

Sheard, Nicholas

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Airports and the Production of Goods and Services

Nicholas Sheard^{1, 2}

Department of Economics, Stockholm University

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Abstract

This paper estimates the effects of airport infrastructure on local employment in the manufacturing and service sectors, using data from the United States. The effects are relevant to the evaluation of airport construction or improvement projects as these often aim to attract firms or improve conditions for existing local firms by making travel to and from the local area more convenient. To address the endogeneity problem that results from demand-driven airport expansion, the 1944 National Airport Plan of the Civil Aeronautics Administration is used to instrument for the current distribution of airports. The Plan had a strong effect on where airports were constructed in the decades following its adoption, but apparently allocated airports for reasons otherwise exogenous to current industry shares. Airport size is found to have a positive effect on local employment in tradable services, with an elasticity of approximately 0.1, and a negative effect on manufacturing. There is no measurable effect on non-tradable services.

Keywords: air transport; services trade; infrastructure

JEL classification: F14, H54, R41

1. Introduction

The aviation industry is dependent for its operation on an extensive network of airports that host takeoffs and landings, the storage and maintenance of aircraft, and the transition of passengers to other modes of transport. These airports are costly to construct and the land they occupy implies a sizeable opportunity cost.³ Airport development is often financed by

¹ Stockholm University, Department of Economics, 106 91 Stockholm, Sweden. Tel: +46 8 16 33 95. Fax: +46 8 15 94 82. E-mail: ns@ne.su.se.

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³ The replacement value of the current stock of airports is difficult to estimate, as most large airports are old facilities that have been developed gradually over several decades. However, the example of the Denver International Airport, opened in 1995 and the only major airport in the United States to be constructed from scratch in recent years, gives some impression of the magnitude of the value of existing facilities. The airport cost \$4.8 billion to construct, \$4.4 billion of which came from public funds (General Accounting Office, 1995). The costs of constructing the proposed new London airport in the Thames Estuary, including the rail link to the city, are currently estimated at £50 billion (Thames Hub Team, 2011).

public funds and arguments made for the expansion of airport capacity regularly cite the effects on local firms, suggesting at least a perceived public interest in the quality of the local air connections. However, due mainly to the difficulty in solving the obvious endogeneity problem that results from airports being developed in response to demand, the effects of an airport on the wider economy have not been reliably quantified.

This paper estimates the effect of improved passenger air connections on employment in the manufacturing and service sectors within a metropolitan area. Sectoral employment is a fundamental outcome variable, as it reflects the importance of the air connection for attracting productive activity in particular industries and consequently for overall local employment. The measurement of these effects is important for the design of policies related to airport construction and improvement, but also contributes to a broader question about the effects of infrastructure improvements. The analysis is conducted for metropolitan areas in the United States of America (henceforth the “US”) using an instrumental variables approach to address the endogeneity problem arising from air traffic potentially being driven by demand from activity in the relevant sectors. Improved air connections are found to have a positive effect on employment in tradable services and a negative effect on employment in manufacturing. The negative effect on manufacturing is interpreted as being due to the substitution of factors to the production of tradable services. There is no measurable effect on employment in non-tradable services.

Understanding the effects of infrastructure improvements is central to the design of public policy. The example of airport improvements is relevant to the effects of infrastructure in a general sense, as better air connections allow easier access to other locations, as well as to the particular case of accessibility via air travel. In particular, as air travel is generally the fastest mode of transport over long distances, better air connections reflect a type of accessibility that prioritises the speed of access. Furthermore, airports, including their navigation and maintenance facilities, represent practically all of the fixed infrastructure required for air travel, little being required along the routes.⁴ This is in contrast to surface-based modes that use infrastructure such as roads, bridges, and canals on the links of their networks, as well as stations, ports, and storage facilities at the nodes. An analysis of airports therefore represents a practically comprehensive treatment of air travel infrastructure.

The global air travel industry is subject to widespread regulation as well as public ownership and management of facilities and airlines, apparently reflecting a public interest in its operation. In terms of the operation of flights, the domestic market in the United States was deregulated in 1978, but many countries still feature state-owned national airlines, and the opening of international routes to competition is a gradual and ongoing process. The operation of facilities, however, exhibits a higher degree of public involvement. Airports are often established and expanded as an initiative of local and national governments, or at least with their participation.⁵ In North America, public ownership and management of airports is

⁴ This was not always the case. In the early days of flight, regularly-operated routes or “airways” were marked with light and then radio beacons and lined with emergency landing fields (Komons, 1978). Modern navigation technology, the greater reliability of aircraft, and the overall prevalence of airfields made these facilities obsolete by the early 1990s (Bilstein, 2001).

⁵ Since the Civil Aeronautics Act was adopted in 1938, the development of US airports deemed necessary to the national air network has been funded by the federal government to up to half of the costs of construction. This is in addition to state and municipal funding. Similar levels of public funding of projects are common across countries.

the norm.⁶ Though the demand for air travel can induce airport construction as a private enterprise, the participation of governments in airport improvements suggests concern about the effects of air travel on the broader economy. To evaluate the effects of such initiatives, it is necessary to understand the effects that an airport has on the local economy.

Airport improvements are usually intended to increase capacity or to make travel to or from the airport more convenient. Often these aims coincide, as higher-capacity airports usually host more frequent flights to a wider range of destinations, provide non-stop flights to more distant destinations, have better ground transport links with nearby communities, and offer more amenities. These aims are therefore well reflected in the number of departures, which is used here as the measure of the quality of air connections. The actual policy may function by expanding the physical size of the airport, but due to the costs of acquiring land and constructing runways and terminals this normally implies the loosening of a constraint on capacity, with the predictable result of an increase in traffic. Airport improvements may also be part of efforts to persuade airlines to operate flights to and from the airport, particularly as a hub of operations. The effects of infrastructure improvements are therefore interpreted in terms of their effects on air traffic, which in turn reflects air connections.

The effect of air travel infrastructure estimated in this paper is that of improved air transport connections on local employment in the manufacturing and service industries. To estimate these effects it is necessary to address the endogeneity problem that results from air traffic adjusting in response to demand. The approach used here is to instrument for the current sizes of airports using the 1944 National Airport Plan of the Civil Aeronautics Administration, the first national plan for the US airport network to come into effect. The 1944 Plan explains a significant amount of the variation in the present-day distribution of airports across metropolitan areas but is exogenous to other determinants of the distribution of industry-level employment. The 1944 Plan greatly influenced the subsequent development of airports as, since the Civil Aeronautics Act of 1938, inclusion in the most recent version of the national plan has been a prerequisite for federal funds to be applied to the construction or expansion of an airport. The persistence of sites developed decades ago was ensured by the high costs of acquiring land to expand present airports or to construct alternative sites. Though later airport development naturally depended on demand from individuals and firms, the 1944 Plan had a lasting effect, and its distribution of airports is otherwise not correlated with the current distribution of industrial sectors.

The analysis in this paper uses data from metropolitan areas in the contiguous mainland of the US (the District of Columbia and all states excluding Alaska and Hawaii). The use of data from the US has several distinct advantages over other potential candidates. Firstly, it is a single political entity with relatively homogeneous institutions and culture, rather than a collection of small, independent states. Secondly, the US has several national airlines with a high degree of overlap in their geographical coverage, notwithstanding a number of 'fortress' hubs that are dominated by single airlines, and there is competition on all major internal routes. Thirdly, the availability of alternative modes of transport is relatively homogeneous over the land mass. Although locations near the coasts and the Great Lakes have particular

⁶ In the United States, most commercial airports are owned and operated by municipal governments or local public authorities, such as the Port Authority of New York and New Jersey that manages the airports in the New York City area. In Canada, most commercial airports are owned by Transport Canada, though many are operated by private entities.

access to sea transport, a national highway network and secondary roads connect settlements in different regions to a relatively similar degree and few metropolitan areas are separated by bodies of water. Fourthly, it is a large economy with many metropolitan areas, providing more data points than other areas that are comparable in terms of the first three factors.

The effects of air connections on employment are estimated for three broadly-defined industries: tradable services, manufacturing, and non-tradable services. Appendix 1 lists the NAICS 2-digit industries included in each of these categories. Tradable services are generally able to be 'shipped' from one location to another, in the sense that they may be consumed in different locations from those in which they are produced: a process that sometimes involves the producers of these services travelling by air. Manufacturing involves the production of goods that are also often shipped some distance to the final consumer, though these goods are predominantly delivered by some mode of surface transportation rather than by air. Non-tradable services involve tasks such as hairdressing that require the producer and consumer to be in the same location.

The estimated effects on employment shares are as follows: an increase in air traffic to or from a metropolitan area has a positive and significant effect on tradable services, a negative and significant (though smaller) effect on manufacturing, and no measurable effect on non-tradable services. The effect of a 10% increase in the level of air traffic is to increase the proportion of the population employed in tradable services by around 0.25% (an elasticity of 0.10) and to decrease the proportion of the population employed in manufacturing by around 0.20% (an elasticity of -0.21). The negative effect on manufacturing appears not to be a direct effect, as a larger airport is unlikely to be an obstacle to manufacturing. The explanation offered here is that it reflects substitution of employment to tradable services, the production of which is aided by the air connection. An analysis of the relationship between air traffic and manufacturing shipments on metropolitan-area pairs supports this explanation. As non-tradable services must be consumed in place, it is intuitive that their production be unrelated to air connections.

The findings presented in this paper are specific to air travel but contribute to a broader literature about the importance of transportation infrastructure. Research on this topic uses a variety of techniques to address the endogeneity problem associated with infrastructure development being related to past or anticipated development. Recent studies on the effects of roads by Baum-Snow (2007), Michaels (2008), Duranton and Turner (2011; 2012), and Duranton, Morrow, and Turner (2011) use historical data including the 1947 federal highway plan to instrument for the current provision of roads, an approach similar to that employed in this paper.⁷ Of these, the exercise most closely related to the current paper is by Duranton, Morrow, and Turner (2011), who estimate the effect of metropolitan-area highways on trade in manufactures. They find a positive effect of highways on the weight but not value of exports from a city, so that cities with more highways specialise in heavier industries. Studies of the effects of railways have instead exploited variation in coverage during the expansion of the rail networks. Donaldson (2010) studies the effects of colonial-era railway development on the Indian subcontinent on trade and welfare. Donaldson and Hornbeck

⁷ Each of these papers instruments using the 1947 federal highway plan except for Michaels (2008), who uses the 1944 federal highway plan. Duranton and Turner (2011; 2012) and Duranton, Morrow, and Turner (2011) additionally use 1898 railways and 1528 to 1850 exploration routes as instruments.

(2011) analyse the historical development of US railways in the late nineteenth century and find a positive effect of railways on land values.

More specifically, this paper contributes to the small literature on the effects of air transport infrastructure. Brueckner (2003) estimates the effect of airports on overall and industry-specific employment growth in US metropolitan areas, using the status of the airports as airline hubs and geographical centrality to instrument for air traffic levels. Consistent with the current paper, he finds a positive effect of airport size on service employment. The exogeneity of the ‘hub’ instrument is questionable, however, as hub status is determined by an endogenous choice on the part of airlines, while the ‘centrality’ instrument is not strong. Green (2007) also uses an instrumental variables approach and finds a positive effect of airports on growth, though the use of current airport size and industry-level employment measures as instruments for air traffic puts the validity of the approach into question.

The current paper contributes to this literature in a number of ways. Firstly, it uses an original type of historical data to instrument for the allocation of airports. The instrument appears to be a more reliable source of exogenous variation than what is obtained in previous studies. Secondly, the instrument is more directly related to current airport size than are alternatives such as airport location and is therefore potentially stronger. Thirdly, the analysis uses data from a far larger number of metropolitan areas than existing studies and so it represents a more comprehensive assessment of the effects of airports. Fourthly, it includes a brief analysis of the relationship between air travel and manufacturing trade on specific routes, rather than being limited to the metropolitan-area level.

The remainder of the paper is organised as follows: the model for the relationship between air travel and industry sizes is described in section 2; the data are described in section 3; the empirical analysis of the effect of airport size on local employment is presented in section 4; and concluding remarks are presented in section 5. The appendices contain some definitions, the first-stage results, and further analysis of the relationship between air traffic and manufacturing shipments.

2. Model

The empirical tests of the effect of airport provision on industry shares are conducted by estimating a reduced-form system of two equations. The first identifies the variation in the level of air traffic in 2007 that is explained by planned 1944 airports. The second takes the estimated 2007 level of air traffic from the first step and relates this to employment shares. The first-stage equation is specified as follows:

$$a_{m,2007} = \alpha + \beta_A A_{m,1944} + \beta_X X_m + \varepsilon_{1,m} \quad (1)$$

And the second-stage equation is:

$$E_m^i = \alpha^i + \beta_a^i a_{m,2007} + \beta_x^i X_m + \varepsilon_{2,m}^i \quad (2)$$

In equation (1), $a_{m,2007}$ is the (log) level of air traffic in metropolitan area m in 2007, $A_{m,1944}$ is the (log) value of the proposed airports in metropolitan area m according to the 1944 National Airport Plan, X_m is a set of geographic and pre-1944 demographic controls, and $\varepsilon_{1,m}$ is an error term.

In equation (2), E_m^i is the share of workers in metropolitan area m who are employed in industry i , $a_{m,2007}$ is the (log) level of air traffic in metropolitan area m in 2007 estimated in (1), X_m is the same set of controls as in (1), and $\varepsilon_{2,m}^i$ is an error term. As the industry employment shares are given as proportions while the airport sizes are in natural logs, a 1% increase in the size of the airport leads to a β_a^i % change in the employment share. This specification has the advantage of making the magnitudes of the effects comparable across industries.

For the effect of air travel on employment to be identified by the system of equations (1) and (2), the following conditions must be satisfied:

$$\beta_A \neq 0 \tag{3}$$

$$\text{Corr}(A_{m,1944}, \varepsilon_{2,m}^i) = 0 \tag{4}$$

The first of these is the relevance condition (3), which requires that the number of planned airports in 1944 explain a significant amount of the variation in the level of air traffic in 2007, given the controls. This condition is tested for by running weak identification tests. The second condition is the exogeneity condition or exclusion restriction (4), which requires that the number of planned airports effect employment only through airport size. Though it is not feasible to test for this condition statistically, there are a number of reasons why the condition is likely to be satisfied, which are explained below.

3. Data

The empirical analysis in this paper uses a dataset constructed from several sources and aggregated by Core Based Statistical Area (CBSA). The CBSAs are defined by the Office of Management and Budget as sets of counties. According to the definition, each CBSA represents an urban core and surrounding areas with which it is highly integrated. The November 2007 definitions are used and only those CBSAs in the continental US are included. In total, 290 CBSAs are included in the sample. A summary of the main variables in the data is given in Table 1.

	Mean	Std. dev.	Minimum	Maximum
1940 population	286,934	861,417	4,745	11,950,188
2010 population	801,264	1,761,394	17,398	18,897,084
Number of existing airports in 1944	4.8	6.0	0	44
Number of proposed airports in 1944	9.5	12.3	1	123
Number of commercial airports in 2007	1.9	1.7	1	16
Number of departing flights in 2007	33,319	81,968	1,003	633,633
Number of departing passengers in 2007	2,568,941	7,299,818	1,898	56,404,489
Manufacturing (31-33) employment	30,931	64,175	60	622,376
Services (51-54, 56) employment	84,273	218,046	548	2,334,855
Information services (51) employment	10,283	29,296	60	322,194
Finance and insurance services (52) employment	19,435	52,072	134	633,580
Real estate services (53) employment	6,557	16,991	60	183,952
Professional-scientific-technical services (54) employment	24,498	68,841	115	680,488
Administrative and support services (56) employment	23,500	55,356	45	514,641
Other services (81) employment	15,288	34,371	191	364,122
Total employment	324,889	733,184	4,643	7,671,171

Note: 290 observations of each variable; employment figures are the numbers of employees during the week including March 12th, 2007

Table 1. Summary of the main variables in the dataset by CBSA.

The data are from several sources. The population statistics are from the decennial census conducted by the United States Census Bureau for each of the relevant years. The locations and sizes of existing and proposed airports in 1944 are from the National Airport Plan of that year authored by the Civil Aeronautics Administration. The traffic levels at each airport in 2007 are from the T-100 segment data made available by the US Bureau of Transportation Statistics. The employment figures are from the 2007 County Business Patterns.

The employment data include CBSA-level figures for total employment and for employment in a selection of 2-digit North American Industry Classification System (NAICS) industries. These industries are henceforth grouped and referred to as *manufacturing* (31-33), *tradable services* (51-54, 56), and *non-tradable services* (81). The services classified as tradable include functions such as publishing, insurance, computer programming, and management – services that can be delivered to locations remote from where they are produced. In contrast, the ‘non-tradable’ services include hairdressing and beauty salons, parking lots, auto repair, and cleaners – services that are impossible or excessively costly to deliver to other locations. A detailed list of the 2-digit NAICS industries included in each category is given in Appendix 1. For a small proportion of CBSAs – no more than 2.0% for any industry by employment share – the employment figures are suppressed and instead a range of values is given. In these cases the values are assumed to be at the midpoint of the range. However, industry 55, “Management of companies and enterprises”, is not included in the analysis because of a substantially higher proportion of suppressed values.

The remaining data are from a variety of sources. The location of a CBSA adjacent to the Pacific Ocean, the Atlantic Ocean, or one of the Great Lakes is read from the November 2007 map of CBSAs from the United States Census Bureau. The elevation data, used to calculate the ‘elevation’ and ‘ruggedness’ variables, are from the Global Positioning System. The elevation variable is measured at the midpoint of the CBSA, defined as the mean location of the 2010 population. The ruggedness variable is calculated as the standard deviation of the elevations of an array of points including the midpoint and eight evenly-spaced points on each of two circles centred on the midpoint: one with a radius of three miles and the other

with a radius of ten miles. The annual heating and cooling degree days and the average wind speed for each CBSA are from the National Oceanic and Atmospheric Administration.

The sample is restricted to CBSAs for which the relevant variables are defined, so each must have a commercial airport and employment data in the County Business Patterns. The sample is further restricted to CBSAs that host at least 1,000 annual departures, which excludes some smaller communities that are likely both to be serviced by better airports outside of the CBSA boundaries. These CBSAs also have fewer residents and therefore noisier figures for employment shares. This leaves 290 CBSAs.

A map of the 290 CBSAs included in the sample as well as the proposed airports in the 1944 National Airport Plan is shown in Figure 1. It can be seen from the map that the sample includes populated areas from all across the country. Indeed, the 290 CBSAs include parts of all 48 of the contiguous states and the District of Columbia. Given the mean 2010 population of around 800,000 for the 290 CBSAs in the sample, the sample includes approximately three quarters of the US population. Employment in the sectors included in the sample represents roughly 40% of total employment: 9% in manufacturing (sectors 31-33), 26% in tradable services (sectors 51-54 and 56), and 5% in non-tradable services (sector 81). The industries not analysed include primary industries, mining, utilities, wholesale and retail trade, education, and health care. These industries are excluded in part because of large proportions of suppressed values and in part because their relationships to air travel are of less interest.

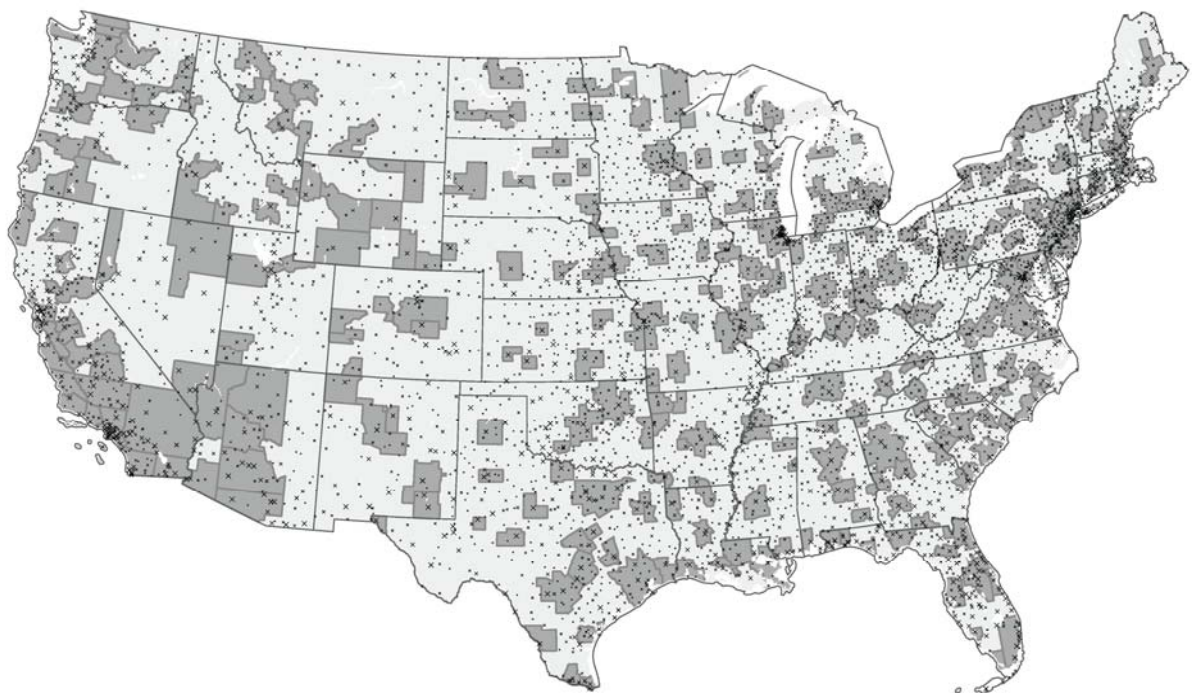


Figure 1. Map of the 290 CBSAs included in the sample (shaded) and the proposed airports in the 1944 National Airport Plan (marked with crosses, the sizes of which reflect the specified class of each airport).

3.1. 1944 National Airport Plan

The empirical strategy used in this paper involves instrumenting for airport sizes and locations using the 1944 National Airport Plan of the Civil Aeronautics Administration

(CAA). This was an updated version of the original national plan devised by the CAA after the passing of the Civil Aeronautics Act in 1938.⁸ This bill removed the existing ban on the federal government providing funding for the construction and improvement of airports, established the CAA, and directed this new authority to propose a plan for the national air network.⁹ In order to receive federal funding, an airport was required to be in the most recently approved version of the plan, a condition that remains in effect to this day. The first National Airport Plan, submitted to Congress in 1939, failed to gain approval for apparently political reasons. However, as a compromise motivated by the exigencies of the war effort, a more limited program was then approved to develop a small number of facilities for military needs.¹⁰ The 1944 National Airport Plan was a revised version of the original plan and became the first to gain approval by Congress, being passed along with the Federal Airport Act in 1946. Indeed the funding framework in the 1944 National Airport Plan was largely instituted in the Federal Airport Act, which defined how federal funds would be applied to airports in the subsequent decades through the Federal Aid Airport Program (Blaine, 1954; Wilson, 1979).

The 1944 National Airport Plan (for the remainder of this section, the “Plan”) lists the 6,305 existing and proposed airports in the 48 states and the District of Columbia. A summary of the numbers of existing and proposed airports by class is given in Table 2. 2,950 of the airports were existing facilities and 3,355 were to be newly built. Of the existing airports, 491 were to be improved and 72 downgraded. The location of each airport is given by the name of the nearest town or city and in some cases by identifying the actual facility. These locations are converted into latitude and longitude figures that are used to identify which CBSA, if any, the airport would be located within. The current and proposed sizes of the facilities are given by their class on a scale of 1 to 5. The smallest were the class 1 and 2 airports, which were appropriate for privately-owned aircraft and some small transport aircraft. Class 3 airports were large enough to handle contemporary twin-engined transport aircraft. The class 4 and 5 airports were substantial facilities with capacity for the largest aircraft then in operation as well as those anticipated to begin operating in the coming years.¹¹ A survey of modern-day airports indicates that the vast majority of the airports in the Plan ended up being built.¹²

⁸ The agency founded in 1938 with the passing of the Civil Aeronautics Act was named the “Civil Aeronautics Authority”. In 1940 the responsibilities of this agency were split between the newly-formed Civil Aeronautics Administration (CAA) and Civil Aeronautics Board (CAB) (Bilstein, 2001).

⁹ The ban on federal funding of airports was instituted by the Air Commerce Act of 1926 (Wilson, 1979).

¹⁰ The 1939 plan was based on a survey conducted in 1938 and 1939 and proposed the development of 4,000 facilities. A bill approving \$80 million for the 1939 plan passed the House of Representatives and seemed set to pass the Senate, but after details were leaked from the House Appropriations Committee the Senate committee received a large amount of mail from constituents requesting funds for their local areas and the Senate reacted by refusing to approve any funds. After President Roosevelt argued that the funding was important for military purposes, a compromise was reached in which \$40 million for 250 airports was approved under the program named Development of Landing Areas for National Defense (DLAND) (Wilson, 1979).

¹¹ For more detail on how the airport classes are defined, see the introductory text of the 1944 National Airport Plan and Chapter 1 of Wilson (1979).

¹² The Plan specifies 99 class-4 and -5 airports to be built on new sites. In 2011, airports had been built on 80 of these 99 sites.

Airport class	Existing in 1944	Planned airports by class in 1944 NAP					Imputed value per airport (\$)
		At same class	Improved	Down-graded	New facilities	Total proposed	
1	988	636	-	40	1,921	2,597	68,641
2	807	673	299	29	1,197	2,198	277,784
3	441	386	127	3	138	654	748,697
4	408	389	52	0	79	520	1,032,047
5	306	303	13	-	20	336	2,412,832
Total	2,950	2,387	491	72	3,355	6,305	

Table 2. Numbers of existing and proposed airports by class in the 1944 National Airport Plan and imputed value of each class of airport.

The rightmost column of Table 2 displays the imputed 1944 replacement values of airports in each class, which are inferred from projected improvement costs across the range of airport classes. These values are calculated to quantify the proposed amount of airport infrastructure in each CBSA in a more meaningful way than a count of the number of facilities by class, which is the extent of the information given directly in the Plan. The Plan lists the existing and proposed class of each facility and the amount, if any, to be spent on improvements; no details of the projected runways or physical sizes of the airports are given. The approach used here is to estimate the total proposed value of each airport by imputing a dollar value for a facility of each class from the set of projected improvement costs, which are applied to all existing airports of that class as their 1944 values, and then to add to this the projected costs specified for improvements to each individual facility. The technique used to estimate the existing values for each class, which are the amounts displayed in Table 2, involves weighting the mean projected costs of establishing new facilities or of improving existing facilities along the scale of five class increments. This technique is explained in detail in Appendix 2. In the second step, each airport is assigned the value corresponding to its existing class. Finally, the projected improvement costs for the airport are added to obtain a total projected value.

To be a relevant instrument, the Plan must explain a significant amount of the variation in 2007 air traffic levels. This is the relevance condition (3). This seems reasonable due to the importance of the Plan in determining which airports would be developed and to the persistence in airport locations. All existing airports were included in the Plan, even if some were recommended to be downgraded, so the Plan largely reflects the airfield development that occurred during the Second World War. Since that time, and according to the Civil Aeronautics Act, an airport has had to be in the most recently-approved version of the national plan to receive federal funding. Though the national plan was updated regularly and the approval of funds in principle did not always lead to improvements being carried out, much of the airport development in the decades following the Second World War was conducted according to the Plan. This was a period of rapid growth for the US air network, which added more than 5% airfields annually during the decade after 1945.¹³ Under the Federal Airport Act, the federal government funded up to half of the costs of all but the very largest projects, for which local governments took a larger share (Wilson, 1979).

¹³ In 1941 there were fewer than 2,500 airfields of all types in the US. By the end of 1945 there were around 4,000 and by 1955 there were nearly 7,000 (Federal Aviation Agency, 1960).

For the Plan to explain the current allocation of airports through its influence on historical airport construction, the locations and sizes of airports must be persistent. This appears also to be true. Due to the large fixed investment involved in establishing a new airport, in particular for the acquisition of a substantial area of ever-scarcer land, historical construction is related to the current locations of airports (Redding, Sturm, and Wolf, 2011). Indeed, with few exceptions, the sites of what would become the nation's major airports had already been established as airfields by the late 1940s (Daley Bednarek, 2001). The F -statistics from the weak instrument tests are large enough to suggest that the instrument comfortably satisfies the relevance condition (3). The coefficients on the instrument from the estimation of the first-stage equation (1), given in Appendix 3, support this result.

The exogeneity condition (4) requires that the instrument affect industry shares only through the allocation of airports, conditional on the control variables. The Plan credibly satisfies this condition for a number of reasons. Firstly, the stated criteria for the selection of sites are not related to sectoral composition or factors that could influence the future growth of particular sectors. The Plan was explicitly designed to connect civilians to the budding air network, the main criterion being population distribution, and to meet potential military needs. Additional criteria included the function of a potential airport in the national air travel network and proximity to trained military aviators who could be employed as commercial pilots.¹⁴ Secondly, the Plan was drawn up after only preliminary consultation with state and local governments about the locations and sizes of airports, minimising the possibilities for local politicians and businesses to influence the distribution of airports to suit local industries (Wilson, 1979). Thirdly, the Plan was made in an era when air travel was at an early stage of development and the extent, manner, and cost of air travel were vastly different from today, limiting the potential for the decisions made in the 1940s about the allocation of airports to be correlated with present-day factors (Bilstein, 2001).

Perhaps the most serious threat to the exogeneity of the instrument would be a relationship between the allocation of airports in the Plan and the contemporary size of either the manufacturing or the service sector. Areas with large shares of a given industry in the 1940s are likely to have large shares today, because of persistence and unobserved factors that make the location suitable for the given industry. Were more airports located in areas with more service firms in the 1940s, it could be that the same areas remain centres of service production today, so the error term $\varepsilon_{2,m}^i$ in equation (2) would be correlated with the number of planned airports $A_{m,1944}$ and the exogeneity condition (4) would be violated. However, it is possible to test for this possibility. Table 3 displays the results of regressions of the (log) value of proposed airports in the Plan on the employment shares of the manufacturing and service industries in 1950, using data from the 1950 Census of Population. The geographical unit in this analysis is the Standard Metropolitan Area (SMA), the contemporary equivalent of the CBSA. The 1950 Census of Population details the population and employment figures for the 151 SMAs that had a population of at least 100,000 in 1950. No significant relationship between proposed airports and industry shares emerges, at least when

¹⁴ The promotion of local businesses is in fact mentioned in the plan as a minor motivation, but these businesses are limited to aircraft sales, flight schools, and services such as restaurants that would be located at the airport, suggesting that the effect on industries not related to air travel were not being considered. Presumably other, larger industries would have been mentioned had the effects on those industries been considered.

geographical controls are introduced, suggesting that airports in the Plan were not allocated according to the location of these industries.

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	OLS	OLS	OLS	OLS
Panel A. Dependent variable: Value (log) of airports in 1944 plan						
Manufacturing share in 1950	-2.755*** (0.793)	-1.701** (0.835)	-1.415 (0.924)	-1.268 (0.958)	-2.116 (1.475)	-1.503 (1.465)
R ²	0.174	0.524	0.539	0.550	0.530	0.557
Panel B. Dependent variable: Value (log) of airports in 1944 plan						
Services share in 1950	4.093 (3.053)	3.346 (2.517)	2.868 (2.544)	3.071 (2.621)	4.850 (3.713)	6.462 (4.587)
R ²	0.118	0.512	0.535	0.549	0.529	0.566
Geography	N	Y	Y	Y	Y	Y
Census divisions	N	N	Y	Y	Y	Y
Climate variables	N	N	N	Y	Y	Y
Minimum 1950 population	-	-	-	-	150,000	200,000
Number of observations	151	151	151	151	113	90

Note: robust standard errors in parentheses; * significant at 10% level, ** significant at 5% level, *** significant at 1% level

Table 3. Proposed airports in the 1944 National Airport Plan and 1950 industry shares.

4. Results

4.1. OLS results

The results from the ordinary least squares (OLS) estimation of (2) for each of the three industries are displayed in Table 4. This technique does not address the potential endogeneity of the airport size measure and the results should therefore not be interpreted as the effects of an exogenous change in airport size. These results are included to give an impression of the overall relationship between air traffic and the industry shares in the data.

The coefficients for the three industries are shown in separate panels in Table 4. The columns represent separate regressions with a range of different control variables. All regressions include the log 1940 population, to control for the overall size of the CBSA at the time the 1944 National Airport Plan was devised. The second column introduces limited geographical controls: the area of each CBSA and location adjacent to the Atlantic or Pacific coast or the shore of one of the Great Lakes. The third column introduces further geographical controls: elevation, ruggedness, and average wind speed. To control for potential regional differences, the fourth column introduces census division fixed effects. Further controls for potential regional variation are included in the fifth and sixth columns, in the form of annual numbers of heating and cooling days. To control for possible variation due to the path of development in 1940, the sixth column includes population figures from the decennial censuses from 1900 to 1930. To check the robustness of the results to the sizes of CBSAs in the sample, the seventh and eighth columns limit the sample to CBSAs above 2010 population thresholds of 50,000 and 100,000, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Panel A. Dependent variable: Manufacturing employment share in 2007								
$\ln(\text{departures}_{2007})$	-0.020*** (0.002)	-0.013*** (0.003)	-0.013*** (0.002)	-0.012*** (0.003)	-0.012*** (0.003)	-0.011*** (0.003)	-0.013*** (0.002)	-0.013*** (0.003)
$\ln(\text{pop}_{1940})$	0.024*** (0.003)	0.022*** (0.003)	0.018*** (0.004)	0.018*** (0.004)	0.015*** (0.004)	-0.041 (0.037)	0.020*** (0.004)	0.018*** (0.004)
R^2	0.170	0.239	0.250	0.299	0.313	0.339	0.376	0.377
Panel B. Dependent variable: Tradable services employment share in 2007								
$\ln(\text{departures}_{2007})$	0.023*** (0.002)	0.023*** (0.002)	0.023*** (0.003)	0.021*** (0.003)	0.021*** (0.003)	0.021*** (0.003)	0.021*** (0.003)	0.021*** (0.003)
$\ln(\text{pop}_{1940})$	0.002 (0.003)	0.003 (0.003)	0.004 (0.004)	0.009** (0.004)	0.008* (0.004)	0.042* (0.021)	0.007 (0.005)	0.005 (0.005)
R^2	0.458	0.476	0.480	0.505	0.506	0.519	0.468	0.444
Panel C. Dependent variable: Non-tradable services employment share in 2007								
$\ln(\text{departures}_{2007})$	-0.001 (0.000)	-0.001 (0.001)	-0.000 (0.001)	-0.000 (0.000)	-0.000 (0.001)	-0.000 (0.000)	-0.001 (0.000)	-0.001 (0.001)
$\ln(\text{pop}_{1940})$	0.001* (0.001)	0.001* (0.001)	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	-0.000 (0.005)	0.001 (0.001)	0.001 (0.001)
R^2	0.012	0.023	0.071	0.143	0.144	0.201	0.160	0.183
Geography	N	Basic	Y	Y	Y	Y	Y	Y
Census divisions	N	N	N	Y	Y	Y	Y	Y
Climate variables	N	N	N	N	Y	Y	N	N
$\{\ln(\text{pop}_t)\}_{t \in \{1900, \dots, 1930\}}$	N	N	N	N	N	Y	N	N
Minimum 2010 population	-	-	-	-	-	-	50,000	100,000
Number of observations	290	290	290	290	290	290	263	229

Note: robust standard errors in parentheses; * significant at 10% level, ** significant at 5% level, *** significant at 1% level

Table 4. OLS estimates of the effects of airport size on the employment shares of manufacturing, tradable services, and non-tradable services in 2007.

A negative relationship between air traffic and manufacturing employment is evident from Table 4. With the share of manufacturing employment as the dependent variable, for all specifications the coefficient of air traffic is negative and strongly significant. Conversely, there is a strong positive relationship between air traffic and the concentration of tradable services employment for all specifications. That is, those CBSAs that host more air traffic in 2007 have higher concentrations of tradable-service employment. There appears to be no relationship between the number of departures from a metropolitan area and the employment share of non-tradable services.

4.2. IV results

The results from the instrumental variables (IV) estimation of (2) are displayed in Table 5. The instrument used in each regression is the value of proposed airports in the CBSA according to the 1944 National Airport Plan. These regressions use the same sets of controls and minimum 2010 populations as in the OLS estimates presented in Table 4.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IV	IV	IV	IV	IV	IV	IV	IV
Panel A. Dependent variable: Manufacturing employment share in 2007								
$\ln(\text{departures}_{2007})$	-0.034*** (0.007)	-0.020 (0.012)	-0.023** (0.011)	-0.011 (0.014)	-0.012 (0.014)	-0.013 (0.014)	-0.024** (0.009)	-0.030*** (0.010)
$\ln(\text{pop}_{1940})$	0.035*** (0.007)	0.027*** (0.010)	0.026** (0.010)	0.016 (0.013)	0.015 (0.013)	-0.038 (0.046)	0.030*** (0.008)	0.031*** (0.009)
Panel B. Dependent variable: Tradable services employment share in 2007								
$\ln(\text{departures}_{2007})$	0.023*** (0.005)	0.024*** (0.008)	0.026*** (0.008)	0.023*** (0.008)	0.021** (0.009)	0.028*** (0.010)	0.022*** (0.008)	0.027*** (0.009)
$\ln(\text{pop}_{1940})$	0.001 (0.005)	0.002 (0.006)	0.002 (0.007)	0.006 (0.008)	0.008 (0.009)	0.031 (0.025)	0.006 (0.008)	0.001 (0.008)
Panel C. Dependent variable: Non-tradable services employment share in 2007								
$\ln(\text{departures}_{2007})$	-0.001 (0.001)	-0.002 (0.002)	-0.001 (0.002)	0.000 (0.002)	0.000 (0.002)	0.000 (0.002)	0.000 (0.002)	-0.000 (0.002)
$\ln(\text{pop}_{1940})$	0.001 (0.001)	0.002 (0.002)	0.001 (0.002)	-0.000 (0.002)	-0.001 (0.002)	-0.001 (0.006)	-0.000 (0.002)	0.000 (0.002)
Geography	N	Basic	Y	Y	Y	Y	Y	Y
Census divisions	N	N	N	Y	Y	Y	Y	Y
Climate variables	N	N	N	N	Y	Y	N	N
$\{\ln(\text{pop}_t)\}_{t \in \{1900, \dots, 1930\}}$	N	N	N	N	N	Y	N	N
Minimum 2010 population	-	-	-	-	-	-	50,000	100,000
Number of observations	290	290	290	290	290	290	263	229
First-stage statistic	75.531	25.892	28.599	24.582	18.123	17.005	22.497	20.827

Note: robust standard errors in parentheses; * significant at 10% level, ** significant at 5% level, *** significant at 1% level

Table 5. IV estimates of the effects of airport size on the employment shares of manufacturing, tradable services, and non-tradable services in 2007.

The estimates of the effect of air travel on the share of manufacturing employment are presented in Panel A of Table 5. For each of the specifications the coefficient is negative in sign and for four of these it is significant. The introduction of census divisions as controls reduces the magnitude and significance of the coefficients, possibly because of correlated inter-regional differences between airports and manufacturing activity. However, the coefficients are nevertheless significant when the sample is restricted to CBSAs with at least 50,000 residents in 2010, even with the census divisions included as controls. The magnitude of the coefficient on manufacturing employment varies but is generally around -0.020, so that a 10% increase in the level of air traffic is associated with a 0.20% reduction in the share of manufacturing employment. This corresponds to an elasticity of approximately -0.21.

The negative effect of air traffic on the share of manufacturing employment demands some explanation, as air travel should not represent any direct obstacle to manufacturing. Indeed, business-class air travel has been linked to trade in certain types of products (Cristea, 2011) and improved air connections could be expected to lead to closer personal and cultural ties, which have been associated with increased trade (Rauch, 2001; Rauch and Trindade, 2002). The explanation offered here is of the substitution of factors towards the expanded service sector. The possible explanations are explored in more detail through the analysis of air traffic and manufacturing shipments between pairs of metropolitan areas in Appendix 4.

The coefficients for the effect of air travel on the employment share of tradable services are displayed in Panel B of Table 5. The coefficient on air traffic is significant and positive in

each of the specifications, indicating that air traffic has a positive effect on employment in tradable services. The coefficient is around 0.025 for each of the specifications. The effect of a 10% increase in air traffic is therefore to increase the employment share of the service sector by 0.25%. The corresponding elasticity is approximately 0.10.

The magnitudes of the point estimates for the effect of airports on the employment share of tradable services are slightly larger in the IV estimation than with OLS. This result deserves some explanation, as the endogeneity of air traffic from industry demands could be expected bias the OLS estimates upwards. However, the difference could reflect the subsequent construction of airports in locations where they are less effective. Duranton, Morrow, and Turner (2011) make a similar finding: the effect of highways on the weight of exports is larger when instrumenting for highways. They conclude that randomly-allocated highways are more effective than those allocated by government action in generating trade. An analogous interpretation could apply here: randomly-allocated airports have a larger effect on production of tradable services than those resulting from deliberate government action. A further potential explanation is that the effects on industries may take time to accumulate. In this case, airport improvements conducted in the 1940s and 1950s could exhibit a larger effect on sector shares than improvements carried out in recent decades.

Panel C of Table 5 displays the coefficients for the effect of air travel on the employment share of non-tradable services. The coefficients are small in magnitude and statistically insignificant in each of the specifications, indicating that there is no measurable effect of air travel on the size of the non-tradable-service sector. This is reasonable as the services in this category are largely either impractical or impossible to transmit between locations, so the distribution of their production must closely match that of their consumption. Unless there are systematic differences in the rates of consumption between metropolitan areas that result from variation in air traffic, there would not be any apparent effect on non-tradable services.

The results from the weak identification tests for the instrument are reported at the bottom of Table 5. The F -statistics for all specifications are above a reasonable threshold to reject the hypothesis of the instruments being weak. The statistics are large enough to pass comfortably in all specifications except that in which the 1900 to 1930 population figures are included as controls. These additional population figures are intended to represent past development at the time the 1944 National Airport Plan was devised. However, they are correlated with planned 1944 airports and their inclusion thereby weakens the instrument.

4.3. Robustness

Table 6 presents the results of additional robustness checks on the IV results presented above. These include a number of alternative specifications, sample restrictions, and additional control variables. For each robustness check, the IV results for the employment shares of manufacturing and tradable services are presented in separate panels. In the interests of space, the results for non-tradable services are not presented. Each of the regressions uses the geography and census division controls and is therefore equivalent to the fourth column of Table 4 and Table 5.

The first three robustness checks use alternative measures of 2007 airport size as the endogenous regressor. Recall that the measure used above is the number of departing flights from the CBSA. In Table 6, column 1 uses the number of departing passengers from the CBSA, column 2 uses the number of destinations flown to at least daily from the CBSA, and column 3 uses the number of flights departing from only the largest airport in the CBSA. The

fourth robustness check, presented in column 4, varies the measure of the airports in the Plan used as the instrument to be the count of proposed class-4 and -5 airports. These are the larger facilities that could most readily be expanded to handle increased traffic and larger aircraft. To check the sensitivity of the results to the metropolitan-area definition, column 5 uses the subset of CBSAs classified as Metropolitan Statistical Areas (MSAs) rather than Micropolitan Statistical Areas (μ SAs). To check the effects of the infrastructure of alternative transport modes, column 6 adds 2007 highway miles in the CBSA as a control. The final two robustness checks treat market access and the availability of airports outside the boundaries of the CBSA. Column 7 introduces a control for the (log) population outside the CBSA but within 100 miles of its population midpoint in 1940. Column 8 removes from the sample CBSAs that are contiguous with a CBSA that has a higher-category airport according to the Federal Aviation Administration system of classification.¹⁵

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IV	IV	IV	IV	IV	IV	IV	IV
	Number pass.	Number dests.	Main airport	Class 4-5 as instr.	MSAs only	Highways	Pop. within 100 miles	No larger near apts.
Panel A. Dependent variable: Manufacturing employment share in 2007								
ln(passengers ₂₀₀₇)	-0.008 (0.010)							
ln(destinations ₂₀₀₇)		-0.011 (0.016)						
ln(departures_main ₂₀₀₇)			-0.011 (0.014)					
ln(departures ₂₀₀₇)				-0.022** (0.011)	-0.029*** (0.011)	-0.071 (0.049)	-0.006 (0.016)	-0.003 (0.015)
Panel B. Dependent variable: Tradable services employment share in 2007								
ln(passengers ₂₀₀₇)	0.018*** (0.006)							
ln(destinations ₂₀₀₇)		0.026*** (0.010)						
ln(departures_main ₂₀₀₇)			0.025*** (0.009)					
ln(departures ₂₀₀₇)				0.019** (0.009)	0.027*** (0.009)	0.017 (0.030)	0.029*** (0.009)	0.023*** (0.008)
Number of observations	290	289	290	290	228	219	285	200
First-stage statistic	19.876	22.585	21.745	20.292	19.367	2.630	19.125	24.739

Note: robust standard errors in parentheses; * significant at 10% level, ** significant at 5% level, *** significant at 1% level

Table 6. Robustness checks of the IV estimates of the effects of airport size on the employment shares of manufacturing and tradable services in 2007.

The results presented in Table 6 indicate that the main IV results are robust to a wide range of alternative factors and specifications. For each of the alternative definitions of airport size used in Table 6, the results are consistent with the standard specification used above. The coefficient for tradable services is positive and significant while the coefficient for manufacturing is negative but not significant. The magnitude of the coefficient on the

¹⁵ This system groups commercial airports into one of five broad categories: “Large Hub”, “Medium Hub”, “Small Hub”, “Nonhub Primary”, or “Nonprimary Commercial Service”.

number of passengers is smaller, which may reflect the costs of congestion: for a given number of flights, larger or fuller planes imply longer waits and less flexibility. The alternative instrument constructed as the number of class-4 or -5 airports yields similar results, except that the coefficient on manufacturing is negative and significant.

Limiting the sample only to MSAs appears to make the results stronger. This is not surprising as the restriction is similar to including only CBSAs with a minimum 2010 population of 100,000, which is described above and yields similar results. The coefficient for tradable services is similar in size and p -value to the estimates produced using the standard assumptions above. On the other hand, the coefficient on manufacturing is more strongly negative.

The inclusion of 2007 highway miles as a control reduces the size and significance of the estimate for tradable services, but increases the size of the estimate for manufacturing. This variable is clearly not exogenous to current industrial composition, but its effects are nonetheless interesting to observe. The reduction of the apparent effect of airports on tradable services could be due to the construction of highways in struggling cities that naturally do not attract service firms. The larger negative effect on manufacturing could arise from highways being positively correlated with airports, but the coefficient is not significant in any case.

Controlling for 1940 population within 100 miles of the CBSA makes little difference to the results. Market access in nearby area thus appears not to be a substantial factor in the effect of airports on industrial composition. The same inference applies to airports in near to but outside of the CBSA, which are related to this population measure but also to the final robustness check that removes any CBSAs from the sample that border a CBSA with a higher-category airport. This controls directly for the presence of airports outside of the CBSA boundaries that would be more convenient for residents to travel via, but has no appreciable effect on the results.

5. Conclusion

This paper estimates the effects of air travel accessibility on local employment in the manufacturing and service sectors. The main difficulty in estimating these effects is the endogeneity of air services, which are likely to increase in response to demand from industries that use air travel. This problem is addressed by instrumenting for current airports using the 1944 National Airport Plan, which explains a substantial amount of the variation in the current distribution of airports but appears to be otherwise unrelated to present sectoral concentrations.

The findings are that a metropolitan area that has better air connections because of an exogenous historical allocation of airports specialises less in the production of manufactured goods and more in the production of tradable services. A 10% increase in the frequency of flights from a metropolitan area is found to decrease the local employment share of manufacturing by 0.20% (an elasticity of -0.21), to increase the local employment share of tradable services by 0.25% (an elasticity of 0.10). There is no measurable effect on employment in non-tradable services.

The interpretation of these results is that tradable services, which can be delivered to another location partly by use of air travel by employees, are produced in the most accessible metropolitan area and exported to other locations. As non-tradable services must be

consumed in close proximity to where they are produced, their employment share is relatively static and is not affected by air travel. Manufacturing is decreasing in the size of the airport but this is unlikely to be due to any direct effect; rather, a larger service sector employs workers, land, and other factors that may otherwise have been used in manufacturing. This interpretation is supported by the analysis of trade flows of manufactures presented in Appendix 4, which shows no correlation between air services to a metropolitan area and the level of exports to the same area.

The findings of this paper are informative about the effects of infrastructure improvements and have implications for the evaluation of policy. Airport construction and expansion are often justified on the basis of the improved accessibility being a positive factor in employment. The results presented above support this justification, as the sectors that most obviously make use of air travel expand when air connections are improved. However, there is evidence of a less obvious effect on other sectors, which may suffer from the reduced availability of factors of land, workers, and other factors of production. Though it may not seem necessary to consider the effects of airport improvements on sectors that do not use air travel, the results presented here suggest that these effects should be taken into account in the evaluation of airport development projects.

References

- Baum-Snow, Nathaniel. 2007. "Did Highways Cause Suburbanization?" *Quarterly Journal of Economics* 122(2): 775–805.
- Bilstein, Roger E. 2001. *Flight in America: From the Wrights to the Astronauts, 3rd ed.* The Johns Hopkins University Press, Baltimore, MD.
- Blaine, J. C. D. 1954. "The Development of a National Airport Plan." *Land Economics* 30(3): 270–274.
- Brueckner, Jan K. 2003. "Airline Traffic and Urban Economic Development." *Urban Studies* 40(8): 1455–1469.
- Civil Aeronautics Administration. 1944. *National Airport Plan*. U.S. Government Printing Office, Washington, DC.
- Cristea, Anca D. 2011. "Buyer-Seller Relationships in International Trade: Evidence from U.S. States' Exports and Business-Class Travel." *Journal of International Economics* 84(2): 207–220.
- Daley Bednarek, Janet R. 2001. *America's Airports: Airfield Developments, 1918-1947*. Texas A&M University Press, College Station, TX.
- Donaldson, David. 2010. "Railroads of the Raj: Estimating the Impact of Transportation Infrastructure." NBER Working Paper No. 16487.
- Donaldson, David, and Richard Hornbeck. 2011. "Railroads and American Economic Growth: New Data and Theory." Preliminary Draft.
- Durant, Gilles, Peter Morrow, and Matthew Turner. 2011. "Roads and Trade: Evidence from the US." Working paper.

- Duranton, Gilles, and Matthew Turner. 2011. "The Fundamental Law of Road Congestion: Evidence from US Cities." *American Economic Review* 101(6): 2616–2652.
- Duranton, Gilles, and Matthew Turner. 2012. "Urban Growth and Transportation." *Review of Economic Studies*.
- Federal Aviation Agency. 1960. *FAA Statistical Handbook of Aviation: 1960 Edition*. U.S. Government Printing Office, Washington, DC.
- General Accounting Office. 1995. *Denver International Airport: Information on Selected Financial Issues*. Report to the Honorable Hank Brown, U.S. Senate, GAO/AIMD-95-230.
- Green, Richard. 2007. "Airports and Economic Development." *Real Estate Economics* 35(1): 91–112.
- Komons, Nick A. 1978. *Bonfires to Beacons: Federal Civil Aviation Policy under the Air Commerce Act, 1926-1938*. U.S. Department of Transportation, Federal Aviation Administration, Washington, DC.
- Michaels, Guy. 2008. "The Effect of Trade on the Demand for Skill: Evidence from the Interstate Highway System." *Review of Economics and Statistics* 90(4): 683–701.
- Rauch, James E. 2001. "Business and Social Networks in International Trade." *Journal of Economic Literature* 39(4): 1177–1203.
- Rauch, James E., and Vitor Trindade. 2002. "Ethnic Chinese Networks in International Trade." *Review of Economics and Statistics* 84(1): 116–130.
- Redding, Stephen J., Daniel M. Sturm, and Nikolaus Wolf. 2011. "History and Industry Location: Evidence from German Airports." *Review of Economics and Statistics* 93(3): 814–831.
- Thames Hub Team. 2011. *Thames Hub: An Integrated Vision for Britain*. Report on the proposed Thames Estuary Airport prepared by Foster + Partners, Halcrow, and Volterra.
- United States Bureau of Transportation Statistics. 2010. *2007 Commodity Flow Survey*. U.S. Government Printing Office, Washington, DC.
- United States Census Bureau. 2008. *Metropolitan and Micropolitan Statistical Areas of the United States and Puerto Rico, November 2007* (map). U.S. Government Printing Office, Washington, DC.
- United States Census Bureau. 2009. *2007 County Business Patterns*. U.S. Government Printing Office, Washington, DC.
- United States Department of Commerce, Bureau of the Census. 1951. *1950 Census of Population*. U.S. Government Printing Office, Washington, DC.

Wilson, John R. M. 1979. *Turbulence Aloft: The Civil Aeronautics Administration amid Wars and Rumors of Wars 1938-1953*. U.S. Department of Transportation, Federal Aviation Administration, Washington, DC.

Appendix 1

Table 7 displays a list of the 2-digit NAICS industries that are included in the samples. For the purposes of this paper industries 31-33 are classified as manufacturing, industries 51-54 and 56 are classified as tradable services, and industry 81 is classified as non-tradable services.

NAICS code	Industry description
31-33	Manufacturing
51	Information
52	Finance and Insurance
53	Real Estate Rental and Leasing
54	Professional, Scientific, and Technical Services
56	Administrative and Support and Waste Management and Remediation Services
81	Other Services (except Public Administration)

Table 7. NAICS titles for the 2-digit industries included in the samples of manufacturing (31-33), tradable services (51-54, 56), and non-tradable services (81).

Appendix 2

This appendix explains the method for imputing the values of airports of each of the five classes that are listed in Table 2. The method involves estimating the replacement values of existing airports as the mean projected costs of new facilities at that class and of the cumulative airport improvements up to that class from the 1944 National Airport Plan. Each observation is an airport that is to be improved to a higher class or built from scratch. A set of coefficients $\{f^j\}_{j=1,\dots,5}$ are defined to represent improvement of the airport on each of the five class increments: an airport that is to be improved from class 2 to class 4, for example, is counted as being improved on the increments between classes 2 and 3 and between classes 3 and 4, but not on the others. The associated logic variable for each airport-class pair is I_i^j , which has value 1 if airport i is to be improved over increment j and 0 otherwise. The costs of the five increments are estimated by fitting a model with fixed effects for the five increments and with no intercept. This technique combines the costs of improvements over single increments with the costs of improvements over multiple increments, weighted by the numbers of observations. The following equation, in which C_i is the projected cost of the project and ε_i is an error term, is fitted using ordinary least squares:

$$C_i = f^1 I_i^1 + f^2 I_i^2 + f^3 I_i^3 + f^4 I_i^4 + f^5 I_i^5 + \varepsilon_i \quad (5)$$

As there is no intercept in (5), the coefficient f^1 represents the replacement value of a class-1 airport, $f^1 + f^2$ represents the replacement value of a class-2 airport, and so on. Table 8 details the estimated coefficients and the estimated replacement values by class, which are simply the cumulative sums of the incremental coefficients.

Class	Incremental coefficient	Imputed value
1	68,641	68,641
2	209,143	277,784
3	470,913	748,697
4	283,350	1,032,047
5	1,380,785	2,412,832

Table 8. Incremental coefficients and imputed replacement values by class.

Appendix 3

Table 9 displays the results from the estimation of equation (1), the first-stage relationship between the (log) value of proposed airports in the 1944 National Airport Plan and the (log) number of departures in 2007. The same sets of controls and minimum CBSA sizes as in Table 4 and Table 5 are used in the regressions represented by Table 9.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
$\ln(\text{airports}_{1944})$	0.598*** (0.092)	0.394*** (0.102)	0.416*** (0.092)	0.414*** (0.103)	0.388*** (0.106)	0.381*** (0.106)	0.462*** (0.120)	0.526*** (0.129)
$\ln(\text{pop}_{1940})$	0.577*** (0.058)	0.592*** (0.061)	0.680*** (0.075)	0.726*** (0.078)	0.750*** (0.077)	1.598** (0.665)	0.729*** (0.092)	0.631*** (0.103)
Geography	N	Basic	Y	Y	Y	Y	Y	Y
Census divisions	N	N	N	Y	Y	Y	Y	Y
Climate variables	N	N	N	N	Y	Y	N	N
$\{\ln(\text{pop}_t)\}_{t \in \{1900, \dots, 1930\}}$	N	N	N	N	N	Y	N	N
Minimum 2010 population	-	-	-	-	-	-	50,000	100,000
R ²	0.608	0.642	0.655	0.682	0.684	0.698	0.657	0.659
Number of observations	290	290	290	290	290	290	263	229

Note: robust standard errors in parentheses; * significant at 10% level, ** significant at 5% level, *** significant at 1% level

Table 9. First-stage coefficients for the effect of planned 1944 airports on 2007 air traffic.

The coefficients displayed in Table 9 reflect that for each of the specifications, the number of planned airports is a strong factor in the level of air traffic in 2007. Figure 2 plots the actual versus predicted numbers of departures obtained from the estimation of (1) using only log 1940 population, the geographical variables, and census division fixed effects as controls. Figure 2 therefore corresponds to the results displayed in the fourth column of Table 9.

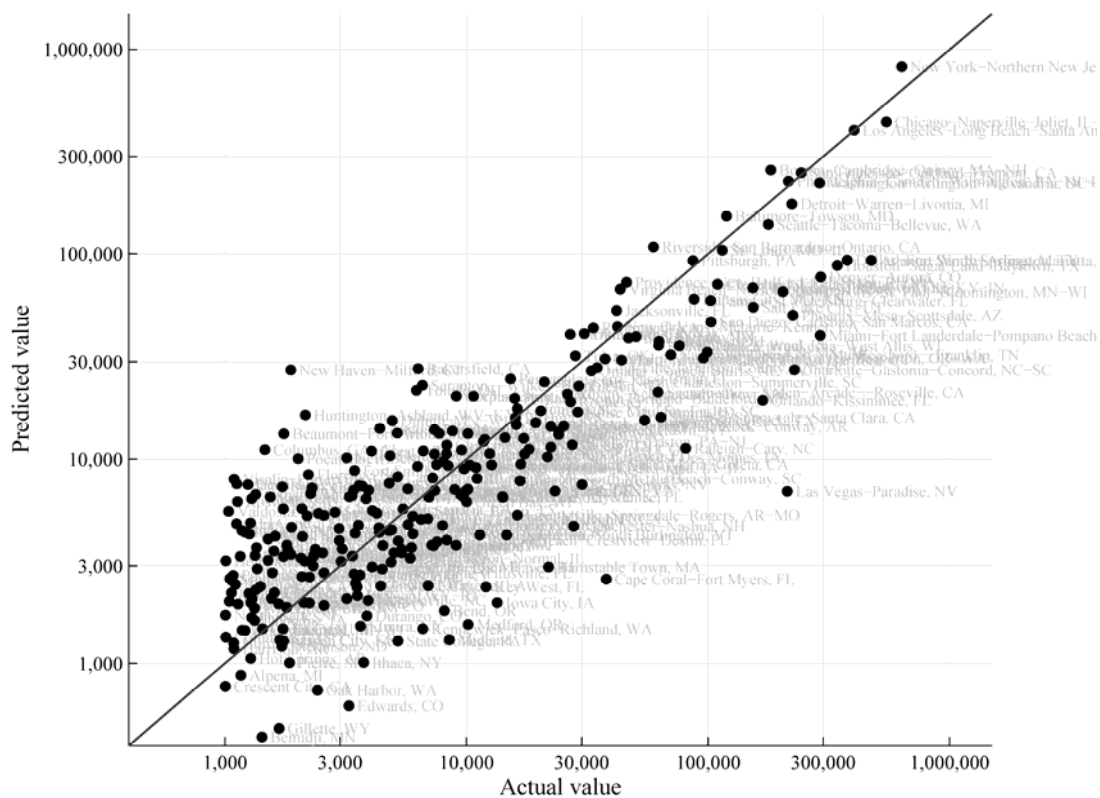


Figure 2. Actual versus predicted numbers of departures from the first-stage estimation.

Appendix 4

The result that an enlarged airport leads to a reduction in the size of the local manufacturing industry can be explored in more detail. The explanation proposed in this paper is of the substitution of factors to an expanded tradable service sector. The alternative would be of a direct relationship: either an effect of the air connection on manufacturing shipments, or of both being influenced by some unobserved factor. These explanations would imply a negative correlation between air traffic and manufacturing shipments on specific routes, not only at the nodes of the network. A simple way to test whether there may be a direct relationship between air connections and manufacturing trade is therefore to test for this relationship on metropolitan area pairs, controlling for origin- and destination-level factors. This appendix describes such a test and presents the results from it.

By its nature, air travel requires a substantial amount of fixed infrastructure at the nodes of the network whereas the links are comprised of essentially homogeneous and non-congestible airspace. Therefore, controlling for distance, all destinations are equally costly to operate flights to from any given metropolitan area, given the costliness of operating flights from the same origin to any destination and the costliness of operating flights from anywhere to the same destination. If manufacturing trade is directly related to air travel, then air traffic patterns should readily adjust in response to demand from the manufacturing industry, or vice versa. A relationship between the two could reflect an external factor that affects both air traffic and manufacturing, that is to say an indirect effect. The absence of a relationship would suggest there not to be a direct relationship between the two.

The analysis of air connections and manufacturing shipments by metropolitan-area pairs uses information from the Commodity Flow Survey (CFS), which details commodity shipments by pair of locations in the US. The geographical unit of observation in the CFS is the Commodity Flow Survey Place (CFSP). The CFSPs are generally larger geographical areas than the CBSAs, though in some cases the two definitions coincide. The commodities in the CFS are classified by Standard Classification of Transported Goods (SCTG) code. A list of the SCTG codes that are classified as manufacturing is included in Table 10. The CFS data are used along with information on air traffic from the T-100 segment data published by the US Bureau of Transportation Statistics, aggregated by CFSP.

SCTG code	Commodity Description
21	Pharmaceutical products
22	Fertilizers
23	Chemical products and preparations, nec
24	Plastics and rubber
26	Wood products
27	Pulp, newsprint, paper, and paperboard
28	Paper or paperboard articles
29	Printed products
30	Textiles, leather, and articles of textiles or leather
31	Nonmetallic mineral products
32	Base metal in primary or semifinished forms and in finished basic shapes
33	Articles of base metal
34	Machinery
35	Electronic and other electrical equipment and components and office equipment
36	Motorized and other vehicles (including parts)
37	Transportation equipment, nec
38	Precision instruments and apparatus
39	Furniture, mattresses and mattress supports, lamps, lighting fittings, and illuminated signs
40	Miscellaneous manufactured products

Table 10. SCTG industries classified as manufacturing.

The test of the relationship between air connections and manufacturing trade on pairs of metropolitan areas involves fitting the following equation for the (log) value of manufacturing shipments in 2007, V_{mn} , where m denotes the origin and n the destination:

$$V_{mn} = \gamma_m^O + \gamma_n^D + \beta_A A_{mn} + \beta_D D_{mn} + \varepsilon_{mn} \quad (6)$$

In equation (6), γ_m^O and γ_n^D are origin and destination fixed effects, A_{mn} is the (log) amount of air traffic between m and n in 2007 (with coefficient β_A), D_{mn} is the (log) distance between m and n (with coefficient β_D), and ε_{mn} is an error term. The fixed effects capture all origin- and destination-level factors, including the overall level of exports from the metropolitan area and so on. As the effect of distance may be highly nonlinear, some higher powers of the (log) distance are also included in the regressions. The measures of air traffic used for A_{mn} are the number of flights and the number of passengers, both of which reflect the quality of the air connection. The results from the estimation of (6) are displayed in Table 11.

	(1)	(2)	(3)	(4)	(5)	(6)
	log(value of manufacturing shipments in 2007)					
	(OLS)	(OLS)	(OLS)	(OLS)	(OLS)	(OLS)
log(number of departures in 2007)	-0.043*** (0.017)	-0.009 (0.018)	-0.010 (0.018)			
log(number of passengers in 2007)				-0.036** (0.016)	-0.006 (0.017)	-0.007 (0.017)
log(distance)	-1.549*** (0.049)	-4.470*** (0.476)	22.922 (28.813)	-1.532*** (0.048)	-4.498*** (0.472)	22.885 (28.783)
log(distance) ²		0.239*** (0.039)	-6.277 (7.325)		0.242*** (0.038)	-6.274 (7.318)
log(distance) ³			0.678 (0.818)			0.678 (0.817)
log(distance) ⁴			-0.026 (0.034)			-0.026 (0.034)
R ²	0.670	0.676	0.677	0.670	0.676	0.677
Number of observations	2,087	2,087	2,087	2,087	2,087	2,087

Note: robust standard errors in parentheses; * significant at 10% level, ** significant at 5% level, *** significant at 1% level

Table 11. Coefficients for the effect of air traffic on manufacturing shipments between a given pair of CFSPs, controlling for distance and using CFSP-level fixed effects.

The results displayed in Table 11 indicate that there is no significant relationship between air connections and manufacturing shipments on pairs of CFSPs. The coefficient on the number of passengers is negative in the most basic specification, but neither measure of air traffic is significantly different from zero when second- or higher-order powers of distance are included. Therefore, it is not possible to reject the null that manufacturing shipments are unrelated to air connections. This result favours the explanation for the apparently negative effect of air connections on the size of the local manufacturing sector as being due to substitution towards the expanded service sector, rather than to a direct effect.