Airports and Urban Growth: Evidence from a Quasi-Natural Policy Experiment

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Abstract

While significant work has been done to examine the determinants of regional development, there is little evidence on the contribution of air services toward this outcome. This paper exploits the unexpected market changes induced by the 1978 Airline Deregulation Act to bring new evidence on the link between airline traffic and local economic growth. Using data for almost 300 Metropolitan Statistical Areas (MSAs) over a two decade time period centered around the policy change, we exploit time variation in long-run growth rates to identify the effects of airline traffic on population, income and employment growth. Our results suggest that air service has a significant positive effect on regional growth, with the magnitude of the effects differing by MSA size and industrial specialization.

JEL: O18, R1, R4
Keywords: airline traffic, urban growth, regional development, Airline Deregulation Act, air transport

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1 Introduction

Almost since the invention of the airplane, policymakers at all levels of government have spent considerable resources to promote air services for their constituents. Currently in the United States, local airports and communities are quite active in providing subsidies and pledging future travel tickets in order to deter airlines from terminating strategic routes (e.g., Portland[1]), or from downgrading a city from its hub status (e.g., Cleveland[2]), or to encourage airlines to add new routes for their region (e.g., Tampa[3]). A 2009 survey by Airports Council International North America found that of the 52 responding airports, 33 had incentive agreements involving domestic air service, and 23 airports had incentive agreements for international air service.[4]

The universal justification for these government policies is the stated belief that air transport is crucial for regional economic growth. In support of this belief, there is certainly anecdotal evidence suggesting that air transport improves business operations by providing quick access to input supplies, stimulates innovative activities by facilitating face-to-face meetings, and represents an essential input for certain industries.[5] On the other hand, it is not clear how much economic activity significantly relies on air service, nor the extent to which other modes of transportation and communication can easily substitute for air services. In the end, a positive correlation between air services and economic growth may make policymakers erroneously believe that there is a causal

[1] See "Port's gamble on Delta pays off" from 06/11/2010 on www.oregonlive.com.

[2] See "Pittsburgh could foreshadow future of Cleveland Hopkins International Airport" from 11/22/2009 on www.cleveland.com

[3] See "Intense competition boosts airport incentives to airlines" at: http://www.tampabay.com/news/business/airlines/intense-competition-boosts-airport-incentives-to-airlines/1042035

[4] McAllister, Brad, "Regaining stability," Airport Business Magazine, september 15, 2011 at: http://www.airportbusiness.com/print/Airport-Business-Magazine/Regaining-stability/137314

[5] Several channels could explain the productivity effect of air transport. First, air travel facilitates face-to-face communication, which is essential for innovation, technology diffusion, and for coordination and efficient allocation of resources (see, among others, Gaspar and Glaeser, 1998; Autretsch and Feldman, 1996; Hovhannisyan and Keller, 2011). Second, the availability of air transport reduces transaction costs, increasing the openness of a region to trade (Poole, 2010; Cristea, 2011). This in turn fosters labor and industrial specialization at micro level, as well as product diversification at regional level, leading to increased aggregate productivity (Glaeser, Kallal, Scheinkman and Schleifer, 1992; Feenstra and Kee, 2006). Finally, air traffic could raise regional productivity via agglomeration effects and the associated positive externalities (see, among others, Rosenthal and Strange, 2004). The location decision of exporters and multinational firm headquarters is influenced by the quality of air services (Lovely, Rosenthal, and Sharma, 2005; Bel and Fageda, 2008). At the same time, both types of firms are shown to exert positive spillovers on local businesses, further affecting productivity (Blomstrom and Kokko, 1998; Arnold, Javorcik and Mattoo, 2011). Our intention in this study is to identify an aggregate net effect of air traffic on urban development, working in part through either of these productivity effects.

relationship that they can affect, when other factors out of their control may be driving the positive correlation.

Estimating the economic benefits of infrastructure projects in general, and of air transport in particular, is difficult because there is a strong interdependence between infrastructure investments and regional development. Communities that benefit from more rapid economic growth tend to also invest more in infrastructure, and in turn the stock of infrastructure further stimulates regional development. Thus, disentangling the causal effect of transportation on economic growth from the natural tendency of infrastructure to increase with the growth of a region is not easy.

Perhaps due to the difficulty of identification, there are only a couple prior studies examining the effect of air transport on regional growth. Brueckner (2003) estimates the effect of airline traffic on employment using cross-sectional data at the Metropolitan Statistical Area (MSA) level and finds that a 10 percent increase in passenger enplanements leads to approximately 1 percent increase in MSA employment, with service sectors responsible for most of the effect. Brueckner uses hub status of an airport, as well as the MSAs centrality within the U.S. and proximity to the nearest large metropolitan area, to instrument for the endogeneity of the level of air transport services. However, hub status may be endogenous with current and expected growth of an MSA, while geographic factors may affect general economic growth of a region just as much as air service.[6] Green (2007) exploits time series rather than cross-sectional data variation to estimate the effect of air transport infrastructure on regional growth. Using information on 83 MSAs, he regresses passenger air traffic levels in 1990 on subsequent decennial population and employment growth, and finds that a 10 percent increase in boardings per capita generate a 3.9 percent higher population growth and 2.8 percent higher employment growth for the period 1990-2000. However, economic outcomes such as population, employment, and even air service are persistent processes. This too makes identification difficult in the absence of any major exogenous and long-lasting shock to the airline service.

To overcome these challenges in identifying the relationship between air services and regional economic growth, we employ a quasi-natural experiment that stems from the dramatic changes in the aviation network following the U.S. Deregulation Act of 1978. This policy change marked the switch of the U.S. aviation industry from tight government regulation to free market. Importantly, it saw the swift dissolution of a regulatory environment that implicitly subsidized (and hence oversupplied) air service

[6] There is a significant economic geography literature showing how spatial location influences regional development and income growth via market access or market potential effects. Among others, see for example Redding and Venables (2004) for a cross-country analysis, or Hanson (2005) and Head and Mayer (2006) for a regional analysis.

to small and medium communities in the U.S., at the expense of larger cities.[7] As we show below, deregulation led to a swift reversal of this distortion, with dramatic average declines in air service to small and medium communities, while it increased for large cities. Interestingly, an unanticipated yet permanent response of air carriers to industry deregulation was a complete reconfiguration of their aviation networks into hub-and-spoke systems. This endogenous response of airlines led to even further disproportionate increases in routes at large airports, which were often chosen to serve as hubs in the post-deregulation period, and accentuated the systematic effects of deregulation on air service to large cities versus other communities in the U.S.. Thus, we exploit the systematic heterogeneous changes in air service to communities from the exogenous deregulation shock to infer the effect of air service on regional growth.

In particular, using historical data on economic and aviation indicators for 296 metropolitan areas in three distinct years spanning the period 1969-1991, we exploit differential changes in long-run growth rates before and after the quasi-natural policy experiment to identify any systematic changes in the rate of economic growth that can be directly attributed to the exogenous changes in air traffic post-deregulation. By exploiting time series variation within each metropolitan area, our econometric strategy is able to appropriately control for unobservable location specific factors, as well as for differences in the natural rate of development for communities of all sizes. This way we can contrast the relative economic performance of regions that experience abnormal (high or low) changes in their aviation network with regions that are identical in all other respects.

Our analysis brings robust evidence for a direct effect of air service on regional development. We find that, for a given MSA, increasing the growth rate of air passenger traffic from the 25th to the 75th percentile level leads on average to a 0.14 percent increase in the annual population growth rate. To put this result in perspective, the estimate accounts for 11.7 percent of the average annual rate of population growth observed across the sampled MSAs over the period 1969-1991. In the same manner, we find that increasing air traffic from the 25th to the 75th percentile leads on average to a 0.20 percent increase in the annual growth rate of income (representing 13.2 percent of the observed average income growth rate for the same 23-year period), and a 0.31 percent increase in the annual employment growth rate (which represents 11 percent of the observed average employment growth rate) for a given MSA. Some differences can

[7] The only major form of regulation in the industry that remained was the Essential Air Service program which mandated service to very small communities. This program has been quite limited in the communities it covers, and currently provides services to approximately 3000 passengers a day

be observed across communities based on their average size, with medium size MSAs benefiting to a lesser degree from air traffic growth. When estimating the employment effects by sector, we find that wholesale and retail industries are the ones experiencing significant growth effects.

This paper contributes to a recent literature evaluating the economic impact of transport infrastructure projects. A prior literature examines the more aggregate relationship between public spending and economic growth, finding mixed results (see, for example, Aschauer (1989), Munnell (1992), and Evans and Karras (1994)).[8] The availability of historical data on road or railroad construction at detailed geographical level has spurred a number of new recent studies on the impact of infrastructure, though almost all of these papers are focused on how infrastructure affects trade between regions, not regional growth, which is the focus of our paper. Michaels (2008) provides evidence that rural counties with access to interstate highways experience an increase in trade-related activities such as trucking and retail sales. He also shows that through increased trade, highways lead to a significant increase in the demand for skilled labor in skill abundant counties, contributing to the increasing skill premium. Duranton Morrow and Turner (2011) bring additional evidence for the role of interstate highways in determining the specialization of urban locations in sectors producing and trading heavy goods. Sheard (2012) uses the 1944 Civil Aeronautics Administration national airport plan as an instrument for current day airport sizes to examine its impact on the composition of industrial activity.[9] Donaldson (2010) examines how the introduction of railroads in India differentially affected incomes and prices across regions.

Our paper also relates to the broader literature on the determinants of urban growth. In two related papers, Glaeser, Kallal, Sheinkman and Shleifer (1992) and Glaeser, Sheinkman and Shleifer (1995) set the theoretical framework for analyzing the determinants of urban growth. While we build our model from the same set-up, they employ it to examine the effect of agglomeration economies and human capital as determinants of growth. A study closer to ours is Duranton and Turner (2012), which examines the causal relation between road transportation and city growth. The study finds large and significant effects of highway kilometers on employment and population growth, focusing particularly on intra-city transportation investments as main determi-

[8]Notable exceptions are Fernald (1999), who shows that when the stock of transportation infrastructure increases, productivity growth tends to rise relative to the average in vehicle-intensive industries, and fall in non-vehicle intensive sectors, and Chandra and Thompson (2000), who find that counties crossed by the interstate highway gain in output and earnings at the expense of adjacent counties.

[9]Note that Sheard's instrument is appropriately exogenous to long-run changes in industrial composition of U.S. communities (the focus of his study), but would not likely be exogenous to long-run growth in population and incomes of U.S. communities, which is the focus of our paper.

nants of growth.

The remainder of our paper proceeds as follows. The next section describes the context and consequences of the Airline Deregulation Act of 1978. Section 3 lays out the theoretical framework and estimation methodology. Section 4 presents the data sources and discusses the results, while section 5 concludes.

2 The 1978 Aviation Deregulation and Its Appropriateness as a Quasi-Natural Experiment

The 1978 Aviation Deregulation in the United States was a significant policy change that led to swift and dramatic changes in the aviation industry. Important for our purposes, the evidence suggests that it had a number of features, which make it an appropriate quasi-natural experiment.

First, the regulatory regime had clearly and systematically distorted air service patterns from what one would see in a free market after deregulation. Before the 1978 aviation deregulation, the development and activity of the airline industry was closely overseen by the Civil Aeronautic Board (CAB). The CAB was in charge of certifying and approving new entrant carriers, and assigning them precise point-to-point routes that they had to operate at predetermined airfares. Except for aircraft capacity and flight frequency, all operation decisions, such as entry and exit, route allocations, intensity of market competition, and price levels, were centrally determined by the CAB (Morrison and Winston, 1986). Entry was tightly controlled, certification being awarded on a per-case basis and only for operating specific routes (Bailey et al., 1985). Rather than aim for industry efficiency, CAB regulations strived to preserve the well-being of all existing airlines. It did so by suppressing market competition and favoring route subsidization (Dempsey, 1987; GAO, 1996). At the peak of the government intervention, in the early 1970s, CAB ceased to certify new carriers entirely, and even rejected requests by existing carriers to enter new city-routes (Borenstein, 1992).

A second important feature of the deregulation was how quickly significant transformations were taking place, as “policy changes followed one another with dazzling rapidity” (Bailey et al., 1985, p. 37). Facing an economic recession, the Ford administration had an economic summit in 1974, where a consensus was reached to tackle federal deregulation. The CAB became an immediate focus and a Senate hearing in 1975 brought much economic evidence to bear that regulation had restricted pricing and entry to the detriment of consumers. When the Carter administration came in

1976 supporting deregulation, there was virtually full political support and the Airline Deregulation Act (ADA) was passed in 1978. In fact, the CAB began significant reforms already by 1977, allowing "pro forma approval of discount fares" and granting "permissive route authority, which would allow a carrier to enter and exit from a route without CAB intervention" (Bailey et al., 1985, p. 33). The ADA specified full deregulation by January 1, 1983, but the CAB already had granted airlines complete route flexibility within a year of the act and new airlines were entering the market.

A third important feature is that the ultimate effects of the deregulation were uncertain and the industry responded in a number of unexpected ways. The rapidity of the deregulation process, as described above, made the effects unlikely to be anticipated and, therefore, exogenous to regional development. The expectation was that the aviation industry would become much more competitive after deregulation, leading to greater efficiencies and lower prices for air travel. The contestable market theory, combined with the lack of evidence in support of economies of scale in the aviation industry, diminished any concerns about anti-competitive effects in markets dominated by single carriers (Borenstein, 1992). While there is significant evidence of lower general prices and competition after deregulation, in many ways, the actual transformations that swept the aviation industry since the deregulation had been surprising, both because of "mistaken expectation and unforeseen outcomes" (Kahn, 1988). For example, one unanticipated response by airlines was the switch from point-to-point service to a hub-and-spoke operation network. This transformation increased industry efficiency because of better capacity utilization, i.e., higher load factors per flight (Borenstein and Rose, 2011).

A final feature of deregulation that is fundamental to our identification strategy in examining the impact on regional growth is that there was systematic heterogeneity in the shocks to air service across local communities in the United States. The CAB undertook many efforts to ensure service to smaller communities under regulation. In fact, the Board deliberately set fares above costs in markets of more than 400 miles and less than the costs in shorter markets (Bailey et al., 1985, p. 20). The loss of this cross-subsidization of markets was a primary concern of legislators considering deregulation, as there were real fears that many small (and even medium-sized) communities would face substantial loss of air service. Ultimately, arguments that commuter air services would likely take the place of traditional airline service to these communities, as well as the institution of the Essential Air Service program to directly subsidize air service to the smallest communities, allowed legislators to back deregulation.[10]

[10]Several very small communities did lose air traffic entirely after deregulation. However, the Essential

In summary, it was well known that the price levels and route allocations set by the CAB favored small communities, such that they benefited from more airline traffic than what the market mechanism would have optimally supplied. The reverse is true for large metropolitan areas: here, the high fares and the suppressed competition hindered the growth and development of air transport services. What was not anticipated, yet contributed further to the systematic changes in air service by city size, was the development of the hub and spoke system. This new pattern of networking air services allowed more frequent departures and more flexibility in flight schedules from hub airports, at the cost of an increase in the average number of connections and travel distance for itineraries originating in smaller airports. Thus, the development of the hub-and-spoke network led to a decrease in the number of flights and nonstop destinations in small and some medium size communities (Dempsey, 1987), but to a much larger increase in service at large metropolitan areas, many of which being selected as hub locations. (GAO, 1996)

The evidence for this systematic change in air traffic patterns across city sizes is quite clear in the data. Figure 1 provides a histogram capturing the absolute difference in the annualized growth rate of air traffic in the period after deregulation (1977-1991) relative to the decade before (1969-1977), averaged across metropolitan areas of different size categories. The histogram suggests that small communities witnessed the largest slowdown in the growth of traffic after deregulation, evidence that the CAB strategy of route cross-subsidization led to an overproduction of air services in small communities prior to 1978, and that any measures to mitigate the deregulation reversal of this trend were not significant. At the same time, large metropolitan areas benefited from an increase in the rate of air passenger growth following the aviation deregulation, consistent with the restricted capacity and high price mark-ups imposed by the CAB prior to 1978.

A similar take-away message is depicted in Figure 2, which provides a detailed view of the average annual changes in air passenger flows in the years before and after the deregulation. Even when expressing air passenger traffic in levels, it is clear from the trend lines how prior to 1978 small MSAs benefited from regulatory support at the expense of large MSAs, but suffered a bigger shock to air service after the full implementation of free market conditions. Our main focus in this paper is to investigate the extent to which these systematic changes in air traffic across city sizes following deregulation contribute to differential changes in population, income, and employment

Air Service (EAS) program allowed many others to keep air connectivity with the nearest hub airport. For more information on costs and benefits of the EAS Program, see the General Accounting Office (GAO, 2000) report, among others.

across regions.

Finally, there are two major events that happened about the same time as the deregulation of the aviation market, and that one may be concerned would confound our ability to identify the effects of airline deregulation on regional growth.

The first is the 1978-9 oil price shocks in the aftermath of the deregulation of the aviation market. If anything, we believe that the oil price shocks strengthen our identification strategy as it also contributed to the greater loss of air service by smaller cities. With the development of jet planes in the 1950s and 1960s, the U.S. government offered high subsidies towards the purchase of larger aircraft (Bailey et al., 1985, p. 112). This stimulus led to the wide spread adoption of larger jet aircraft in the industry, even for servicing smaller cities. In fact, the percent of aircraft in local fleets that were turbo prop or piston powered dropped from 99 percent to just 35 percent by 1976 (Bailey et al., 1985, p. 113). On a time line starting in 1950, alongside the price trend for crude oil, Figure 3 marks the date of the first flight for the most common jet aircraft models. It is clear from the trends that the commercialization of jet aircrafts overlapped with a period of persistently low oil prices, and the development of ever-larger jets tailed off for a significant period after the oil price shocks of the mid- and late-1970s.

Most importantly for our analysis, the timing of the 1978-9 oil price shock hit the small communities especially hard, where the high cost of jet service could not be supported by the local demand for air travel. And local air carriers could now freely exit unsustainable routes and relocate equipment to larger, denser markets. Thus, the interaction between aircraft innovations and oil price shocks at the time of the industry deregulation provides additional motivation to view the policy change as an appealing quasi-natural experiment.

A second series of events that may be of concern for our estimation strategy is the full or partial deregulation of other industries during the same period – most notably the trucking and railroad industries.[11] However, unlike the airline industry, we are not aware of any evidence that suggests these deregulation events led to systematic heterogeneous changes in activity across regions of different population sizes. While increased competition and improved cost efficiency in the absence of regulation have favored industry expansion and a rapid output growth, these trends have been observed nationwide. This point is essential for our identification strategy. It implies that any systematic deviations from national trends in local economic growth rates pre- versus post- the 1978 aviation deregulation that we find across different-sized communities

[11] Winston (1993) porvides a comprehensive survey of the regulatory reforms implemented in the U.S. at the end of 1970s and beginning of 1980s, including the deregulation of the transport sector.

cannot be attributed to regulatory initiatives happening simultaneously in other sectors.

3 Framework and Empirical Strategy

This section presents a simple framework that formalizes the process of urban growth. We follow the set-up in Glaeser, Scheinkman and Shleifer (1995), which we amend by allowing air services to enter both as a productivity shifter and as a local amenity. The main aim here is to provide guidance for the empirical analysis. We use the derived structural equation to obtain an estimation equation and then discuss its virtues in terms of econometric identification.

3.1. Set-up

Each metropolitan area is viewed as a separate open economy that shares a common (national) stock of capital and labor endowments. Free factor mobility ensures that capital and labor will be distributed across MSAs in equilibrium such that the rental rate and per-capita income, adjusted for local amenities, are equalized. A direct implication of this equilibrium outcome is that neither exogenous changes in labor supply, nor in saving rates, can be used as explanations for differences in urban growth. Instead, factors rooted in local fundamentals should be considered. In that respect, a common view in the regional development literature is to assume that MSAs differ only in the *level of productivity* and the *quality of life* determined by local amenities.

Let the total output in a metropolitan area be given by:

$$Y_{it} = A_{it} f(L_{it}) \tag{1}$$

where A_{it} represents the level of productivity in the metropolitan area i at time t, and L_{it} measures the population of the MSA i at time t.[12] $f(.)$ is assumed to be a Cobb-Douglas production function that is common across urban communities:

$$f(L_{it}) = L_{it}^{\alpha} \tag{2}$$

Individuals derive utility U_{it} from the labor income they earn, denoted W_{it}, and

[12] The production function can be extended to include other factors of production as long as they are local and immobile, such as non-tradeable capital or government spending on local infrastructure, urban transportation, etc. This extension is straightforward but is not necessary for our empirical work, so we prefer to keep the framework simple. Given that our identification strategy accounts for location specific time trends, under a constant rate of capital accumulation over time, the impact of non-tradeable capital and local infrastructure is implicitly controlled for.

the quality of life they enjoy in their community, labeled Λ_{it}.[13] The two components are assumed to enter the utility function multiplicatively:

$$U_{it} = W_{it}\Lambda_{it} \tag{3}$$

Workers get paid the value of their marginal product (with output price normalized to one), which implies that labor income is given by:

$$W_{it} = \alpha A_{it} L_{it}^{\alpha-1} \tag{4}$$

The quality of life term, Λ_{it}, captures a host of location specific factors. It is assumed to decrease in the population size of the metropolitan area, mainly because of the impact of size on housing prices, traffic congestion, criminality, etc. It also varies with several other factors that are exogenous to the production technology such as, for example, local amenities. We summarize these factors, for now, by the vector Q_{it}. That is:

$$\Lambda_{it} = L_{it}^{-\delta} Q_{it} \tag{5}$$

where $\delta > 0$.

Free mobility of individuals ensures that in equilibrium utility is constant across space at a given point in time, i.e., $U_{it} = U_t, \forall i$. This also implies that changes in utility over time happen at the same rate across MSAs. Using equations (3)-(5), the following must hold for each metropolitan area:

$$\begin{aligned} \log\left(\frac{U_{t+1}}{U_t}\right) &= \log\left(\frac{W_{it+1}}{W_{it}}\right) + \log\left(\frac{\Lambda_{it+1}}{\Lambda_{it}}\right) \\ &= \log\left(\frac{A_{it+1}}{A_{it}}\right) + (\alpha - \delta - 1)\log\left(\frac{L_{it+1}}{L_{it}}\right) + \log\left(\frac{Q_{it+1}}{Q_{it}}\right) \end{aligned} \tag{6}$$

where the left hand side of equation (6) is identical across all MSAs. For this identity to hold for all i, it must be the case that population growth in every metropolitan area adjusts each period such that, given the productivity growth and any changes in local amenities, utility grows at a rate that is common nationwide. Therefore, from equation

[13] It is possible to extend the utility function to include consumption of intra-city transport (i.e., commuting) and consumption of land. Doing so would introduce congestion effects and rising rental rates for communities that witness a rapid growth in population and per-capita income. These disutility effects associated with economic growth provide additional counter-balance against regional expansionary forces.

(6) we can express the rate of population growth as:

$$\log\left(\frac{L_{it+1}}{L_{it}}\right) = \frac{1}{1-\alpha+\delta}\left[\log\left(\frac{A_{it+1}}{A_{it}}\right) + \log\left(\frac{Q_{it+1}}{Q_{it}}\right)\right] + \kappa_t \tag{7}$$

with κ_t a constant.[14]

Re-writing the labor income in equation (4) as an annual growth rate and substituting for population growth using equation (7), we can derive the following expression for the income growth at the MSA level:

$$\log\left(\frac{W_{it+1}}{W_{it}}\right) = \frac{1}{1-\alpha+\delta}\left[\delta\log\left(\frac{A_{it+1}}{A_{it}}\right) + (\alpha-1)\log\left(\frac{Q_{it+1}}{Q_{it}}\right)\right] + \omega_t \tag{8}$$

with $\omega_t \equiv (\alpha-1)\kappa_t$ a constant.

Most empirical studies on regional development and urban growth focus on identifying the determinants of population and income growth. For equations (7) and (8) to serve such a purpose, one needs to specify the stochastic process of productivity as well as the exogenous factors that define the appealing characteristics of an urban area. It is customary to include the initial (base year) conditions as the main determinants of the subsequent growth in productivity and quality of life, respectively. Of particular interest to this paper is the provision of air transport services, which we expect to have a direct effect on both the local productivity growth, as well as on the valuation consumers attach to that location.[15] Thus, we assume that:

$$\log\left(\frac{A_{it+1}}{A_{it}}\right) = (X_{it})'\gamma_1 + \beta_1\log\left(\frac{AIR_{it+1}}{AIR_{it}}\right) + \nu_{it+1} \tag{9}$$

$$\log\left(\frac{Q_{it+1}}{Q_{it}}\right) = (X_{it})'\gamma_2 + \beta_2\log\left(\frac{AIR_{it+1}}{AIR_{it}}\right) + \upsilon_{it+1} \tag{10}$$

where X_{it} is a vector of characteristics for MSA i observed in the base year t[16], and AIR_{it} denotes the volume of airline traffic in the metropolitan area i at time t (a proxy for the local aviation network).

Substituting equations (9) and (10) into (7) and (8) respectively, replacing the structural coefficients with reduced form ones, and relabeling the variables' growth rates

[14] Formally, $\kappa_t \equiv \log\big(U_{t+1}/U_t\big)/(\alpha-\delta-1)$.

[15] While counting air services as part of a location's amenities seems obvious, their impact on regional productivity may be less transparent. The discussion in footnote 5 suggests several channels that could explain the productivity effect of air transport. They include technology diffusion, trade and agglomeration effects.

[16] The fact that the same vector X_{it} determines both the productivity and life quality growth rates is not restrictive as long as coefficients in both β and γ vectors are allowed to take zero values.

with the corresponding small letters for notational simplicity, we get:

$$\log l_{it+1} = (X_{it})'\gamma + \beta \log(air_{it+1}) + \varepsilon_{it+1} \quad (11)$$

$$\log w_{it+1} = (X_{it})'\tilde{\gamma} + \tilde{\beta} \log(air_{it+1}) + \xi_{it+1} \quad (12)$$

where $y_{it+1} \equiv Y_{it+1}/Y_{it}$ denotes the growth rate of variable Y, with Y $\in \{L, W, AIR\}$; and $\beta, \gamma, \tilde{\beta}, \tilde{\gamma}$ are parameters derived from the structure of the model.[17]

3.2. Estimation Strategy

Our interest lies in estimating the net effect of air services on regional growth by taking equations (11) and (12) to the data. The identification strategy exploits the structural change in the domestic aviation network induced by the industry deregulation of 1978. This policy change triggered unanticipated and permanent shocks to the regional airline traffic growth (i.e., air_{it+1}). In particular, metropolitan areas that had enjoyed an excess supply of air services during the pre-deregulation period as a consequence of the imposed regulations may have lost service after deregulation (or at least seen a much more sluggish growth in flights post-deregulation). Similarly, regions that had been undersupplied relative to their potential need, may have witnessed a significant increase in traffic growth post deregulation. The empirical test we perform essentially evaluates whether the differential changes in air passenger traffic growth across metropolitan areas are systematically related to differences in population and income growth.

Estimating the growth regression models given by equations (11) and (12) raises several issues. First, for properly identifying the effect of air traffic on regional development, one needs to fully specify all the fundamental determinants of urban growth, including factors affecting local changes in productivity or quality of life (i.e., the X_{it} variables in equations (11) and (12)). However, many such determinants may be unobservable or very hard to measure over longer periods of time. Fortunately, we can overcome this challenge by using MSA specific effects. Since our identification strategy exploits the time dimension of the data, we can conveniently remove any time invariant determinants of urban growth (or time-varying ones that affect equally all MSAs in the sample). Thus, variables such as initial economic conditions, area and geographic location, climate and natural resource endowments, socio-cultural characteristics, all fall in this category of time-invariant determinants of growth. Unless either of these variables has a differential effect on regional growth over the sample period (i.e., have

[17]Formally, $\gamma = (\gamma_1 + \gamma_2)/(1 - \alpha + \sigma)$; $\beta = (\beta_1 + \beta_2)/(1 - \alpha + \sigma)$; $\tilde{\gamma} = (\delta\gamma_1 + (\sigma - 1)\gamma_2)/(1 - \alpha + \sigma)$; and $\tilde{\beta} = (\delta\beta_1 + (\sigma - 1)\beta_2)/(1 - \alpha + \sigma)$.

time-dependent elasticities), we can safely rely on the MSA fixed effects to completely remove any location specific trends.

The second issue comes from the fact that the economic outcome variables measuring regional growth, such as population, per-capita income or employment, tend to change slowly over time. This means that long run growth rates may be the most appropriate metrics for capturing regional development. Unlike year-on-year changes, taking long differences of the data is more appropriate for correctly identifying any persistent, long-term relation between the variables of interest in the presence of significant autocorrelation (Bertrand and Duflo, 2004).

For these reasons, in our estimation we consider two subsample periods indexed by s: one that defines the time interval *before* the aviation deregulation, i.e., 1969-1977, and one defining the time interval *following* the policy change, i.e., 1977-1991.[18] Let the indicator variable *"Post"* define the two time periods, with $Post = 0$ denoting the pre-deregulation period and $Post = 1$ the post-deregulation period, respectively. Then, based on the discussion above, the empirical specification corresponding to equations (11) and (12) respectively, can be written as follows:

$$\log y_{is} \quad = \quad \alpha_i + \beta \log(air_{is}) + Post_s + \epsilon_{is} \tag{13}$$

where $y \in \{l, w\}$ stands for annualized growth rates for population, employment or per-capita income, respectively, calculated over each time period s[19]; α_i indexes the MSA fixed effect and accounts for pre-deregulation trends; and $Post_s$ acts as a time effect and captures any nation-wide macroeconomic factors specific to the post-deregulation period that may influence regional development. We expect the coefficient β on air traffic growth to be positive in a regression explaining population, per-capita income or employment growth rates across metropolitan areas.

It is worth pointing out however that a double-differencing of the data – first, to construct the long run growth rates, and second, to identify the main coefficient

[18] We choose the year 1977 as the cutoff point rather than 1978, which is when the Airline Deregulation Act entered into effect, mainly because we want to calculate long-run changes in air traffic before any major changes take place in terms of price levels or routes operated.

[19] To be specific, we compute the annualized growth rate $y \in \{l, w\}$ as follows:

$$y_{is} = \begin{cases} \left(\frac{Y_{i,1977}}{Y_{i,1969}}\right)^{1/8}, & \text{if time period } s \text{ is 1969-1977} \\ \left(\frac{Y_{i,1991}}{Y_{i,1977}}\right)^{1/14}, & \text{if time period } s \text{ is 1977-1991} \end{cases}$$

where the capital letter $Y \in \{L, W\}$ denotes the level of the variables of interest, population and per-capita income, respectively.

of interest separately from MSA fixed effects – may be very demanding in terms of data variation. In particular, if the exogenous shocks are not large enough to generate substantial variation in the variables of interest, or if the time period considered is not long enough to allow the regional outcome variables to fully adjust to the new equilibrium levels following the policy shock, then any useful variation in the data may be swept away. Yet Figure 2 provides convincing evidence that, at least for the case of air traffic, this should not be a problem.

One may still be concerned that the empirical specification in equation (13) may suffer from potential omitted variable bias. This becomes an issue to the extent that there are determinants of urban growth, X_i, that go through systematic changes during the same time period as the aviation deregulation. For example, it is customary for economic growth regressions to include variables that control for initial economic conditions, such as, population, income level, factor endowments or industrial specialization. Moreover, it is possible that their effect on regional growth varies over the two time periods in a way that is location-specific and thus not captured by the time fixed effects (i.e., $Post_s$). If that is the case, then the level of these initial condition variables may still be an important determinant of the differential growth rates of population and per-capita income across MSAs and over time. If ignored, these location-specific time-varying effects may incorrectly load on our coefficient of interest β and bias upwards the estimated effect of air traffic on urban growth.

To account for such systematic changes in population, per-capita income or employment growth, which may occur at the time of the aviation deregulation, but are unrelated to any changes in air traffic growth, we augment the baseline regression model as follows:

$$\log y_{is} \quad = \quad \alpha_i + \beta \log(air_{is}) + (X_i * Post_s)'\theta + Post_s + \epsilon_{is} \tag{14}$$

where X_i now captures any MSA specific characteristics that could affect urban growth differentially across the two time periods. In the estimation exercises, we will allow the growth rates for the dependent variable to vary across periods with the MSA size category (i.e., small, medium or large metropolitan areas), to vary with the MSA level of population or income in the base year 1969, as well as with the industrial composition of an MSA in the base year 1969 (i.e., employment shares in manufacturing, services, retail and wholesale sectors). This means that the identification of our coefficient of interest β comes from comparing how differential changes in air traffic post-deregulation affect urban growth across those MSAs that otherwise should have the same time-varying growth paths across the considered sample period.

4 Data and Estimation Results

4.1. Data Description

The data used in this study correspond to years 1969, 1977 and 1991, and are collected from various sources. The beginning and end years of the sample period are dictated by data availability, as well as the distance in time away from the policy shock of the 1978 aviation deregulation. The data, collected at city or county level for the 48 contiguous U.S. states, are aggregated to the level of the metropolitan statistical area (MSA). This seems the most appropriate spatial unit for evaluating the economic impact of an airport's transport services.

The air passenger transport data are collected by the Department of Transportation (DOT). For the early years, 1969 and 1977, we get the data from the *Airport Activity Statistics of Certificated Route Air Carriers*, published by the Federal Aviation Administration (FAA). We restrict attention to scheduled service and, for each city or airport in the U.S., we record the total annual number of enplaned passengers. Starting with 1991, aviation datasets have become available electronically and have improved much in their level of detail. We use the dataset *T3* from the *U.S. Air Carrier Airport Activity Statistics* database provided by the Bureau of Transport Statistics (BTS), and supplement it with *Schedule T1* from the *Small Air Carrier Statistics* database in order to construct the total annual number of enplaned passengers by U.S. airport.[20] We map all U.S. airports or city locations into the corresponding counties using information from the FAA, and then map counties into MSAs based on the concordance available from the U.S. Census Bureau.

Data on population and per-capita income is provided by the Bureau of Economic Analysis at the county level, which we then aggregate to the MSA level.[21] Employment data - total and by major sectors (i.e., manufacturing, services, wholesale, retail, construction, transportation and utilities) - is available from the *County Business Patterns* (CBP) provided by the U.S. Census.[22]

After combining all sources of data over the three selected years 1969, 1977 and

[20]We benefited from guidance from the BTS representatives in choosing the appropriate datasets and constructing airport traffic statistics that are consistent over the three disparate years.

[21]Nominal per-capita income rates are converted into real values using the consumer price index (CPI) series provided by the Bureau of Labor Statistics (BLS).

[22]The U.S. Census provides electronic data on CD-ROMs only starting from year 1986. For some years prior to that, including 1969 and 1977, the Inter-University Consortium for Political and Social Research (ICPSR) provides CBP data files and this is what we use here.

1991, and screening the resulting sample for potential outliers, we end up with a sample of 296 metropolitan areas.[23] Each of these MSAs hosts at least an airport that has been operative in every one of the three years spanning the 23 year period. The summary statistics on the variables of interest, including the constructed annual growth rates for the 1969-1977 and 1977-1991 periods, are reported in Table 1. An important thing to notice is the substantial variation in the growth rates over the two periods, especially with respect to passenger traffic. This gives us confidence that there is sufficient time variation in the data to be usefully exploited in our model.

The specifications we estimate are given by equation (14), which is provided in its baseline form in equation (13). We use population and employment as measures of labor force, and per-capita income as proxy for wage growth generated by productivity effects. Before discussing the estimation results, Table 2 provides correlation coefficients between several sets of variables. Panel A reports the correlation between changes in growth rates over the two time periods for the economic outcomes of interest and for passenger traffic across the two periods. Except for the correlation between population and employment, and between income and employment, the differences in growth rates are not highly correlated, suggestive of sufficient differentiation in development patterns across metropolitan areas. This is in contrast to the correlation coefficients between the level of these variables. As noticed in Panel B of Table 2, scale differences across regions are large enough to make the volume of air traffic highly correlated with the size of population and employment.

Two additional things are worth mentioning here. First, given the high correlation between population and employment in 1969, we do not include both variables as controls for initial conditions. Second, given the significant drop in correlation coefficients moving from levels to differences in growth rates (Panel B versus A), we can reasonably argue that most of the factors that simultaneously determine both travel and regional economic agglomerations are eliminated, diminishing endogeneity concerns. More evidence on the reduced concern for endogeneity comes from the relatively low correlation between first period growth rates in economic outcome variables and subsequent period growth in air traffic, as seen from Panel C of Table 2. In particular, the correlation coefficient between population growth in the pre-deregulation period and passenger growth post deregulation is 0.31 (absent any other controls). In the event that this may still reflect potential endogeneity in the differential growth of air passenger traffic, we revisit this concern in one of the robustness exercises.

[23] In obtaining the estimation sample, we have dropped the top and bottom 1 percent of MSAs based on (per-period) passenger growth rates in order to remove any outliers.

4.2. Estimation Results

Table 3 reports the results from estimating equation (14) with population growth as the regional economic outcome. The specification in the first column includes only the air traffic variable of interest, in addition to time and MSA fixed effects. This corresponds to the baseline model formalized by equation (13). The specification controls for any systematic differences in the annual population growth rates across metropolitan areas and also for any post-deregulation macroeconomic shocks that may affect population growth nation-wide.

The growth of air passenger traffic has a positive and significant effect on the rate of population growth. This result however, while significant, does not take into account the possibility that MSA population growth rates may change following the 1978 aviation deregulation for reasons unrelated to changes in air passenger traffic but related to particular MSA characteristics. It is possible that the growth trajectory of small MSAs evolves differentially over time compared to medium or large MSAs in the sample. For example, the 1979 oil crisis may have had a more severe or more prolonged effect on small versus large metropolitan areas. Such unobserved factors could bias the estimated coefficient upwards, explaining the positive and significant effect of air traffic on regional growth. To remove this concern, we first include interaction terms between the deregulation period dummy and the size category of an MSA (small, medium or large) in the regression.[24] This implicitly controls for any differential trends in the rate of population growth across the three MSA size categories. Column 2 reports the results. The effect of air services on population growth decreases in magnitude, but remains highly significant.

To allow for even more flexibility in population growth paths across MSAs, in column 3 we interact the post-deregulation time dummy with MSA characteristics capturing economic conditions at the start of the sample period. In particular, we allow MSAs with different population and income levels in 1969 to respond differently to unobserved shocks occurring in the post-1977 time period. However, the industrial composition of a city's activities is a significant determinant of urban growth. Glaeser et al. (1992) found evidence that inter-industry knowledge spillovers facilitated by a diverse industrial base explain economic agglomerations. At the same time, the industrial composition of a region also determines its average level of human capital. More importantly, Brueckner (2003) provides evidence from a cross-section of MSAs that service activities benefit more

[24] The small, medium and large MSA categories are defined by splitting the sample distribution of 1969 population levels in three equal sized parts.

than manufacturing from the availability and quality of air services. Therefore, we also allow post-deregulation growth rates to differ according to the industrial composition of MSAs at the beginning of the sample period. Essentially, this means that we identify the coefficient of interest by comparing communities with identical characteristics at the beginning of the sample period, and exactly the same time growth paths until the 1978 aviation deregulation, when they experience differential shocks to air services with direct implications for their subsequent population growth rates.

Column 3 of Table 3 reports the results from this augmented model specification, which becomes our preferred specification. The coefficient on the variable of interest remains positive and significant, with a one percent increase in the air traffic growth rate generating on average a 0.03 percent increase in the annual population growth rate, or a cumulative 0.60 percent increase over a 20-year period. Increasing the rate of air passenger traffic growth from the 25th percentile to the 75th percentile level (i.e., a 4.6 percent change) leads on average to a 0.14 percent increase in the annual population growth rate. To put our result in perspective, this estimate represents 11.7 percent of the average annualized rate of population growth observed across MSAs over the 23-year sample period.[25]

We further verify if the estimated elasticity varies by size category of MSA. Column 4 reports the specification with the full set of controls for initial conditions, as well as interaction terms between passenger growth and MSA size category. While the interaction terms are negative, they are imprecisely estimated, suggesting no significant differences in the effect of air traffic growth on population growth across MSAs.

Overall, the estimates in Table 3 provide robust evidence that regional growth, as measured by population size, is directly affected by the availability of air services. Next, we investigate whether per-capita income responds in a similar matter. If air transport is an important factor of productivity growth, then the theory predicts it should directly affect per-capita income growth. Table 4 reports the estimation results following the same model specifications as in Table 3. In all specifications, the impact of air traffic on per-capita income growth is positive and significant. The magnitude of the effects decreases as we mitigate the potential for omitted variable bias by controlling for simultaneous changes in growth rates post-deregulation. Based on the preferred specification reported in column 3, increasing the air passenger growth rate from the 25th to the 75th percentile leads to a 0.20 percent increase in the annual rate of per-capita income growth on average. Given an annual income growth rate of 1.53 percent

[25] The average population growth rate over the sample period 1969-1991 is equal to 1.18 percent per year.

for the average MSA over the sample period 1969-1991, our estimate corresponds to 13.2 percent of the observed average per-capita income growth rate. These effects are bigger for small and large MSAs (see column 4), corresponding to 18 percent of the observed average income growth rate.

While there are several reasons why population growth may be preferred to employment as an indicator of regional growth, it is customary in the urban economics literature to investigate the effects of air traffic on regional employment. Significant research work has shown that agglomerations, through the positive externalities they provide, represent a strong force of attraction for future businesses. The effect of air passenger services on employment growth may operate not only through productivity effects, but also through quality of life considerations (i.e., urban amenities). Given the high correlation between employment and population across MSAs, both in terms of levels and growth rates, we have additional reasons to expect significant effects. The results reported in Table 5 confirm that. Again, columns 1 to 4 provide the results from specifications that increase in the set of control variables for the regional growth path. Focusing on the preferred specification in Column 3, we find that a one percent increase in regional air traffic leads on average to 0.07 percent increase in annual employment growth, or a cumulative 1.35 percent growth in employment over a 20-year period. This result is comparable with estimates in the literature.[26] The coefficient is larger in magnitude than the effect of traffic growth on population, suggesting that there are additional channels through which traffic affects employment growth, which operate independent of population growth.[27]

To better understand the economic magnitude of our finding, it is useful to contrast the estimated effects with actual employment growth rates. Increasing an MSA's rate of air traffic growth from the 25th percentile to the 75th percentile (i.e., a 4.6 percent change) leads on average to an increase in employment of 0.31. This corresponds to 11 percent of the average annual employment growth rate observed over the 23-year

[26] It is useful to note that our estimates in column 4 of Table 5 can be compared with results in the literature if one assumes that the parameters in the regression model given by equation (14) are the same underlying parameters as in a regression model expressed in *levels*, i.e., $lnY_{it} = \beta lnT_{it} + \alpha_t + \alpha_i + \alpha_i * t + \theta X_i * \alpha_t + \epsilon_{it}$. In particular, under this model assumption, our results suggest that a 10 percent increase in the air passenger traffic at a large MSA leads to a 0.9 - 1 percent increase in employment, which is very similar to the estimate obtained by Brueckner (2003) from a cross-section of 91 predominantly large MSAs. Our results also relate to the findings of Duranton and Turner (2012), who find that a 10 percent increase in the stock of highways leads to a 1.1 percent growth in employment over a 20-year period.

[27] In unreported regressions, we have estimated all the specifications reported in Table 5 with the MSA population growth rates included as control variables. The estimated effect of air traffic on employment growth was always positive and significant even net of population growth effects.

sample period. The interaction terms reported in Column 4 reveal that these average employment effects are heterogeneous across MSA size categories, being mainly driven by small and large MSAs. In fact, the employment gains to small urban areas from increased growth in air passenger traffic represent 16 percent of the observed average sample employment growth rate.[28]

To bring further evidence on the employment effects of air traffic, in Table 6 we investigate which sectors respond in their demand for labor to changes in air traffic. Studies analyzing the impact of road infrastructure find robust evidence that retail and wholesale industries benefit the most from improved market access and lower transportation costs (e.g., Michaels, 2008). Our results reported in Table 6 are consistent with their findings. The total employment effects previously estimated are mainly driven by growth in employment in trade-related industries.[29]

4.3. Robustness Checks

The identification strategy that we pursue in this study exploits the exogenous variation in the long run growth rates generated by the quasi-natural experiment of the 1978 Airline Deregulation Act. Working with historical data covering two consecutive long term periods has the great advantage of being able to exploit the MSA growth rates from the pre-treatment period as a counterfactual for what subsequent growth rates should have been in the absence of the policy shock. This estimation approach removes many unobservable factors that influence both the demand for air transport and the level of economic development at regional level, mitigating severe endogeneity concerns coming from simultaneity or omitted variables.

Nevertheless, one could still worry that previous growth rates in population and per-capita income may influence air carriers' decision to supply air service in a region after deregulation, thus determining the size of passenger traffic post-deregulation. If such serial correlation is happening in the data and none of the control variables are already accounting for it, then high population growth during 1969-1977 will be positively correlated with passenger growth during the subsequent period 1977-1991, as well as with subsequent urban growth measures. To account for this possibility, as a robustness check we re-estimate our preferred specification with additional controls for those MSAs

[28]The small estimates found for medium-sized MSAs should be interpreted with some caution. To the extent that the insignificant results are a consequence of little data variation available in medium size MSAs, this finding should not be taken necessarily as saying that medium MSAs do not benefit from the availability of good air service.

[29]Given that our sample period starts in 1969, when most interstate highway constructions projects were already completed, we do not believe that our results capture the effects of road construction.

that witness particularly high or particularly low population growth over the initial time period. More precisely, within each MSA size category (i.e., small, medium, large) we identify those communities that belong to the top and bottom quartiles based on population growth during the period 1969-1977. We then estimate our preferred specification using these additional 6 indicator variables interacted with the deregulation time dummy. This implicitly controls for any systematic differences in growth rates over time that take place among, for example, small and fast growing MSAs versus large and slow growing ones. However, the estimate on air traffic growth barely changes in magnitude, maintaining its sign and significance irrespective of the urban growth measure to be explained. For this reason and in the interest of space, we only make these results available upon request.

Despite the exogeneity of the policy experiment and the range of controls that we already account for, reverse causality may still be a potential issue with our findings so far. In particular, it may be the case that positive shocks to income growth that occur in some communities in the period after the aviation deregulation generate both an increase in the demand for consumption goods, which triggers employment in retail and wholesale sectors, as well as an increase in the consumption of air travel services (viewed as a luxury good). Of course, such a scenario must happen systematically across certain MSAs to generate the consistently positive and significant results obtained so far. However, communities in the close proximity of large metropolitan areas may in fact be a case in point. Economic geography forces such as market and supplier access could provide possible reasons for why these locations may experience positive income shocks, and also be strategic locations for wholesale and retail establishments.[30] If these positive income shocks also determine consumers in these locations to enjoy more air travel, then the effect of air traffic on urban growth must be larger for the MSAs located in the vicinity of large urban areas. Table 7 reports the results from a specification augmented with an interaction term between the air traffic growth rate and and indicator for the small and medium sized MSAs located within 150 miles from a large metropolitan area. In all specifications the sign of the interaction term is negative although not always precisely estimated.[31] Based on results in columns 2 and 4 respectively, we conclude that there

[30] Appendix Table A1 provides some evidence that small and medium size MSAs located within 150 miles from large urban areas witness a positive change in income, and a positive yet insignificant change in population and employment growth over the two time periods. The reported coefficients are estimated from a regression model having as dependent variable: $\Delta y_i = \frac{1}{14} log(\frac{y_{i,1991}}{y_{i,1977}}) - \frac{1}{8} log(\frac{y_{i,1977}}{y_{i,1969}})$, where $y \in$ {population, income, employment} and i indexes an MSA.

[31] The distance between two MSAs is calculated as the straight line distance between the airports hosted by those cities. Therefore, there is some noise in our constructed distance measures when compared to actual distances between their centroids. This may lead to attenuation bias in the regression

is some evidence that proximity to large cities makes population and income growth in small communities less responsive to changes in air passenger traffic.

5 Conclusion and Policy Implications

Public spending on aviation at federal, state and local level have constantly increased since the beginning of commercial aviation, reaching 10 percent of total public spending on infrastructure by 2004 (CBO, 2007). To evaluate the benefits of such resource allocations, it is crucial that we understand the implications of these investments for regional development and economic growth. Surprisingly, this research question has received little attention in the empirical literature, to a large extent because of the difficulty in going beyond correlations to identify actual causation.

This paper exploits the quasi-natural experiment created by the signing of the 1978 Airline Deregulation Act in order to more rigorously identify the link between airline traffic and local economic growth. Our findings suggest that exogenous increases in air service lead to statistically and economically significant increases in regional growth. For example, increasing the annual growth rate of air passenger traffic in a given MSA from the 25th percentile to the 75th percentile level leads to additional regional population growth in a MSA that is equivalent to 11.7 percent of the average annual rate of population growth observed over our 23-year sample period (we get similar magnitudes with respect to air service effects on per-capita income and employment growth). From these estimates, one can do simple calculations about how much a region may gain in additional income from increased air service. For example, an average MSA that witnesses an increase in the air traffic growth rate equivalent to a move from the 25th percentile to the 75th percentile level observed in our data sample will gain in discounted present value terms a 2.9 percent increase in its total real GDP over a 15-year period, on average.[32] This estimate is equivalent to a total discounted present value of 209 million dollars in 1978.

Our analysis also finds that differences can be observed across communities based on their average size and geographic location. In particular, medium size MSAs seem to benefit to a lesser degree from air traffic growth, while smaller communities located in close proximity of large hub cities appear to be less sensitive to local changes in air services. We also find evidence for shifts in industrial composition associated with a

estimates.

[32] This estimate combines the effects of air service on population growth and per-capita income growth over the same time interval.

growth in aviation networks. When estimating the employment effects by sector, we find that wholesale and retail industries are the ones experiencing significant growth effects.

These findings are important for better understanding the determinants of regional growth, but also for influencing policies designed to allocate public infrastructure spending. And while the identification strategy forced us to focus on a period of time when commercial aviation might not have been as essential to consumers and businesses as it is today, this observation could only reinforce our results. From this perspective, the estimated effects may be taken as a lower bound.

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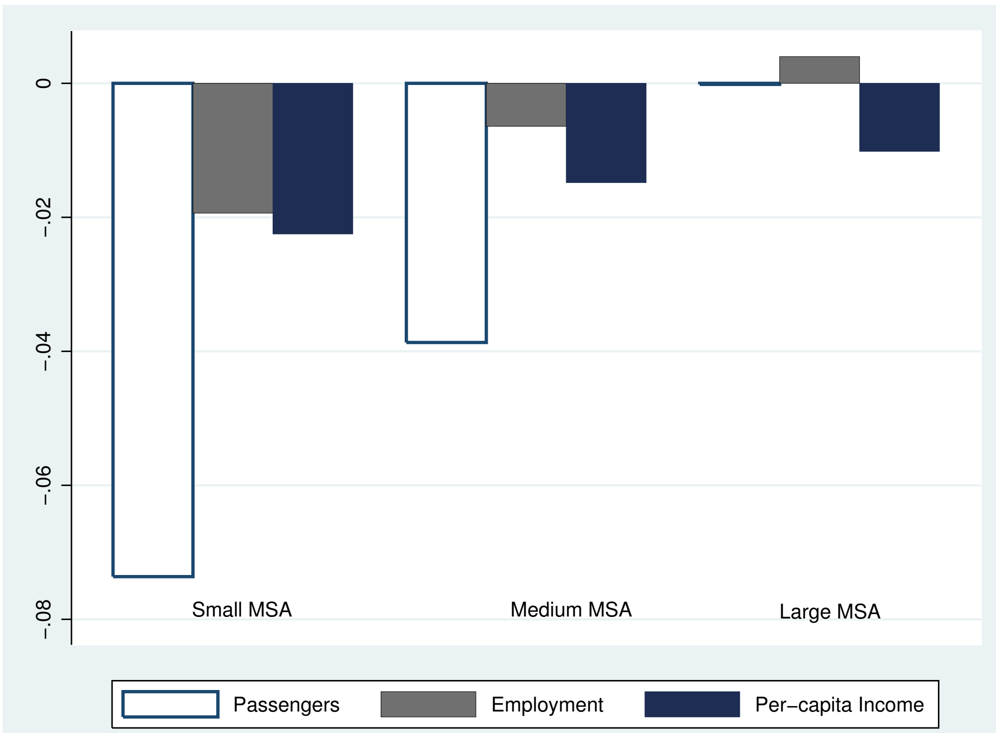


Figure 1: Changes in Growth Rates Before and After Deregulation by MSA size category

Note: For each metropolitan area in our sample, we compute the difference between the annualized long-run growth rate for the time period *following* the aviation deregulation (1991-1977), and the annualized long-run growth rate for the period *preceding* the policy change (1969-1977), as follows: $\Delta y_i = \frac{1}{14} log\left(\frac{y_{i,1991}}{y_{i,1977}}\right) - \frac{1}{8} log\left(\frac{y_{i,1977}}{y_{i,1969}}\right)$, with $y \in$ {air passenger traffic; income per capita; employment}. The graph bar plots the sample means for Δy_i by each of the three MSA size categories. This illustrates the systematic variation in growth rate changes surrounding the quasi-natural experiment of the 1978 Airline Deregulation Act.

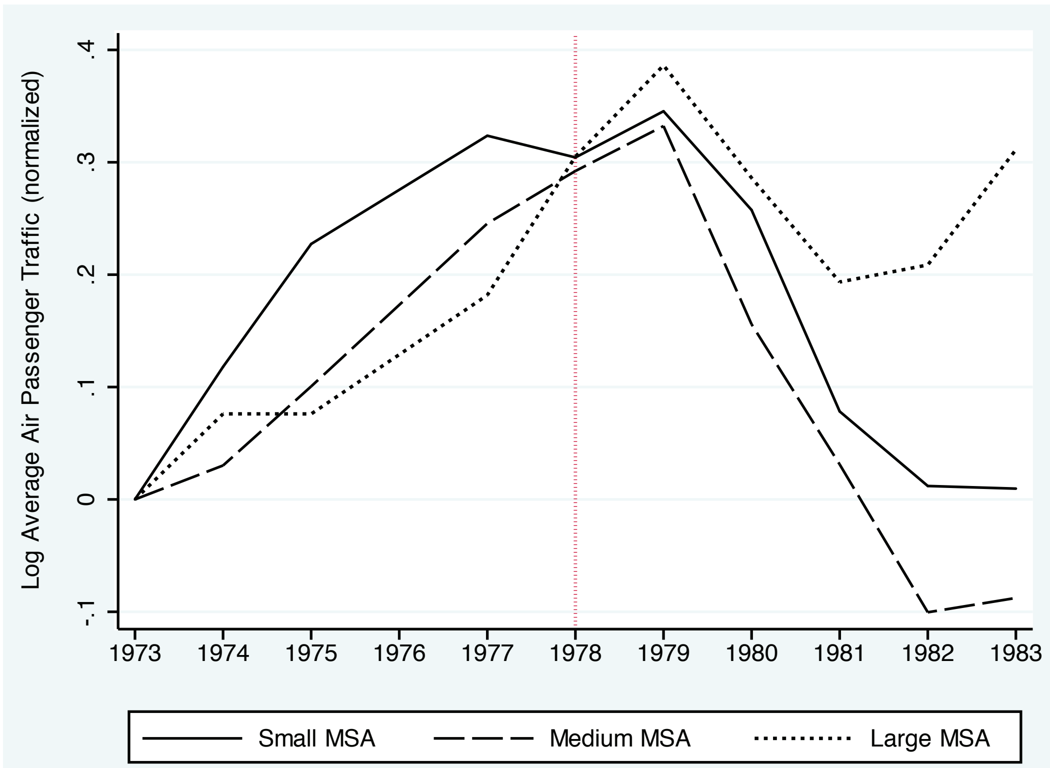
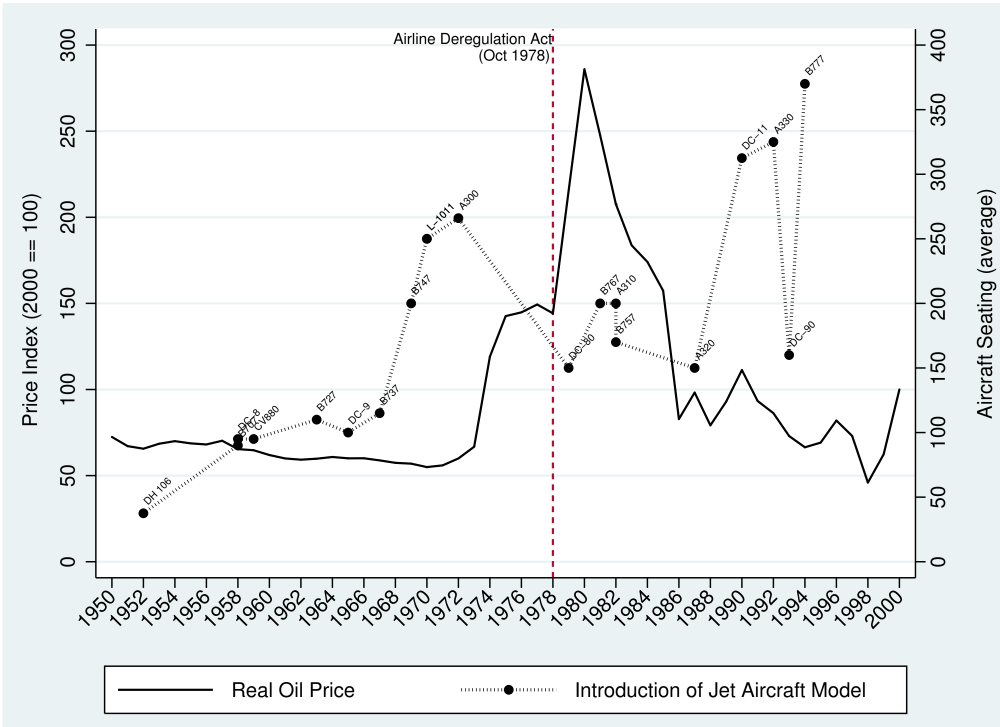


Figure 2: Trends in Air Passengers by MSA Size Category

Note: Each series plots the average (log) number of air passengers across all the MSAs in a given size category. The data is available at annual frequency between 1973 and 1983. To eliminate the level differences across urban size categories, each series was adjusted by the average value level for 1973. The use of geometric averages in constructing the trends is dictated by concerns about potential data outliers.



Source: Authors' Calculations

Figure 3: The Introduction of Jet Aircrafts and Oil Price Shocks

Note: This graph illustrates the countercyclical relationship between real oil prices and the capacity of newly introduced airline jets. Data on fuel prices is provided by IATA (International Air Transport Association). Data on the introduction of jet planes by model and average seating capacity is constructed from Wikipedia sources. This list may not be exclusive, however it covers the main aircraft manufacturers and the most common civil airplanes.

Table 1: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Growth rates: total sample					
Passenger Growth (log)	592	0.027	0.056	-0.157	0.197
Population Growth (log)	592	0.124	0.013	-0.014	0.080
Income Growth(log)	592	0.017	0.011	-0.021	0.052
Employment Growth(log)	592	0.028	0.019	-0.033	0.114
Growth rates 1969-1977					
Passenger Growth '69-'77 (log)	296	0.046	0.048	-0.157	0.197
Population Growth '69-'77 (log)	296	0.015	0.013	-0.012	0.080
Income Growth '69-'77 (log)	296	0.025	0.009	-0.021	0.052
Employment Growth '69-'77 (log)	296	0.032	0.021	-0.033	0.115
Growth rates 1977-1991					
Passenger Growth '77-'91 (log)	296	0.009	0.057	-0.156	0.150
Population Growth '77-'91 (log)	296	0.009	0.012	-0.138	0.060
Income Growth '77-'91 (log)	296	0.009	0.007	-0.136	0.025
Employment Growth '77-'91 (log)	296	0.025	0.015	-0.014	0.071
Initial Condition Variables					
Log Passengers 1969	296	11.205	1.887	7.004	16.624
Log Population 1969	296	12.005	1.367	9.425	16.644
Log Income 1969	296	9.119	0.170	8.478	9.554
Log Employment 1969	296	10.585	1.520	7.745	15.586
Share Manufacturing 1969	296	0.292	0.145	0.021	0.705
Share Services 1969	296	0.187	0.055	0.066	0.504
Share Wholesale 1969	296	0.068	0.024	0.015	0.187
Share Retail 1969	296	0.228	0.058	0.096	0.417
Share Transport/Utilities 1969	296	0.068	0.023	0.028	0.171
Share Construction 1969	296	0.066	0.029	0.023	0.282

Table 2: Correlation Coefficients

Panel A: Correlation Coefficients between Changes in Variables' Growth Rates

	Δ Passenger Growth	Δ Population Growth	Δ Income Growth	Δ Employment Growth
Δ Passenger Growth (level)	1.00			
Δ Population Growth (log)	0.31	1.00		
Δ Income Growth (log)	0.37	0.26	1.00	0
Δ Employment Growth (log)	0.40	0.57	0.65	1.00

Note: Each variable is constructed at MSA i level as follows: $\Delta y_i = \frac{1}{14}log(\frac{y_{i,1991}}{y_{i,1977}}) - \frac{1}{8}log(\frac{y_{i,1977}}{y_{i,1969}})$, with $y \in$ {passengers; per capita income; employment}.

Panel B: Correlation Coefficients between (log) Base Year Variables

	Passengers 1969	Population 1969	Income 1969	Employment 1969
Passengers 1969	1.00			
Population 1969	0.90	1.00		
Income 1969	0.51	0.50	1.00	
Employment 1969	0.89	0.98	0.52	1.00

Panel C: Correlation Coefficients between Variables' Growth Rates across Periods

	Passenger Growth 69-77	Population Growth 69-77	Income Growth 69-77	Employment Growth 69-77	Passenger Growth 77-91	Population Growth 77-91	Income Growth 77-91	Employment Growth 77-91
Passenger Growth 69-77	1.00							
Population Growth 69-77	0.54	1.00						
Inccome Growth 69-77	0.21	0.15	1.00					
Emplloyment Growth 69-77	0.49	0.75	0.43	1.00				
Passenger Growth 77-91	0.16	0.32	-0.20	0.07	1.00			
Population Growth 77-91	0.40	0.72	-0.09	0.52	0.48	1.00		
Income Growth 77-91	-0.04	0.03	-0.36	-0.13	0.32	0.10	1.00	
Employment Growth 77-91	0.34	0.58	-0.20	0.42	0.44	0.81	0.45	1.00

Table 3: Effect of Air Service on Population Size

	Population Growth Rate (log)			
	(1)	(2)	(3)	(4)
Passenger Growth Rate (log)	0.043**	0.028*	0.030*	0.041$^+$
	[0.012]	[0.014]	[0.014]	[0.024]
Passenger Growth * Medium MSA				-0.022
				[0.021]
Passenger Growth * Large MSA				-0.015
				[0.026]
Post	-0.004**	-0.007**	-0.126**	-0.129**
	[0.001]	[0.002]	[0.042]	[0.042]
Post * Medium MSA		0.001		
		[0.001]		
Post * Large MSA		0.006**		
		[0.002]		
Post * Population_{1969}			0.002**	0.002*
			[0.001]	[0.001]
Post * Income_{1969}			0.010*	0.011*
			[0.004]	[0.004]
Post * $\text{Sh\_Manufacturing}_{1969}$			0.001	0.001
			[0.003]	[0.003]
Post * $\text{Sh\_Services}_{1969}$			-0.004	-0.004$^+$
			[0.002]	[0.002]
Post * Sh_Retail_{1969}			0.011*	0.011*
			[0.005]	[0.005]
Post * $\text{Sh\_Wholesale}_{1969}$			-0.002	-0.002
			[0.002]	[0.002]
Post * $\text{Sh\_Transp/Utilitities}_{1969}$			-0.000	-0.001
			[0.002]	[0.002]
Post * $\text{Sh\_Construction}_{1969}$			-0.003$^+$	-0.003$^+$
			[0.002]	[0.002]
MSA fixed effect	yes	yes	yes	yes
Observations	592	592	592	592
R-squared	0.359	0.397	0.454	0.459

** $p < 0.01$, * $p < 0.05$, $^+p < 0.1$. Robust standard errors in brackets.

Notes: The reported results correspond to the regression equation (14) in the main text. The constructed panel includes only two time periods surrounding the 1978 aviation deregulation, 1969-1977 and 1977-1991, with the post-deregulation time effects controlled by the dummy variable *Post*. The dependent variable represents the long-run annual population growth rate calculated at MSA level over two time periods. The main variable of interest is the long run air passenger growth rate and is calculated in the same way. Each specification includes MSA fixed effects, which account for average growth trends across metropolitan areas. Initial economic conditions characterizing the MSAs at the beginning of the sample period are interacted with the *Post* dummy to capture differential changes in urban growth over time. Base year population terciles are used to construct small/medium/large MSA size groups.

Table 4: Effect of Air Passenger Travel on Local Per-Capita Income

	Per-Capita Income Growth Rate (log)			
	(1)	(2)	(3)	(4)
Passenger Growth Rate (log)	0.072**	0.049**	0.044**	0.059**
	[0.013]	[0.014]	[0.013]	[0.018]
Passenger Growth * Medium MSA				-0.043*
				[0.021]
Passenger Growth * Large MSA				0.009
				[0.026]
Post	-0.013**	-0.019**	-0.074^{+}	-0.080^{+}
	[0.001]	[0.002]	[0.177]	[0.174]
Post * Medium MSA		0.006**		
		[0.002]		
Post * Large MSA		0.008**		
		[0.002]		
Post * Population$_{1969}$			0.003**	0.003**
			[0.001]	[0.001]
Post * Income$_{1969}$			0.005	0.006
			[0.005]	[0.005]
Post * Sh_Manufacturing$_{1969}$			0.007**	0.007**
			[0.002]	[0.002]
Post * Sh_Services$_{1969}$			0.004	0.004
			[0.004]	[0.004]
Post * Sh_Retail$_{1969}$			0.016**	0.015**
			[0.005]	[0.005]
Post * Sh_Wholesale$_{1969}$			-0.009**	-0.008**
			[0.003]	[0.003]
Post * Sh_Transp/Utilitities$_{1969}$			-0.002	-0.003
			[0.003]	[0.003]
Post * Sh_Construction$_{1969}$			0.004^{+}	0.004^{+}
			[0.002]	[0.002]
MSA fixed effect	yes	yes	yes	yes
Observations	592	592	592	592
R-squared	0.642	0.667	0.727	0.733

** $p < 0.01$, * $p < 0.05$, $^{+}p < 0.1$. Robust standard errors in brackets.

Notes: The reported results correspond to the regression equation (14) in the main text. The constructed panel includes only two time periods surrounding the 1978 aviation deregulation, 1969-1977 and 1977-1991, with the post-deregulation time effects controlled by the dummy variable *Post*. The dependent variable represents the long-run annual per-capita income growth rate calculated at MSA level over two time periods. The main variable of interest is the long run air passenger growth rate and is calculated in the same way. Each specification includes MSA fixed effects, which account for average growth trends across metropolitan areas. Initial economic conditions characterizing the MSAs at the beginning of the sample period are interacted with the *Post* dummy to capture differential changes in urban growth over time. Base year population terciles are used to construct small/medium/large MSA size groups.

Table 5: Effect of Air Passenger Travel on Local Employment

	Employment Growth Rate (log)			
	(1)	(2)	(3)	(4)
Passenger Growth Rate (log)	0.120**	0.077**	0.067**	0.100**
	[0.024]	[0.026]	[0.024]	[0.037]
Passenger Growth * Medium MSA				-0.081*
				[0.034]
Passenger Growth * Large MSA				-0.011
				[0.046]
Post	-0.002^{+}	-0.013**	-0.137*	-0.149*
	[0.001]	[0.003]	[0.068]	[0.067]
Post * Medium MSA		0.009**		
		[0.003]		
Post * Large MSA		0.017**		
		[0.003]		
Post * Population$_{1969}$			0.004**	0.003**
			[0.001]	[0.001]
Post * Income$_{1969}$			0.009	0.011
			[0.008]	[0.008]
Post * Sh_Manufacturing$_{1969}$			0.012**	0.012**
			[0.004]	[0.004]
Post * Sh_Services$_{1969}$			-0.001	-0.002
			[0.005]	[0.006]
Post * Sh_Retail$_{1969}$			0.012	0.011
			[0.007]	[0.007]
Post * Sh_Wholesale$_{1969}$			-0.009**	-0.007*
			[0.003]	[0.003]
Post * Sh_Transp/Utilitities$_{1969}$			-0.005	-0.006
			[0.004]	[0.004]
Post * Sh_Construction$_{1969}$			0.002	0.001
			[0.003]	[0.003]
MSA fixed effect	yes	yes	yes	yes
Observations	592	592	592	592
R-squared	0.244	0.325	0.474	0.490

** $p < 0.01$, * $p < 0.05$, $^{+}p < 0.1$. Robust standard errors in brackets.

Notes: The reported results correspond to the regression equation (14) in the main text. The constructed panel includes only two time periods surrounding the 1978 aviation deregulation, 1969-1977 and 1977-1991, with the post-deregulation time effects controlled by the dummy variable *Post*. The dependent variable represents the long-run annual employment growth rate calculated at MSA level over two time periods. The main variable of interest is the long run air passenger growth rate. Each specification includes MSA fixed effects, which account for average growth trends across metropolitan areas. Initial economic conditions characterizing the MSAs at the beginning of the sample period are interacted with the *Post* dummy to capture differential changes in urban growth over time. Base year population terciles are used to construct small/medium/large MSA size groups.

Table 6: Effect of Air Passenger Travel on Local Employment by Sector

	Sector Employment Growth Rate			
	Manufacturing	Services	Wholesale	Retail
	(1)	(2)	(3)	(4)
Passenger Growth Rate (log)	0.042	0.046	0.120**	0.54**
	[0.043]	[0.031]	[0.040]	[0.018]
Post	-0.331^{+}	-0.107	-0.371*	-0.051
	[0.183]	[0.121]	[0.155]	[0.068]
Post * Employment$_{1969}$	-0.012	-0.002	0.016^{+}	0.015
	[0.011]	[0.010]	[0.008]	[0.005]
Post * Population$_{1969}$	0.011	0.006	-0.010	-0.012*
	[0.010]	[0.009]	[0.008]	[0.005]
Post * Income$_{1969}$	0.045*	-0.015	0.035	-0.000
	[0.020]	[0.014]	[0.022]	[0.007]
Post * Sh_Manufacturing$_{1969}$	0.033**	0.007	0.004	0.005
	[0.009]	[0.006]	[0.006]	[0.004]
Post * Sh_Services$_{1969}$	0.026^{+}	0.008	0.015	-0.017**
	[0.014]	[0.007]	[0.017]	[0.004]
Post * Sh_Retail$_{1969}$	0.005	-0.002	-0.022	0.036**
	[0.021]	[0.012]	[0.026]	[0.009]
Post * Sh_Wholesale$_{1969}$	0.008	-0.006	-0.008	-0.008*
	[0.009]	[0.005]	[0.009]	[0.003]
Post * Sh_Transp/Utilitities$_{1969}$	-0.017	0.001	0.009	-0.007^{+}
	[0.011]	[0.006]	[0.009]	[0.004]
Post * Sh_Construction$_{1969}$	0.009	0.007	0.003	-0.006*
	[0.009]	[0.005]	[0.007]	[0.003]
MSA fixed effect	yes	yes	yes	yes
Observations	586	592	590	592
R-squared	0.303	0.151	0.319	0.498

** $p < 0.01$, * $p < 0.05$, $^{+}p < 0.1$. Robust standard errors in brackets.

Note: The reported results correspond to the regression equation (14) in the main text. The constructed panel includes only two time periods surrounding the 1978 aviation deregulation, 1969-1977 and 1977-1991, with the post-deregulation time effects controlled by the dummy variable *Post*. The dependent variable measures long-run annual growth rates in sector level employment *shares* calculated at MSA level over the two time periods. The main variable of interest is the long run air passenger growth rate. Each specification includes MSA fixed effects, a time dummy to control for the post-deregulation time effects, and interaction terms between initial economic conditions and the *Post* dummy to capture differential changes in urban growth over time. Base year population terciles are used to construct small/medium/large MSA size groups.

Table 7: Robustness Check: Effect of Proximity to Large Airport Hubs for Small and Medium size MSAs

	Population Growth Rate		Income Growth Rate		Employment Growth Rate	
	(1)	(2)	(3)	(4)	(5)	(6)
Passenger Growth Rate	0.035*	0.033*	0.058**	0.047**	0.086**	0.069*
	[0.016]	[0.015]	[0.016]	[0.014]	[0.029]	[0.026]
D(Dist<150 & S, M) * Passenger Gr.	-0.035*	-0.019	-0.048^{+}	-0.015	-0.052	-0.014
	[0.018]	[0.016]	[0.024]	[0.022]	[0.034]	[0.028]
Post	-0.007**	-0.124*	-0.018**	-0.072^{+}	-0.012**	-0.136*
	[0.002]	[0.042]	[0.002]	[0.044]	[0.003]	[0.068]
Post * Medium MSA	0.001		0.005**		0.009**	
	[0.001]		[0.002]		[0.003]	
Post * Large MSA	0.005**		0.008**		0.016**	
	[0.002]		[0.002]		[0.003]	
Post * Population_{1969}		0.002**		0.003**		0.004**
		[0.001]		[0.001]		[0.001]
Post * Income_{1969}		0.010*		0.005		0.009
		[0.004]		[0.005]		[0.008]
Post * $\text{Sh\_Manufacturing}_{1969}$		0.001		0.007**		0.012**
		[0.003]		[0.002]		[0.004]
Post * $\text{Sh\_Services}_{1969}$		-0.004		0.005		-0.001
		[0.002]		[0.004]		[0.005]
Post * Sh_Retail_{1969}		0.010*		0.015**		0.011
		[0.005]		[0.005]		[0.007]
Post * $\text{Sh\_Wholesale}_{1969}$		-0.002		-0.008**		-0.008*
		[0.002]		[0.003]		[0.003]
Post * $\text{Sh\_Transp/Utilitities}_{1969}$		-0.000		-0.002		-0.005
		[0.002]		[0.003]		[0.004]
Post * $\text{Sh\_Construction}_{1969}$		-0.027**		0.008		0.001
		[0.009]		[0.015]		[0.018]
MSA fixed effect	yes	yes	yes	yes	yes	yes
Observations	592	592	592	592	592	592
R-squared	0.405	0.456	0.672	0.728	0.330	0.474

** $p < 0.01$, * $p < 0.05$, $^{+}p < 0.1$. Robust standard errors in brackets.

Note: The results report estimates from augmenting the preferred specification reported in the third column of Tables 3, 4 and Table 5 respectively, with information on economic geography. The variable *D(Dist<150 & S, M)* is an indicator variable equal to one if a Small or Medium size MSA lies within 150 miles from a large hub airport (as classifies by the Federal Aviation Administration). Its interaction with the variable of interest identifies any differential response of smaller communities to changes in air passenger growth based on proximity to large airport hubs.

A Appendix Tables

Table A1: The Effect of Proximity to a Large Hub on Changes in Growth Rates for the Variables of Interest

	Δ Population Growth	Δ Income Growth	Δ Employm. Growth
	(1)	(2)	(3)
D(Dist<150 & S, M)	0.002	0.006**	0.005
	[0.001]	[0.002]	[0.003]
Population 1969 (log)	0.001	0.004**	0.006**
	[0.001]	[0.001]	[0.002]
Per Capita Income 1969 (log)	0.011*	0.005	0.004
	[0.005]	[0.005]	[0.009]
Medium MSA==1	0.000	0.002	0.004
	[0.001]	[0.002]	[0.003]
Large MSA==1	0.003	-0.000	0.006
	[0.003]	[0.004]	[0.005]
Constant	-0.118**	-0.108*	-0.117
	[0.038]	[0.046]	[0.072]
Observations	296	296	296
R-squared	0.158	0.212	0.236

** $p < 0.01$, * $p < 0.05$, $^{+}p < 0.1$. Robust standard errors in brackets.

Notes: Each dependent variable is constructed at MSA i level as follows: $\Delta y_i = \frac{1}{14} log(\frac{y_{i,1991}}{y_{i,1977}}) - \frac{1}{8} log(\frac{y_{i,1977}}{y_{i,1969}})$, with $y \in$ {passengers; per capita income; employment}. The variable *D(Dist<150 & S, M)* is an indicator variable equal to one if a Small or Medium size MSA lies within 150 miles from a large hub airport (as classifies by the Federal Aviation Administration). All other variables are self explanatory.