6)
	Mean distance		Mean fare		Mean flight delay	
	Per flight	Per pass.	Per ticket	Per mile	Carrier	NAS
Panel A. OLS estimation.						
num_airports $_{2010}$	-0.13^c	-0.08	0.06^b	0.01	0.01	-0.03
	(0.07)	(0.08)	(0.03)	(0.03)	(0.06)	(0.04)
ln(*pop* $_{2010}$)	0.36^a	0.39^a	-0.22^a	-0.13^a	0.16^c	0.00
	(0.07)	(0.07)	(0.04)	(0.03)	(0.09)	(0.06)
R^2	0.51	0.52	0.38	0.43	0.33	0.47
Panel B. TSLS estimation.						
num_airports $_{2010}$	-0.06	-0.07	0.09	-0.03	-0.07	-0.14
	(0.12)	(0.11)	(0.06)	(0.05)	(0.12)	(0.11)
ln(*pop* $_{2010}$)	0.35^a	0.39^a	-0.22^a	-0.13^a	0.17^b	0.02
	(0.06)	(0.06)	(0.04)	(0.03)	(0.08)	(0.06)
First-stage F-statistic	34.47	34.47	34.27	34.27	29.37	29.19
Hausman test p-value	0.48	0.96	0.56	0.38	0.42	0.25
Number of observations	287	287	284	284	235	236

Note: robust standard errors in parentheses; a, b, c denote significance at 1%, 5%, 10%; each regression uses the full set of geographic, climate, and demographic controls; the dependent variable in each regression is in logs

Table 4: Relationships between the number of airports and mean flight distances, fares, and flight delays in 2010.

Columns 1 and 2 of Table 4 present estimates of the relationships between the number of airports and the logs of the mean distances of the flights that operate from airports in the CBSA. Column 1 uses the mean distance of flights from the CBSA and Column 2 uses the mean distance weighted by the number of passengers. The OLS results suggest perhaps a slight negative relationship between the number of airports and the distances flown. The TSLS results do not exhibit any effect of the number of airports on the mean distance. Although the number of airports has positive effects on the numbers of flights and destinations, the additional flights appear not to be to destinations that are systematically nearer or further away.

The results in Columns 3 and 4 indicate that there is no measurable effect of the number of airports on ticket prices. This suggests that having been allocated a larger number of airports does not significantly affect the prices of trips, even though there is an advantage in terms of the frequency of flights. This result fits with the predictions of the theory outlined in Figure 1, which showed that the effect on ticket prices is ambiguous even if there is an effect on the level of traffic.[16]

[16] It is also consistent with the findings of Borenstein (1989), who showed that the higher an airline's share of traffic

However, the effects on ticket prices are more difficult to assess than those on traffic, as the number and composition of flights are also affected by the number of airports. The situation is further complicated by the variation in load factors and the fact that ticket prices can vary widely even within a single airline's operations on a single route.[17] This makes it difficult to measure ticket prices in a way that compares actual prices with a reasonable counterfactual, so there may in fact be an effect on ticket prices that is not revealed by the data due to measurement error. Nevertheless, the measures of ticket prices used in the analysis were chosen to capture contrasting basic features of the prices, presumably making it more likely for an effect to be measured. The fare per ticket is a raw measure of the price of flying from a given airport to the destinations that passengers actually fly to, while the fare per mile adjusts for the mean distances of the flights.

The final set of estimates presented in Table 4 are of the relationship between the number of airports in a CBSA and two measures of the mean flight delays at those airports. Column 5 uses delays that are within the carrier's control, such as fuelling, maintenance, and loading or unloading the aircraft. Column 6 uses the National Aviation System (NAS) delays, which are beyond the control of the airlines but exclude weather and security delays. Examples of NAS delays are problems related to traffic volume and air traffic control. The signs on the TSLS coefficients on the number of airports for both types of delays are negative but neither is significantly different from zero. This analysis therefore does not show any evidence of an effect of the number of airports on the lengths of the delays.[18]

There is a literature that connects concentration of air traffic by airline to the operation of airports. Brueckner (2002) showed that airlines internalise the congestion costs that they impose on their own operations, so that, in the absence of a system of congestion tolls that adjust for the degree of concentration, a higher degree of concentration would lead to fewer or shorter delays. Empirical studies by Ater (2012) and Greenfield (2014) have confirmed the negative relationship between airline concentration and flight delays. Given that the results in Table 3 exhibit a positive

at an airport or on a route, the higher the prices it is able to charge. As the results in Table 3 showed that there is no effect on the degree of airline concentration by CBSA, there would not be the resulting effect on the fares.

[17]Borenstein and Rose (1994) showed that the variation in ticket prices for a given airline on a given route is on average around one third of the absolute ticket prices.

[18]When the estimation is run using only the delays on departing flights or only those on arriving flights, the coefficients are similar in magnitude and significance to those in Table 4.

effect of the number of airports on the concentration of air traffic at those airports, this literature would suggest that the effect on delays should be negative. Though the TSLS coefficients on the number of airports in Columns 5 and 6 of Table 4 are not significant, there may in fact be some effect that is not evident because of say measurement error or a small sample size.

Similarly, it fits with intuition that flight delays would have a negative causal effect on ticket prices. This relationship is confirmed by Forbes (2008) using a policy change at LaGuardia Airport as a quasi-experiment. It is plausible that flight delays and fares could form part of the mechanism by which the number of airports affects air traffic. However, the relationship between these variables is of less interest here as neither is found in Table 4 to be affected by the number of airports.

5.1 Relative sizes of the local airports

As the airports that serve a metropolitan area may vary greatly in how much traffic they handle, it is relevant to ask what role the sizes of the airports play in determining the level of air traffic. For example, a metropolitan area with a major airport and a small airport that handles little traffic may not be substantially different from a metropolitan area with only a major airport. The importance of the sizes of the airports is investigated in Table 5.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	No airports <10% of local		No CBSAs with apt <10% of local		HHI (airport) controls		HHI (airport) as endog. regressor	
	flights	pass.	flights	pass.				
Panel A. OLS estimation. Dependent variable: Log number of departing flights in 2010.								
num_airports $_{2010}$	0.22	0.35^c	0.40^b	0.52^a	0.45^b	0.30^c		
	(0.16)	(0.18)	(0.18)	(0.19)	(0.19)	(0.16)		
herf_flights $_{2010}$					0.87		−0.74	
					(0.72)		(0.48)	
herf_pass $_{2010}$						0.10		-0.92^c
						(0.67)		(0.51)
ln(*pop* $_{2010}$)	0.93^a	0.92^a	0.83^a	0.82^a	0.88^a	0.90^a	0.92^a	0.92^a
	(0.15)	(0.16)	(0.16)	(0.16)	(0.15)	(0.15)	(0.16)	(0.16)
R^2	0.82	0.82	0.80	0.80	0.82	0.82	0.82	0.82
Panel B. TSLS estimation. Dependent variable: Log number of departing flights in 2010.								
num_airports $_{2010}$	1.38^a	1.65^a	1.29^a	1.86^a	1.79^b	1.22^b		
	(0.53)	(0.63)	(0.49)	(0.72)	(0.77)	(0.54)		
herf_flights $_{2010}$					5.70^c		-3.71^a	
					(2.95)		(1.27)	
herf_pass $_{2010}$						3.16		-4.36^a
						(2.09)		(1.51)
ln(*pop* $_{2010}$)	0.92^a	0.90^a	0.79^a	0.75^a	0.76^a	0.81^a	0.90^a	0.90^a
	(0.16)	(0.16)	(0.16)	(0.17)	(0.17)	(0.16)	(0.15)	(0.16)
First-stage F -statistic	17.81	13.82	17.07	12.43	8.86	12.84	33.08	21.44
Hausman test p -value	0.00	0.01	0.02	0.01	0.02	0.02	0.00	0.00
Number of observations	287	287	275	272	287	287	287	287

Note: robust standard errors in parentheses; a , b , c denote significance at 1%, 5%, 10%; each regression uses the full set of geographic, climate, and demographic controls

Table 5: Relationships between the number of airports or Herfindahl–Hirschman Index of local airport sizes and the number of flights in 2010.

Columns 1 to 4 of Table 5 recreate the estimation of (1) and (2) from the main results in Table 2 using samples that exclude minor airports. Columns 1 and 2 exclude any airports that hosted less than 10% of the total air traffic in their respective CBSAs in 2010 from the calculation of the number of airports and the level of traffic. The threshold proportion of traffic is calculated on the number of flights in Column 1 and as the number of passengers in Column 2. With each measure, roughly half of the CBSAs with multiple airports have at least one airport that is below the respective threshold. Columns 3 and 4 use samples that exclude the CBSAs with any airports under the 10% thresholds for CBSA-level air traffic in 2010.

The sample selections applied in Columns 1 to 4 reduce the amount of variation in the numbers of airports by CBSA, which is reflected in lower F-statistics on the first stage. However, the TSLS coefficients on the number of airports are actually larger in these regressions than in the main results. Though there are concerns about sample selection, this suggests that if the airports in a CBSA with multiple airports are all major facilities, then the effect of the number of airports on the number of flights may actually be larger than that estimated in the main results.

Columns 5 and 6 of Table 5 include controls for the HHI of air traffic by airport in each CBSA in 2010, measured as the numbers of flights and passengers. The HHI in this context is a measure of how concentrated the traffic is in a subset of the airports. It takes values between zero and one and the value is increasing in the degree of concentration. The HHI is equal to one by definition if there is only one airport in a CBSA, so including it as a control naturally captures some of the variation in the number of airports by CBSA and leads to a weaker first stage. Nevertheless, the coefficients on the number of airports are if anything higher than in the main results.

Columns 7 and 8 of Table 5 use the two measures of the HHI for airport concentration in place of the endogenous regressor n_m in the estimation equations (1) and (2). In these cases, the instrument – the number of planned airports in 1944 – is used to explain the variation in the HHI in the first stage. The first-stage statistics at the bottom of the table indicate that the instrument explains a significant amount of the variation in the HHI. The TSLS coefficients for the second stage indicate that the HHI has a negative effect on the level of traffic, when controlling for all of the factors for air-travel demand including the log population in 2010. As the HHI index is increasing in the level of concentration, these results are consistent with the positive effect of the number of airports on the level of traffic.

5.2 Controlling for the composition of flights and ticket prices

The results presented in Table 4 show no measurable effect of the number of airports on the mean distances of flights or the prices paid for tickets. However, it would be possible for the composition of flights or ticket prices to partly determine the level of air traffic through channels other than the number of airports. If this were true and the flight distances and fares were not controlled for, then the estimated coefficients on the number of airports could be biased.

Table 6 presents estimates of the effect of the number of airports on the number of departing flights with controls for the mean distances flown per flight and per passenger and the mean fares per ticket and per mile flown. The OLS estimates are presented in Columns 1 to 4 and the TSLS estimates are presented in Columns 5 to 8.

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) TSLS	(6) TSLS	(7) TSLS	(8) TSLS
num_airports $_{2010}$	0.32^b	0.30^b	0.22^c	0.27^b	0.72^a	0.72^a	0.56^a	0.63^a
	(0.13)	(0.13)	(0.12)	(0.12)	(0.24)	(0.24)	(0.21)	(0.22)
ln(*pop* $_{2010}$)	0.82^a	0.81^a	1.06^a	0.93^a	0.75^a	0.75^a	1.01^a	0.88^a
	(0.15)	(0.15)	(0.13)	(0.14)	(0.15)	(0.15)	(0.12)	(0.14)
ln(*dist_per_flight* $_{2010}$)	0.22				0.26^c			
	(0.16)				(0.14)			
ln(*dist_per_pass* $_{2010}$)		0.21				0.24^b		
		(0.14)				(0.12)		
ln(*fare_per_ticket* $_{2010}$)			0.75^b				0.69^b	
			(0.31)				(0.29)	
ln(*fare_per_mile* $_{2010}$)				0.24				0.23
				(0.32)				(0.30)
R^2	0.83	0.83	0.85	0.84				
First-stage F-statistic					34.59	34.49	34.75	34.06
Hausman test p-value					0.03	0.02	0.04	0.04
Number of observations	287	287	284	284	287	287	284	284

Note: robust standard errors in parentheses; a, b, c denote significance at 1%, 5%, 10%; each regression uses the full set of geographic, climate, and demographic controls

Table 6: Relationship between the number of airports and the number of flights in 2010 with controls for mean flight distances and mean fares.

The results in Table 6 indicate that the controls for mean flight distances and fares make only small differences to the estimates for the effect of the number of airports on the number of flights. The OLS and TSLS coefficients are somewhat smaller when the controls are used, suggesting that the distances and fares capture some of the variation in air traffic. However, in each case the difference between the coefficients in Table 6 and the main results in Table 2 is within one standard error. This suggests that the variation in local air traffic captured by the composition of flights or fares, whatever its source, does not make a substantial difference to the estimated effects of the number of airports.

5.3 Robustness checks

Table 7 presents the results from a number of robustness checks for the main TSLS results. Each of the regressions in Table 7 uses the log number of departing flights as the measure of air traffic.

	(1) State FEs	(2) State capitals	(3) NAP imp val ctrls	(4) NAP num apts ctrls	(5) NAP exist cat 5	(6) NAP prop cat 4-5	(7) NAP prop all airports	(8) Instr for 2010 pop
$num\_airports_{2010}$	0.73^a	0.71^a	0.56^b	0.97^b	0.76^a	0.48^b	0.36	0.74^a
	(0.25)	(0.24)	(0.22)	(0.41)	(0.28)	(0.23)	(0.29)	(0.27)
$\ln(pop_{2010})$	0.75^a	0.85^a	0.85^a	0.83^a	0.84^a	0.87^a	0.89^a	0.12
	(0.14)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.40)
$state\_capital$		0.05						
		(0.14)						
$\ln(nap\_imp\_value_{1944})$			0.10					
			(0.07)					
$nap\_num\_airports_{1944}$				−0.02				
				(0.02)				
First-stage F-statistic	30.89	35.07	39.39	14.97	24.65	16.11	12.46	10.50
Hausman test p-value	0.03	0.02	0.11	0.04	0.04	0.25	0.71	0.02

Note: 287 observations for each regression; robust standard errors in parentheses; a, b, c denote significance at 1%, 5%, 10%; each regression uses the full set of geographic, climate, and demographic controls

Table 7: Robustness checks for the main TSLS results. The dependent variable in each regression is the log number of departing flights.

Column 1 in Table 7 uses state fixed effects in place of the Census Division fixed effects in the main results. The state fixed effects are intended to capture any region-specific factors such as market access and climate that may not have been fully captured by the Census Division fixed effects. For example, the location of a metropolitan area may influence current air traffic, due to its proximity to potential destinations or because the climate is advantageous for aviation, and the same factors would apply today. However, the results with the state fixed effects are similar to the main results: the instrument remains strong and the coefficient on the number of airports is practically the same. The remaining columns use the Census Division fixed effects as in the main results.

Column 2 includes a binary control variable for the status of a metropolitan area as a state capital. In case there is something peculiar about the airports in state capitals, for example if they receive more funding or if the functions of the state government create additional demand for air travel, it should be captured by this variable. Again the results barely change.

Columns 3 and 4 address further potential concerns about the relationship between current air traffic and the anticipated need for air travel in 1944. If more large airports were proposed for a metropolitan area in the Plan simply because more traffic is anticipated, then the orthogonality condition could be violated. This concern is addressed by controlling for the total imputed value and number of all proposed airports in the Plan.[19] If the number of category-5 airports in the Plan can simply be explained by the total anticipated level of air traffic, then these controls would capture most of the variation in the first stage. The coefficient on the number of airports is somewhat smaller when controlling for the imputed value, but somewhat larger when controlling for the number of proposed airports. The F-statistic for the first stage is reduced by the control for the total number of proposed airports, but it is actually somewhat larger when controlling for the total value of the proposed airports.

Columns 5 to 7 use alternative instruments. Column 5 uses the number of existing category-5 airports in the Plan. The coefficient on the number of airports is similar in magnitude to the main results while the first-stage relationship remains strong. Therefore, the results would be similar if only the major airports constructed by 1944 are used as the instrument.

Column 6 uses the proposed number of category-4 and -5 airports. This is a broader class than only the category-5 airports and includes many more airports that are not commercial airports today. Predictably, the F-statistic on the first stage and the coefficient on the number of airports in the second stage are somewhat smaller. Column 7 uses the number of proposed airports in any of the five categories. This leads to an even weaker first stage and a coefficient on the number of airports that is not significant. These results represent further evidence that it is the number of large airports in the Plan rather than the overall number of airports that determines how many commercial airports a metropolitan area has today.

Column 8 uses an alternative specification in which both the number of airports in 2010 and the log population in 2010 are instrumented for, by adding the log population in 1940 as an instrument. This is done to address the potential concern that a greater allocation of airports may have led to population growth, which in turn affects the current demand for air traffic. This specification produces a weaker first stage but a coefficient on the number of airports that is practically identical to the main results.

[19] The values of the proposed airports are imputed by summing the value of a typical airport of the class assigned to each existing facility in 1944 and the projected improvement costs. The method used to calculate these values is detailed in Sheard (2014).

6 Conclusion

This paper estimates the effects of the number of airports in a metropolitan area on the provision of air services, using data from the US. The results show that a metropolitan area that is randomly allocated a larger number of airports tends to have more air traffic and services to more destinations. The positive effect of the number of airports on air traffic is due in large part to metropolitan areas with multiple airports being used as hubs.

One possible interpretation of these results is that the costs of congestion at US airports exceed the scale economies of having traffic concentrated at a smaller number of facilities. This would lead to lower marginal operating costs and therefore more traffic in metropolitan areas with more airports. Another possible interpretation is that metropolitan areas with more airports have a greater capacity to meet the needs of local travellers, with for example shorter trips between people's homes or workplaces and the local airports. Both explanations involve lower costs, though one case involves lower costs for the airport operator and the other case involves lower direct costs for travellers. However, given the high fixed cost of constructing an airport, it should be noted that in the long term the cost of having an additional airport may outweigh the benefits.

The results appear to be consistent with the findings of Bazargan and Vasigh (2003), who studied US airports using financial data and found that smaller airports operate at lower cost per unit of output than larger airports. However, Martín and Voltes-Dorta (2008) and Martín and Voltes-Dorta (2011) studied airports from several countries using a similar technique and found that larger airports operate at lower unit costs, from which they inferred that it is more efficient to have a single airport than multiple airports serving a city. The results presented here suggest that having a larger number of airports may lead to lower operating costs, at least for the current set of airports serving US cities. Nevertheless, the difference between these results and the findings of Martín and Voltes-Dorta (2008) and Martín and Voltes-Dorta (2011) may be due to the lower costs of accessing local airports in cities where there are multiple airports, the sunk costs of constructing an airport, or the competition between the local airports for market share. If the difference was explained by cities with more airports having easier access for travellers or greater traffic due to competition between the airports, then it would be due to a benefit that is not captured in the airports' financial results.

The potential advantages of having air traffic split between multiple airports should be a consideration when designing airport policy. Public debates about how to deal with capacity-constrained airports, such as London's Heathrow Airport or San Diego International Airport, regularly feature proposals to 'relocate' the operations to a new facility. Indeed, this was the approach adopted in Denver, Colorado and Austin, Texas in the 1990s, where new airports were constructed and the old airports dismantled. In some scenarios this may be preferable, but the results presented here indicate that, at least in the context of the US, more air services would end up being provided if capacity was simply added elsewhere without abandoning the existing airport. This in turn means better access for local residents and firms.

The assumption that an existing airport should be closed when a new facility is opened may result from a misunderstanding about how air travel is operated. A substantial proportion of travellers change planes during their journeys and naturally it is easier to transfer between flights that arrive and depart at the same airport. The fact that travellers arriving on the same flight can connect to different flights means that the benefits of each additional route are increasing in the number of other routes at the same airport. However, as each airline mostly sells tickets with connections between flights operated by itself or its partners, flights operated by other airlines contribute little to the benefits of concentration. As congestion is a function of the overall traffic at an airport, operating costs are lower if flights that in any case would not be connected to one another are operated at different airports.

An issue not addressed by this paper is the externalities that airports impose on their neighbours such as noise and air pollution. The noise from aircraft is often an issue for airports in densely populated areas. Schlenker and Walker (2016) showed that pollution from aircraft has a significant negative effect on the health of people near an airport. Whether the effects are greater or smaller if traffic is consolidated at a single airport is not studied here, though the answer will naturally depend on how many people live or work near the airports in question.

A further issue that is beyond the scope of this paper is that the airports that serve a city may offer different types of services. A major airport may be complemented by a less accessible airport that operates low-cost flights, or an 'executive' airport may operate flights using smaller aircraft from a location close to downtown. In such a case the argument for having multiple airports could be stronger, as the airports would fulfil diverse needs. Understanding the trade-offs involved in operating airports of these types remains a potential avenue for further research.

References

Ater, I.: 2012, Internalization of Congestion at US Hub Airports, *Journal of Urban Economics* **72**(2-3), 196–209.

Bazargan, M. and Vasigh, B.: 2003, Size versus Efficiency: A Case Study of US Commercial Airports, *Journal of Air Transport Management* **9**(3), 187–193.

Bilotkach, V.: 2015, Are Airports Engines of Economic Development? A Dynamic Panel Data Approach, *Urban Studies* **52**(9), 1577–1593.

Blonigen, B. A. and Cristea, A. D.: 2015, Air Service and Urban Growth: Evidence from a Quasi-Natural Policy Experiment, *Journal of Urban Economics* **86**, 128–146.

Borenstein, S.: 1989, Hubs and High Fares: Dominance and Market Power in the U.S. Airline Industry, *RAND Journal of Economics* **20**(3), 344–365.

Borenstein, S. and Rose, N. L.: 1994, Competition and Price Dispersion in the U.S. Airline Industry, *Journal of Political Economy* **102**(4), 653–683.

Brueckner, J. K.: 2002, Airport Congestion When Carriers Have Market Power, *American Economic Review* **92**(5), 1357–1375.

Brueckner, J. K.: 2003, Airline Traffic and Urban Economic Development, *Urban Studies* **40**(8), 1455–1469.

Brueckner, J. K., Lee, D. and Singer, E.: 2014, City-Pairs vs. Airport-Pairs: A Market-Definition Methodology for the Airline Industry, *Review of Industrial Organization* **44**(1), 1–25.

Civil Aeronautics Administration: 1944, *National Airport Plan*, U.S. Government Printing Office, Washington, DC.

Duranton, G. and Turner, M.: 2012, Urban Growth and Transportation, *Review of Economic Studies* **79**(4), 1407–1440.

Forbes, S. J.: 2008, The Effect of Air Traffic Delays on Airline Prices, *International Journal of Industrial Organization* **26**(5), 1218–1232.

Goetz, A.: 2013, Suburban Sprawl or Urban Centres: Tensions and Contradictions of Smart Growth Approaches in Denver, Colorado, *Urban Studies* **50**(11), 2178–2195.

Gourlay, C. and Gadher, D.: 2008, 'Boris Island' Airport May Replace Heathrow, *The Sunday Times* (Sept. 21, 2008).

Green, R.: 2007, Airports and Economic Development, *Real Estate Economics* **35**(1), 91–112.

Greenfield, D.: 2014, Competition and Service Quality: New Evidence from the Airline Industry, *Economics of Transportation* **3**(1), 80–89.

Luhnow, D.: 2014, Mexico Plans New $9.2 Billion Airport, *Wall Street Journal* (Sept. 2, 2014).

Martín, J. C. and Voltes-Dorta, A.: 2008, International Airports: Economies of Scale and Marginal Costs, *Journal of the Transportation Research Forum* **47**(1), 5–22.

Martín, J. C. and Voltes-Dorta, A.: 2011, The Dilemma between Capacity Expansions and Multi-Airport Systems: Empirical Evidence from the Industry's Cost Function, *Transportation Research Part E: Logistics and Transportation Review* **47**(3), 382–389.

McGraw, M. J.: 2014, Perhaps the Sky's the Limit? The Historical Effects of Airports on Local Economies. Processed, UC Berkeley.

Oum, T. H., Yan, J. and Yu, C.: 2008, Ownership Forms Matter for Airport Efficiency: A Stochastic Frontier Investigation of Worldwide Airports, *Journal of Urban Economics* **64**(2), 422–435.

Pels, E., Nijkamp, P. and Rietveld, P.: 2003, Inefficiencies and Scale Economies of European Airport Operations, *Transportation Research Part E: Logistics and Transportation Review* **39**(5), 341–361.

Redding, S. J., Sturm, D. M. and Wolf, N.: 2011, History and Industry Location: Evidence from German Airports, *Review of Economics and Statistics* **93**(3), 814–831.

Schlenker, W. and Walker, W. R.: 2016, Airports, Air Pollution, and Contemporaneous Health, *Review of Economic Studies* **83**(2), 768–809.

Sheard, N.: 2014, Airports and Urban Sectoral Employment, *Journal of Urban Economics* **80**, 133–152.

Sheard, N.: 2015, Airport Improvements and Urban Growth. AMSE Working Paper 2015-09.

A First-stage results

Table 8 displays the results from the estimation of the first-stage relationship, using the same sets of controls as in Table 2. The dependent variable in each regression is the number of Primary Airports in the CBSA in 2010. The R-squared and the F-statistic on the instrument are displayed at the bottom of the table. It is clear that the number of category-5 airports in the Plan is a positive and highly significant factor for the current number of airports.

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS	(7) OLS	(8) OLS
nap_num_cat5_airports $_{1944}$	0.22^a	0.19^a	0.19^a	0.19^a	0.19^a	0.19^a	0.19^a	0.19^a
	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
$\ln(pop_{2010})$		0.06^b	0.09^a	0.07^a	0.05	0.05	0.09	0.11
		(0.02)	(0.03)	(0.02)	(0.04)	(0.04)	(0.06)	(0.07)
R^2	0.41	0.44	0.49	0.50	0.52	0.53	0.54	0.54
F-statistic on the instrument	39.27	37.71	35.78	33.77	34.59	35.68	34.38	34.47
Physical geography, climate			Y	Y	Y	Y	Y	Y
Census divisions				Y	Y	Y	Y	Y
$\{\ln(pop_t)\}_{t\in\{1910,\ldots,1940\}}$					Y	Y	Y	Y
1940 education; 1950 income						Y	Y	Y
2010 age, education, income							Y	Y
2010 man. and serv. shares								Y

Note: 287 observations for each regression; robust standard errors in parentheses; a, b, c denote significance at 1%, 5%, 10%

Table 8: Stage-1 results for the effect of the instrument on the number of Primary Airports in 2010.

B Full sets of coefficients for main OLS and TSLS results

This appendix shows the full sets of coefficients for the OLS and TSLS estimation in Table 2. Table 9 displays the OLS results and Table 10 displays the TSLS results. The 'Pacific coast', 'Atlantic coast', and 'Great Lake shoreline' variables are binary variables that indicate whether a CBSA has a section of shoreline on the specified body or bodies of water. The 'Census Division' variables are a set of fixed effects that capture factors specific to the nine Census Divisions in the US.[20]

[20] There are fixed effects for eight of the Census Divisions, as the ninth is captured by the constant in the regressions.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
num_airports $_{2010}$	1.68^{a}	0.37^{a}	0.22^{c}	0.23^{c}	0.24^{c}	0.26^{b}	0.27^{b}	0.29^{b}
	(0.19)	(0.12)	(0.13)	(0.13)	(0.12)	(0.12)	(0.13)	(0.13)
ln(*pop* $_{2010}$)		0.98^{a}	1.05^{a}	1.08^{a}	1.36^{a}	1.37^{a}	1.05^{a}	0.90^{a}
		(0.04)	(0.07)	(0.07)	(0.12)	(0.12)	(0.15)	(0.15)
ln(*land area*)			0.22^{c}	0.20	0.25	0.27^{c}	0.25	0.23
			(0.13)	(0.13)	(0.16)	(0.16)	(0.16)	(0.15)
ln(*mean county size*)			−0.07	−0.04	−0.13	−0.13	−0.06	−0.05
			(0.09)	(0.12)	(0.15)	(0.16)	(0.16)	(0.15)
Pacific coast			0.97^{a}	0.97^{a}	0.91^{a}	0.89^{a}	0.59^{c}	0.47
			(0.30)	(0.33)	(0.31)	(0.32)	(0.31)	(0.30)
Atlantic coast			0.46^{a}	0.38^{b}	0.29^{c}	0.27	0.24	0.23
			(0.15)	(0.18)	(0.18)	(0.18)	(0.18)	(0.18)
Great Lake shoreline			0.18	0.22	0.26	0.28	0.39	0.38^{c}
			(0.19)	(0.22)	(0.22)	(0.23)	(0.24)	(0.23)
Mean land elevation ('000 feet)			0.11^{b}	0.09	0.04	0.06	−0.02	−0.02
			(0.05)	(0.06)	(0.07)	(0.07)	(0.07)	(0.07)
Standard deviation of land elevation ('000 feet)			−0.08	−0.02	−0.10	−0.14	−0.01	0.07
			(0.28)	(0.31)	(0.32)	(0.31)	(0.32)	(0.31)
Wind speed (mph)			−0.03	0.00	−0.01	−0.02	−0.04	−0.03
			(0.03)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Heating degree days ('000)			0.23^{a}	0.31^{a}	0.37^{a}	0.34^{a}	0.27^{a}	0.25^{a}
			(0.07)	(0.09)	(0.08)	(0.09)	(0.09)	(0.09)
Cooling degree days ('000)			0.36^{a}	0.43^{a}	0.45^{a}	0.42^{b}	0.39^{b}	0.31^{b}
			(0.13)	(0.17)	(0.16)	(0.16)	(0.16)	(0.16)
Census division 1				−0.37	−0.33	−0.15	−0.27	−0.13
				(0.65)	(0.60)	(0.63)	(0.65)	(0.61)
Census division 2				−0.16	−0.07	0.08	0.17	0.30
				(0.34)	(0.33)	(0.34)	(0.39)	(0.38)
Census division 3				−0.34	−0.38	−0.25	−0.11	−0.03
				(0.39)	(0.36)	(0.38)	(0.37)	(0.37)
Census division 4				−0.31	−0.40	−0.24	−0.12	−0.03
				(0.36)	(0.34)	(0.38)	(0.39)	(0.39)
Census division 5				0.14	0.09	0.26	0.29	0.22
				(0.37)	(0.35)	(0.37)	(0.39)	(0.38)
Census division 6				−0.04	−0.06	0.19	0.24	0.27
				(0.38)	(0.35)	(0.37)	(0.39)	(0.38)
Census division 7				−0.14	−0.14	0.01	0.15	0.19
				(0.38)	(0.35)	(0.37)	(0.39)	(0.39)
Census division 8				−0.16	−0.16	−0.12	0.12	0.13
				(0.34)	(0.34)	(0.33)	(0.33)	(0.33)
ln(*pop* $_{1910}$)					0.65^{a}	0.66^{a}	0.38^{b}	0.29
					(0.20)	(0.21)	(0.18)	(0.18)
ln(*pop* $_{1920}$)					$−1.18^{a}$	$−1.09^{a}$	$−1.05^{a}$	$−0.93^{b}$
					(0.36)	(0.37)	(0.37)	(0.37)
ln(*pop* $_{1930}$)					0.95^{c}	1.02^{c}	1.20^{b}	1.12^{b}
					(0.53)	(0.55)	(0.56)	(0.53)
ln(*pop* $_{1940}$)					−0.74	$−0.97^{c}$	−0.72	−0.64
					(0.53)	(0.52)	(0.52)	(0.48)
Proportion of adults with 5 years of school in 1940						−0.21	−0.02	−0.22
						(0.71)	(0.72)	(0.68)
Proportion aged 7-13 enrolled in school in 1940						1.14	0.64	0.89
						(1.01)	(0.90)	(0.99)
Proportion aged 14-17 enrolled in school in 1940						−0.19	−0.05	−0.03
						(0.36)	(0.41)	(0.37)
ln(*median_income* $_{1950}$)						0.44	0.23	0.11
						(0.36)	(0.39)	(0.35)
Proportion aged 0-18 in 2010							0.57	−2.49
							(2.99)	(3.06)
Proportion aged 65+ in 2010							−1.83	−2.79
							(2.51)	(2.45)
Proportion of adults high-school educated in 2007							−1.05	−1.94
							(2.11)	(2.13)
Proportion of adults college educated in 2007							1.53	−1.10
							(1.77)	(1.92)
ln(*mean_income* $_{2007}$)							1.11^{b}	0.95^{c}
							(0.56)	(0.57)
Proportion of employment in manufacturing in 2010								−1.53
								(1.32)
Proportion of employment in services in 2010								5.44^{a}
								(1.42)
R^2	0.22	0.73	0.77	0.77	0.79	0.80	0.81	0.82

Note: 287 observations for each regression; robust standard errors in parentheses; *a* , *b* , *c* denote significance at 1%, 5%, 10%

Table 9: OLS results for the relationship between the number of airports and the number of flights in 2010.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
num_airports $_{2010}$	2.71^a	0.61^b	0.63^b	0.67^b	0.76^a	0.75^a	0.75^a	0.71^a
	(0.46)	(0.29)	(0.29)	(0.29)	(0.27)	(0.26)	(0.25)	(0.24)
ln(*pop* $_{2010}$)		0.94^a	0.99^a	1.01^a	1.31^a	1.34^a	1.00^a	0.85^a
		(0.06)	(0.08)	(0.09)	(0.12)	(0.12)	(0.15)	(0.15)
ln(*land area*)			0.21^c	0.18	0.22	0.25^c	0.23	0.21
			(0.13)	(0.13)	(0.15)	(0.15)	(0.15)	(0.14)
ln(*mean county size*)			−0.11	−0.08	−0.15	−0.16	−0.07	−0.06
			(0.10)	(0.12)	(0.15)	(0.16)	(0.15)	(0.15)
Pacific coast			0.78^a	0.74^b	0.64^b	0.64^b	0.35	0.26
			(0.28)	(0.32)	(0.29)	(0.29)	(0.30)	(0.29)
Atlantic coast			0.35^b	0.27	0.17	0.15	0.13	0.13
			(0.16)	(0.20)	(0.19)	(0.20)	(0.19)	(0.18)
Great Lake shoreline			0.15	0.16	0.20	0.21	0.33	0.33
			(0.19)	(0.23)	(0.23)	(0.23)	(0.23)	(0.22)
Mean land elevation ('000 feet)			0.11^b	0.08	0.05	0.06	−0.01	−0.01
			(0.05)	(0.06)	(0.07)	(0.07)	(0.07)	(0.06)
Standard deviation of land elevation ('000 feet)			−0.11	−0.03	−0.13	−0.17	−0.05	0.04
			(0.28)	(0.31)	(0.31)	(0.30)	(0.30)	(0.29)
Wind speed (mph)			−0.03	0.00	−0.02	−0.02	−0.04	−0.03
			(0.03)	(0.04)	(0.05)	(0.05)	(0.05)	(0.04)
Heating degree days ('000)			0.22^a	0.30^a	0.35^a	0.32^a	0.25^a	0.23^a
			(0.07)	(0.09)	(0.08)	(0.09)	(0.09)	(0.09)
Cooling degree days ('000)			0.33^a	0.39^b	0.40^b	0.37^b	0.34^b	0.26^c
			(0.13)	(0.16)	(0.16)	(0.16)	(0.15)	(0.15)
Census division 1				−0.41	−0.38	−0.18	−0.32	−0.16
				(0.63)	(0.58)	(0.60)	(0.61)	(0.56)
Census division 2				−0.22	−0.14	0.03	0.11	0.26
				(0.34)	(0.32)	(0.33)	(0.37)	(0.36)
Census division 3				−0.33	−0.35	−0.21	−0.08	0.00
				(0.38)	(0.35)	(0.37)	(0.35)	(0.35)
Census division 4				−0.34	−0.43	−0.25	−0.14	−0.05
				(0.37)	(0.34)	(0.37)	(0.38)	(0.38)
Census division 5				0.16	0.11	0.29	0.33	0.25
				(0.37)	(0.35)	(0.38)	(0.38)	(0.37)
Census division 6				−0.04	−0.05	0.23	0.29	0.31
				(0.38)	(0.36)	(0.38)	(0.39)	(0.37)
Census division 7				−0.09	−0.05	0.10	0.23	0.27
				(0.37)	(0.35)	(0.36)	(0.38)	(0.37)
Census division 8				−0.17	−0.21	−0.17	0.06	0.08
				(0.33)	(0.33)	(0.32)	(0.32)	(0.31)
ln(*pop* $_{1910}$)					0.66^a	0.67^a	0.39^b	0.29^c
					(0.19)	(0.20)	(0.18)	(0.17)
ln(*pop* $_{1920}$)					-1.05^a	-0.96^a	-0.93^a	-0.82^b
					(0.35)	(0.35)	(0.35)	(0.34)
ln(*pop* $_{1930}$)					1.05^b	1.14^b	1.32^b	1.22^b
					(0.50)	(0.51)	(0.51)	(0.48)
ln(*pop* $_{1940}$)					-1.00^b	-1.26^a	-1.00^b	-0.87^b
					(0.50)	(0.48)	(0.48)	(0.44)
Proportion of adults with 5 years of school in 1940						−0.32	−0.15	−0.35
						(0.65)	(0.66)	(0.62)
Proportion aged 7-13 enrolled in school in 1940						1.30	0.87	1.11
						(0.88)	(0.79)	(0.87)
Proportion aged 14-17 enrolled in school in 1940						−0.15	−0.06	−0.06
						(0.34)	(0.41)	(0.36)
ln(*median_income* $_{1950}$)						0.50	0.31	0.18
						(0.34)	(0.37)	(0.33)
Proportion aged 0-18 in 2010							1.92	−1.42
							(2.89)	(2.84)
Proportion aged 65+ in 2010							−0.93	−2.02
							(2.25)	(2.15)
Proportion of adults high-school educated in 2007							−0.57	−1.56
							(2.03)	(2.02)
Proportion of adults college educated in 2007							2.24	−0.54
							(1.68)	(1.76)
ln(*mean_income* $_{2007}$)							1.11^b	0.94^c
							(0.51)	(0.52)
Proportion of employment in manufacturing in 2010								−1.47
								(1.21)
Proportion of employment in services in 2010								5.62^a
								(1.37)
First-stage *F* -statistic	39.27	37.71	35.78	33.77	34.59	35.68	34.38	34.47
Hausman test *p* -value	0.00	0.25	0.06	0.04	0.01	0.02	0.02	0.02

Note: 287 observations for each regression; robust standard errors in parentheses; *a* , *b* , *c* denote significance at 1%, 5%, 10%

Table 10: TSLS results for the effect of the number of airports on the number of flights in 2010.