# Airport Runway Capacity and Economic Development:

# A Dynamic Panel Data Analysis of Metropolitan Statistical Areas*

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## Abstract

**Abstract**



This study analyzes the economic development impact of airport capacity in metropolitan areas that have one commercial airport. Based upon panel data for 33 medium and large airports over a 7 year period 2001 – 2007, there is a positive relationship between the number of runways and real GMP, all else constant including runway length. A more detailed analysis revealed that an additional runway had differential effects (positive and negative) across the metropolitan areas. Longer average flight delays were an important determinant of economic development, decreasing gross metropolitan product 2.9% and labor productivity 1.31%. In a probit analysis of new runway additions for the period 1991 – 2007, annual passenger growth rate, freight shipped per runway, and land area of the airport increase the likelihood of a new runway. This study provides new findings on the effects that airport public capital and, specifically runways, have upon MSA economic development. Yet, more research is required to better understand the linkages between airport capacity and economic development and to expand upon those factors which increase the likelihood that a MSA will add a new runway.



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| JEL Classification | O18, R11, R41, R53 |

## I Introduction

Accounting for economic growth presents a persistent difficulty as many measures exist that reflect growth and economic development. An economic approach to identifying changes in growth and development focuses on available resources and choices. Assuming that individual market participants make decisions in their own best interest, changes in the quantity and productivity of resources at the aggregate level will be consistent with economic development, growth, and economic welfare.

In this study, we focus on aggregate measures of resources. These measures include real wages, employment, and physical capital. We adopt an aggregate production function to model economic activity within a metropolitan area using traditional factors of production and their contributions in different economic sectors. Within this context, public capital or infrastructure (e.g. highways, water systems) is a factor of production that contributes to economic development and growth. In contrast to most analyses, however, this study focuses upon airport infrastructure, and in particular runways. This study develops and estimates models that analyze the impact of airport runways on economic development in metropolitan areas.

Similar to other aggregate productivity studies that include public capital, runways are an input into a metropolitan area's production function and interact with labor, capital, and other factors to generate metropolitan output. An increasing number of runways reduces transactions costs across many margins and facilitates economic development and growth. However, runways are discrete and their use is subject to initial low marginal costs which then begin to rise as congestion sets in and ultimately become infinite as take-offs and landings near the technical limit for safe operations. Once take offs and landings reach this limit, the resource costs of additional throughput becomes a choke point whose sustained effects can retard economic growth.

For this study, we use real gross metropolitan product, the output of goods and services, to measure the level of economic activity in a metropolitan area. Gross output at the metropolitan level is particularly relevant since the objective is to identify the economic impact of runways. The strongest effects are likely to occur in the metropolitan area where the airport is located and these effects are expected to diminish with distance from the metropolitan area.[1]

[1] Similar to gross state and gross domestic product, gross metropolitan product does not include non-market transactions and an area's environmental profile (e.g. air pollution, water quality, traffic congestion), Hence, measures of output do not measure economic welfare. However, assuming that market participants act in their own self interests, these measures

## II Review of Literature

Since the 1980s, there has been an increasing number of papers analyzing the impact of public capital on economic growth and exploring the extent to which public capital affects total factor productivity and economic growth.[2] Researchers use two main approaches to analyze the relationship between the stock or flow of public capital and aggregate or private output: 1) an aggregate production function approach to estimate the impact of capital, labor, and public capital on economic growth; and 2) a cost function to estimate the effect of public capital on costs of private production.

Costa, Richard, and Martin (1987) estimate the impact of public capital on regional output at the state level using a translog production function. Defining public capital as outlays of state and local governments, the study finds that public capital experiences diminishing returns with respect to gross value of production and the results support the inference that labor and public capital are complements.

Aschauer (1989) considers the relationship between aggregate productivity and the stock and flow of government expenditures on public infrastructure over the period from 1949 – 1985. This study estimates a significant private return to public capital where a 1 percent increase in the ratio of public to private capital stocks raises total factor productivity by 0.39 percent.[3]

Munnell (1990a), building upon Aschauer's findings, explores whether changes in the amount of public capital combine with the growth of private capital and labor to explains the productivity slowdown in the 1970s.[4] Assuming that services are proportional to the public sector capital stock and under constant returns to scale, Munnell finds that a 1 percent increase in public capital increases labor productivity by 0.31 to 0.39 percent for total nonmilitary public capital and core infrastructure, respectively.[5]

Munnell (1990b) uses a translog production function approach to estimate the impact of public capital on gross state product (GSP) at the state and regional level. Since no observations on the stock of private or public capital are available on a state-by-state basis, Munnell segregates the

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are expected to be positively correlated with economic welfare so that an increase (decrease) in GMP is expected to increase (decrease) economic welfare.

[2] Aschauer, 1989, p194.

[3] Aschauer, 1989, p182.

[4] Munnell, 1990, p4.

[5] Detailed discussion is included in the appendix of Munnell, A.H., *Why Productivity Growth Declined? Productivity and Public Investment*. New England Economic Review, 1990(Jan./Feb.): p. 3-22.

national totals based on input category.[6] In this study, Munnell estimates a 0.15 elasticity on public capital, more than half the value found in Aschauer (1989) and Munnell (1990a).

In a further analysis, Munnell analyzes the impact of various components of public capital on output and finds that the major impact on output from derives from highways (0.06) and water and sewer systems (0.12)[7]. And in a regional analysis, Munnell reports uniformly positive but varying elasticities of the productivity of public capital: 0.07 for the Northeast, 0.12 for North Central states, 0.36 for the South, and 0.08 for the West.[8]

Eisner (1991) utilizes the same dataset as Munnell (1990b) and replicates the calculations using pooled time series, pooled cross section, and first difference regression equations to explore the disparity between the national level and state level results. Eisner's time series analysis approach does not yield a statistically significant estimate for the elasticity of public capital under the assumption of constant return to scale. However, his cross section analysis estimates the elasticity of public capital with respect to gross state product at 0.165.[9] These results suggest that more public capital generates a larger gross state product.

Tatom (1991) presents a theoretical argument critical of the existing public capital hypothesis and reviews the claims made by proponents of the infrastructure deficit view. Tatom argues that most of the previous literature does not account for nonstationarity in the time series, ignores the trend or broken trend of productivity, and overlooks the impact of changing energy prices. Accounting for these will reduce conventional estimates of elasticity of private capital output to public capital by 30-40 percent to 0.13 percent for a 1 percent change in public capital.

Holtz-Eakin (1994) argues that refined empirical methodology reconciles the differences between those who support the hypothesis that public sector capital affects the private sector output and those who do not. Estimates of production function that control for unobserved, state-specific characteristics reveals no role for public capital in affecting private sector productivity.[10] Only estimates of state production functions that do not include such controls find substantial productivity impacts.[11]

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[6] Munnell, 1990b, p12. The Bureau of Labor Statistics publishes the national totals.
[7] Munnell, 1990b, p17.
[8] Eisner, 1991, p47.
[9] Eisner, 1991, p48.
[10] Holtz-Eakin, 1994, p12.
[11] Holtz-Eakin, 1994, p12.

Garcia-Mila, McGuire, and Porter (1996) presents the analysis of the effect of public capital on gross state product in state-level production function using observations for the 48 contiguous states from 1970-1983. This study tests for random effects, fixed effects, nonstationarity, endogeneity of the private inputs, and measurement error. The systematic investigation leads the authors to choose the first difference with fixed state effects as the preferred specification. In the presence of a statistically significant estimate for private capital and the absence of a statistically significant estimate for public capital, Garcia-Mila, McGuire, and Porter conclude that only private capital impacts private output within the frame work of an aggregate production function. This result is consistent with Holtz-Eakin (1994).

A number of recent studies focus upon explicitly upon airports and economic development. Exploring air passenger travel and urban development, Goetz (1992) finds a positive correlation between increases in per capita passenger flows and past and future urban growth, consistent with the notion that air travel is important for economic development. Hakfoort et al. (2001) and Brueckner (2003) study the impact that airports have upon metropolitan employment. Using an input-output framework to analyze the effects on the Greater Amsterdam region from an expansion at Amsterdam's Schiphol Airport, Hakfoort et al. find a 1-1 relationship, a one job increase at Schiphol producing 1 job from indirect and induced effects. Exploring linkages between employment and air traffic in the Chicago metropolitan area, Brueckner (2003) finds that a 1% increase in passenger enplanements increases employment in service related industries 0.1%. This has important implications for metropolitan development from airport expansions. Brueckner's results indicate that expanding Chicago O'Hare International Airport would generate 185,000 service related jobs.

Green (2007) uses various measures of airport passenger and cargo activity to analyze the linkage between airports and metropolitan growth. After controlling for various factors, Green finds passenger activity is a strong predictor of population and employment growth.

The current study adds to the literature on the productivity of public capital and, in particular, airports and runway capacity. Further, in focusing upon metropolitan growth and development, this study adds to the developing literature on the role of airports in metropolitan growth and will have implications for regional, metropolitan, and local policy makers.

## III Empirical Methodology

Consider a MSA aggregate production function with two inputs, $Q_{it} = f(L_{it}, K_{it}; \gamma)$, where $Q_{it}$ is aggregate output, $L_{it}$ is aggregate labor, and $K_{it}$ is aggregate private capital for MSA i in year t. $\gamma$ is the state of technology. Assuming standard neoclassical production theory, this framework and the underlying properties of the production function are sufficiently general to address a wide variety of questions, depending on one's purpose. For example, including public capital as an explicit input enables one to explore the impact that public capital has on private output (i.e. the productivity of public capital); and in a framework with more than two inputs, one can explore whether pairs of inputs are substitutes or complements in production.

Our analysis adopts a commonly employed Cobb-Douglas aggregate production function in order to motivate the empirical model. A Cobb-Douglas production function is multiplicative in inputs and generates a double log empirical specification.[12] Including public capital $R_{it}$ as a factor of production gives the following Cobb-Douglas specification for metropolitan output:

$$GMP_{it} = A_i L_{it}^{\alpha_2} K_{it}^{\alpha_3} R_{it}^{\alpha_4} e^{\varepsilon_{it}} ,$$

where $A_i$ is a constant (reflects fixed effects), $\alpha_2$, $\alpha_3$, and $\alpha_4$ are parameters to be estimated, and $\varepsilon_{it}$ is a stochastic term. Taking the logarithm of both sides gives

$$(1) \qquad \ln(GMP_{it}) = \alpha_i + \alpha_2 \ln L_{it} + \alpha_3 \ln K_{it} + \alpha_4 \ln R_{it} + \alpha_4 \, Year_t + \varepsilon_{it}$$

where $\alpha_i = \ln(A_i)$ is a fixed effect for cross section i, $Year_t$ is a trend variable which reflects technological and other unobserved factors that change over time, and $\varepsilon_{it}$ is an error term.

[12] The Cobb-Douglas and similar empirical forms have a number of econometric problems including endogeneity ($GMP_{it}$ depends on $L_{it}$, $K_{it}$, and $G_{it}$ and each of the inputs depends on $GMP_{it}$ as well as the other inputs), multicollinearity among the inputs, and heteroskedasticity (non-constant variance).The source of some of these problems reflect decisions made at the microeconomic level. Because private or public managers face similar economic environments and resource constraints, they tend to make similar marginal allocations of productive inputs. At the individual level, the effects of these decisions are evident as labor and capital decision move together with (private and public) output over time. At the MSA level, gross metropolitan product reflects the cumulative decisions on aggregate labor and capital in the private and public sectors. To the extent possible, this analysis will address these issues.

## IV Data Sources and Descriptive Analysis

We develop a panel of 35 MSA's with only one commercial airport, identified by the FAA as a medium or large hub.[13] For the panel of 35 MSA's and corresponding airports, Table 1 provides airport and metropolitan descriptive statistics for three groups, the Full Sample, Over Airports (summing across years), and Over Years (summing across airport cross sections). As seen in Table 1, depending upon the series, the availability of some variables ranges from 21 years for some variables to 18 years and 6 years for others. Entries in the table that list the current year gives information as of 2009 (e.g. airport land area).

For each group, the overall variable means remain the same but the variances differ. Focusing upon airport characteristics for the sample during the period of analysis, there is an average of 105 thousand domestic annual departures and 4,182 annual international departures. An annual average of 8.2 million passengers flew on non-stop unlinked segments per airport and airlines carried, on average, 127 million pounds of freight. In 2009, on average, the airports covered over 5,500 acres on average and there is an average of 3.4 runways per airport. 19 airports were large hubs and 16 were medium sized hubs.[14]

For the full panel of 35 MSAs during the 18-21 year period, the average annual population in the MSAs is just over 2 million persons with an annual average of 1.22 million workers, of which 1.03 million are wage and salary workers. The average annual real-wage-and-salary disbursement per worker is $19,256 and annual average real per capita income is $16,875. The average unemployment rate over all MSAs and observed years is 4.8% and there are just fewer than 51,000 establishments on average per year.

Starting in 2001, the Bureau of Economic Analysis began reporting gross metropolitan product. For the 7-year period from 2001 to 2007, Table 1 reports that annual real GMP averaged $49.0 billion for the full panel. This reflects an average annual per capita GMP of $41,995. On average, for the sample period, annual GMP represents 40% of gross state product. When disaggregated by type of activity, the Finance sector accounts for almost half of MSA

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[13] Isolating the effect of additional runways on economic development becomes more difficult when a MSA supports multiple airports. In order to avoid this potential problem, this analysis includes only MSAs with a single commercial airport.

[14] Large hubs are defined as airports with "1% of US Enplanements or more"; medium hubs are defined as "less than 1% but more than 1/4%".

**Table 1**

**Panel Data Descriptive Statistics**

| Variable | Mean | Standard Deviation | | |
|---|---|---|---|---|
| | | Total Sample | Across Years | Across Airports |
| Airport, Domestic Departures* | 105,306 | 70,301 | 298,610 | 113,222 |
| Airport, Freight Shipped, Non-Stop Segments (million pounds)* | 126.7 | 362.1 | 898.4 | 699.0 |
| Airport, International Departures* | 4182 | 5396 | 22089 | 8052 |
| Airport, Land Area of Airport (acres)**** | 5589 | 5804 | 26977 | 0 |
| Airport, Large = 1, Medium = 2** | 1.5 | 0.5 | 2.3 | 0 |
| Airport, Number of Diverted Airport Landings** | 171 | 128 | 494 | 232 |
| Airport, Number of Diverted Airport Take-Offs** | 1261 | 1531 | 4902 | 3962 |
| Airport, Number of Runways* | 3.4 | 1.3 | 5.8 | 0.9 |
| Airport, Passengers, Non-Stop Unlinked Segments (million)* | 8.2 | 6.0 | 26.2 | 8.1 |
| Metropolitan Area, Employment** | 1,220,311 | 703,863 | 3,170,836 | 872,440 |
| Metropolitan Area, Number of Establishments** | 50,925 | 31,058 | 141,243 | 30,514 |
| Metropolitan Area, Population (persons)** | 2,020,215 | 1,170,432 | 5,326,622 | 1,058,136 |
| Metropolitan Area, Real GDP Quantity Index (100=2001)*** | 108.4 | 9.3 | 23.7 | 40.7 |
| Metropolitan Area, Real GMP ($ million)*** | 49,011 | 28,464 | 119,053 | 5,999 |
| Metropolitan Area, Real GMP - Education and Health ($ million)*** | 6,698 | 5,598 | 24,850 | 4,179 |
| Metropolitan Area, Real GMP - Finance ($ million)*** | 20,843 | 16,210 | 73,176 | 7,289 |
| Metropolitan Area, Real GMP - Government ($ million)*** | 9,292 | 4,922 | 22,804 | 955 |
| Metropolitan Area, Real GMP - ICT ($ million)*** | 5,094 | 5,924 | 24,028 | 4,542 |
| Metropolitan Area, Real GMP - Leisure and Hospitality ($ million)*** | 3,729 | 2,549 | 11,584 | 1,244 |
| Metropolitan Area, Real GMP - Private Goods ($ million)*** | 15,545 | 10,334 | 42,686 | 5,451 |
| Metropolitan Area, Real GMP - Private Services ($ million)*** | 41,757 | 25,031 | 102,483 | 16,201 |
| Metropolitan Area, Real GMP - Profession and Business ($ million)*** | 10,917 | 9,814 | 40,492 | 8,230 |
| Metropolitan Area, Real GMP - Transportation and Utilities ($ million)*** | 3,645 | 3,412 | 13,788 | 2,617 |
| Metropolitan Area, Real GMP as % of Real GSP*** | 0.4 | 0.4 | 1.7 | 0.2 |
| Metropolitan Area, Real GMP per Capita ($)*** | 41,995 | 6,234 | 27,866 | 8,166 |
| Metropolitan Area, Real Wage and Salary Income per Worker (1982-84 $)** | 19,256 | 2,343 | 8,454 | 8,200 |
| Metropolitan Area, Real per Capita Income (1982-84=100, $)** | 16,875 | 2,347 | 7,720 | 9,276 |
| Metropolitan Area, Unemployment Rate* | 4.8 | 1.3 | 3.4 | 8.0 |
| Metropolitan Area, Wage and Salary Employment (persons)** | 1,026,457 | 611,375 | 2,773,262 | 650,174 |
| State, Higher Education Enrollment** | 479,896 | 427,708 | 1,961,089 | 279,628 |
| State, Real GSP (Chained 1982-1984 $million)** | 179,023 | 156,203 | 700,331 | 184,590 |

* 1990 - 2007, 18 years and 35 airports, 630 observations

** 1987 - 2007, 21 years and 35 airports, 735 observations

*** 2001 - 2006, 6 years and 35 airports, 238 observations

**** Data missing for Jacksonville, FL airport

GMP, followed by the Profession and Business, Government, and Education and Health sectors. Private goods production is about one-third the contribution of private services to GMP.

Observations by sub-groups display greater heterogeneity between the cross section units than when measuring across time, as is often the case with panel data. With few exceptions, the standard deviation for all variables is greater, and at times considerably greater, across airports and MSAs than across the years. For example, over the entire sample, non-stop unlinked segments accounted for an annual average of 8.2 million passengers with a standard deviation of 6 million passengers. When summed over airports so that only the year varies, the standard deviation is 8.1 million passengers, which generally reflects long term passenger trends. Summing over time to measure the differences between MSA's, however, gives a standard deviation of 26.2 million passengers, which reflects the size distribution of sampled airports.

The two primary exceptions to this variance pattern are real per capita income and the unemployment rate. This deviation from the pattern is to be expected since dividing income by population adjusts for size differences across MSAs and, as a result, real per capita income across MSAs is less heterogeneous than across time, with an observed standard deviation of $9,276 versus $7,720. And, because economic cycles tend to affect all geographic areas to a similar degree, unemployment rates exhibit less heterogeneity across MSAs than across time, with an observed standard deviation of 8% over time versus 3.4% over MSAs.

Table 2 identifies the sampled airports in the MSA analysis and the airport's hub status. There are 19 large hub airports and 16 medium hub airports in the panel data set.

### *IV.1 Empirical Considerations*

For this analysis, metropolitan area employment is our measure of aggregate labor. Because measures of MSA capital are not available, we use the number of MSA establishments as a proxy for the level of private capital.[15]

This analysis includes three variables to capture the effects of airport public capital. First, the relationship between changes in the number of runways and economic development is of primary interest. To explore this, we measure the total number of runways at an airport. It is

[15] In preliminary analyses, we also included population density to capture potential differences in invested capital (as well as other sources of heterogeneity) across metropolitan areas. This variable added little to the final model's explanatory power.

**Table 2**
**Hub Airports for MSA Analysis**

| Large Hub | Medium Hub |
|---|---|
| Hartsfield-Jackson Atlanta International, ATL | Albuquerque International, ABQ |
| General Edward Lawrence Logan, BOS | Austin-Bergstrom International, AUS |
| Baltimore-Washington International, BWI | Nashville International, BNA |
| Charlotte/Douglas International, CLT | Cleveland-Hopkins International, CLE |
| Cincinnati/Northern Kentucky, CVG | Port Columbus International, CMH |
| Denver International, DEN | Indianapolis International, IND |
| Detroit Metro Wayne, DTW | Jacksonville International, JAX |
| Honolulu International, HNL | Kansas City, International, MCI |
| McCarran International, LAS | Memphis International, MEM |
| Orlando International, MCO | General Mitchell International, MKE |
| Minneapolis-St. Paul International, MSP | New Orleans International, MSY |
| Philadelphia International, PHL | Portland International, PDX |
| Phoenix Sky Harbor International, PHX | Raleigh-Durham International, RDU |
| Pittsburgh International, PIT | Southwest Florida International, RSW |
| San Diego International, SAN | San Antonio International, SAT |
| Seattle-Tacoma International, SEA | Sacramento Metro, SMF |
| Salt Lake City International, SLC | |
| Lambert-St. Louis International, STL | |
| Tampa International, TPA | |

expected that adding an additional runway will increase GMP, all else constant. Second, we include maximum runway length. The longer the runway, the larger the plane a runway can accommodate and this enables the airport to serve more passengers and ship more freight, all else constant. Recognizing that airports can substitute between adding runways to increase the number of flights that can land and lengthening the runways to allow aircraft with higher passenger capacities to land in order to increase total passengers moved, we include a cross product variable between the number of runways and maximum runway length. And third, systemic runway congestion reduces the quality of runways which potentially constrains the extent to which a MSA can sustain economic development. To capture this effect, we include in the model the average flight delay, in minutes. All else constant, an increase in average flight delays is expected to decrease $GMP_{it}$.

In addition to airport public capital, we include two variables as proxies for quantity and productivity of highway infrastructure.[16] An increase in the number of freeway and arterial lane miles is expected to reduce market transactions costs and increase metropolitan output. Second, to reflect the quality of highway travel, the model includes a road congestion index for each metropolitan area. All else constant, the higher the index the more congested the roads, the more damage on the roads, and the higher the resource costs of economic activity. At the same time, all else constant, congested roads imply a more economically thriving environment which enhances metropolitan output, an effect which is expected to dominate negative effect on output from increased resources devoted to non-productive travel during peak periods.

Gross metropolitan product measures metropolitan market activity. The Bureau of Labor Statistics provides data on real gross metropolitan product for the years 2001 – 2007. For this part of the analysis, we omit all observations before 2001 and after 2007.[17] Additionally, because the Bureau of Labor Statistics does not provide observations for Jacksonville, FL MSA and runway information was missing for Charlotte/Douglas International Airport, we omit Jacksonville (JAX) and Charlotte/Douglas (CLT) International Airports.

## V Metropolitan Statistical Area Estimation Results

### *V.1 Gross Metropolitan Product Results*

Equation (2) identifies the base model for the gross metropolitan product analysis. Substituting the specific empirical measures for $L_{it}$ , $K_{it}$ , and $R_{it}$ yields the estimating equation:

$$(2)\quad \ln(GMP_{it}) = \sum_i \alpha_i + \alpha_2 \ln(GMP_{i,t-1}) + \alpha_3 \ln(Employment_{i,t-1}) +$$

$$\alpha_4 \ln(Establishments_{i,t-1}) + \alpha_5 \ln(Number\ of\ Runways_{i,t-1}) +$$

$$\alpha_6 \ln(Maximum\ Runway\ Length_{i,t}) +$$

$$\alpha_7 \ln(Number\ of\ Runways_{i,t-1} * Maximum\ Runway\ Length_{i,t}) +$$

$$\alpha_8 (Average\ Flight\ Delay_{t-1}) + \alpha_9 (Large\ Hub_{i,t}) + \alpha_{10} \ln(Lane\ Miles_{i,t-1}) +$$

$$\alpha_{11} (Road\ Congestion\ Index_{i,t}) + \sum_{j=12}^{18} \alpha_j\ Regional\ Dummy\ Variable_j +$$

[16] We explored alternative measures of highway public capital. Lane miles and the congestion index led to better overall fits.

[17] Gross State Product for a more extended time is available from several sources. However, states possess a large geographic area compared to the MSA which weakens the expected effect, all else constant, of additional runway capacity in a given MSA.

$\alpha_{19}$ ln (Real Gross Domestic Product$_t$) + $\varepsilon_{it}$

(i = 1,…, 33; t = 2002 – 2007)

Equation (2) also includes lagged gross metropolitan product, $GMP_{t-1}$ as an additional explanatory variable to represent a dynamic version of the model and to account for serial correlation in the error terms.[18] Lagged values for Employment, Establishments, the Number of Runways, Average Flight Delay, and Arterial Streets Daily VMT were used as instrumental variables in order to reduce, if not eliminate, concerns with endogeneity that often characterize aggregate models. Real GDP serves as a measure of overall economic activity and operates to show the impact of the period preceding the recession. In addition, standard errors for all parameter estimates are robust to departures from a constant variance assumption.[19]

As a proxy for human capital investment, state research and teaching budgets were found to have little explanatory power in exploratory analyses. And extreme collinearity problems precluded a full fixed effects specification. However, by including region variables, it was possible to, at least partially, account for cross section heterogeneity and differences across MSAs from unobserved or omitted variables. In particular, the model included seven FAA region variables: Eastern, Great Lakes, New England, Northwest Mountain, Southern, Southwest, and Western Pacific. The reference (omitted) region is FAA's Central region.[20]

Table 4 reports the estimation results and the model fits the data well. The adjusted $R^2$ is .9988, which indicates that the model explains 99.88% of the variance in metropolitan $GMP_{it}$.[21]

As expected, lagged $GMP_{it}$ is a strong determinant of current $GMP_{it}$. Increases in lagged employment increase $GMP_{it}$. All else constant, a 1% increase in lagged employment increases real $GMP_{it}$ in the current period 3.0% or $1.5 billion on average all else constant.[22] As a proxy for private

[18] Exploratory analyses found that serial correlation coefficients ranged from a low of .33 to a high of .99. Theoretically, assuming that gross metropolitan product only partially adjusts to changes in the explanatory variables in the given time period motivates a dynamic version of equation (1) (Ramanathan, 3rd Edition, 1995).

[19] Specifically, the standard errors are calculated from a heteroskedastic consistent covariance matrix (Greene.1997).

[20] States included in the regions are: Eastern: DE, MD, NJ, NY, VA, WV; New England: CT, MA, ME, NH, VT; Great Lakes: IN, IL, MI, MN, ND, OH, SD, WI; Southern: AL, FL, GA, KY, MS, NC, SC, TN; Southwest: AR, LA, NM, OK, TX; Northwest Mountain: CO, ID, MT, OR, UT, WA, WY; Western Pacific: AZ, CA, HI, NV; and Central: IA, KS, MO, NE.

[21] The reported model provides the best overall fit and the reported estimates were robust to alternative specifications. In other analyses, we substituted two variables, log(current number of runways) and a dummy variable for added runway, for log (number of runways)$_{-1}$. Also, we estimated various models with up to four years of either the number of runways or the dummy variable for the presence of a new runway. For these alternative specifications, the estimated values of included variables were robust and the lagged values did not show consistent significance and, with GDP in the model, was not significant.

[22] From Table 1, the sample average real GMP is $49.0 billion, 1.4% of which is $695 million.

capital, Establishments has the expected positive sign and is statistically significant, with a 1% increase in Establishments raising real $GMP_{it}$ 4.8% or $2.4 billion on average, all else constant.[23] As expected, the log of real $GDP_{it}$ was positive and significant. Associated with a 1 % increase in real $GDP_{it}$ was a 20% increase in real $GMP_{it}$.[24]

The variables of most interest for this analysis are the Number of Runways, Maximum Runway Length, the cross product of those two variables, and Average Flight Delay. Based upon these results adding a new runway increases real GMP as long as the maximum runway is less than 9958 feet, a result which was significant at the 0.01 level for the number of runways and its cross product. [25]

In addition, and as expected, extending the length of runways benefits a metropolitan area's economic development, a result that is statistically significant at the 0.01. While not addressed here, the negative and significant interaction term raises an interesting question on what factors determine whether an airport should increase capacity by extending existing runways (assuming that not all runways have maximum length) or by adding runways. Also consistent with expectations, Average Flight Delay has a negative impact upon economic development. All else constant, the results in Table 4 indicate that a 1% increase in average flight delays decreases annual real GMP by 2.9% or $1.5 billion on average.

Additional results from Table 4 indicate that metropolitan areas with a large hub airport experience, on average, a $934 million (1.9%) benefit per year. As proxies for the quantity and productivity of metropolitan highway infrastructure, the quantity of lane-miles and the road congestion index have the expected signs, and are statistically significant at the .03 and .01 levels, respectively. The sign and strength of statistical significance of the road congestion index indicates that the economic benefits flowing from a thriving community more than offsets one of the major externalities in metropolitan areas, highway congestion.

Also, relative to the FAA Central and all other regions, MSA GMP in the Eastern and New England regions was $790 million and $1.44 billion higher, all else constant. And, notwithstanding

[23]Preliminary analyses found that a dummy variable for the 9-11-2001 terrorist attack had no appreciable effect on GMP.
[24] In order to explore the potential for reverse causality, we regressed the log of real $GDP_{it}$ against the log of real $GMP_{it}$ The estimated $R^2$ was .09 and, more importantly, the estimated coefficient was not significant at any reasonable level (0.244 p-value). Given these results, reverse causality does not appear to be a significant issue.
[25] We added a quadratic direct and interaction term for the number of runways to explore non-linear effects and whether these would affect the marginal impact of an additional runway. These analyses produced insignificant effects for the quadratic terms.

**Table 4**
**Gross Metropolitan Product Estimation Results**
**2002 - 2007**

Dependent Variable: ln ($GMP_{it}$)

| Variable | Estimate | Approx Std Err | Approx Pr > \|t\| |
|---|---|---|---|
| Constant | -3.54254 | 0.704 | <.0001 |
| ln $(GMP)_{t-1}$ | 0.9039 | 0.028 | <.0001 |
| ln $(Employment)_{t-1}$ | 0.0296 | 0.011 | 0.0062 |
| ln $(Establishments)_{t-1}$ | 0.0478 | 0.022 | 0.0316 |
| ln $(Lane\ Miles)_{t-1}$ | 0.0207 | 0.01 | 0.0325 |
| ln (Road Congestion Index) | 0.0878 | 0.018 | <.0001 |
| ln $(Number\ of\ Runways)_{t-1}$ | 0.9982 | 0.278 | 0.0004 |
| ln (Real Gross Deomestic Product) | 0.1999 | 0.059 | 0.0009 |
| ln $(Average\ Flight\ Delay)_{t-1}$ | -0.0292 | 0.008 | 0.0002 |
| ln (Maximum Runway Length) | 0.2093 | 0.049 | <.0001 |
| ln (Number of $Runways_{it-1}$ * Maximum Runway Length) | -0.1086 | 0.03 | 0.0004 |
| | | | |
| Hub Size (1 if large hub; 0 otherwise) | 0.019 | 0.006 | 0.0021 |
| Eastern Region | 0.016 | 0.006 | 0.0095 |
| Great Lakes Region | -0.0072 | 0.006 | 0.2397 |
| New England Region | 0.0289 | 0.011 | 0.0088 |
| Northwest Mountain Region | 0.0038 | 0.008 | 0.6347 |
| Southern Region | 0.0031 | 0.007 | 0.6436 |
| Southwest Region | -0.0143 | 0.009 | 0.1257 |
| Western Pacific Region | 0.0188 | 0.009 | 0.0404 |
| | | | |
| # observations | 198 | | |
| Adjusted $R^2$ - 0.9988 | | | |

Notes
7 years, 35 airports = 245 observations
Missing data on JAX, CLT => 224 observations
Lose 32 observations due to lagging => 198 observations
Using current terms for lemp and lest had little impact on the results
other than stronger rejections of the null in most cases

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Authors' calculations.
The model does not include Jacksonville, FL. and Charlotte, NC due to the absence of data on some variables. Thirty-three 2001 observations were not included due to a one-period lag. Standard errors are heteroskedastic consistent covariance matrix (hccm) standard errors.

the relatively short time span for this analysis, GMP increased an average of 0.24% or $117 million per year.

### *V.1.i A Further Analysis of Runway Effects*

Table 5 reports estimation results for a model that replaces the Number of Runways variable with a set of dummy variables associated with the airports that added an additional runway. This specification enables

**Table 5**
**GMP Estimation Results, 2002 - 2007**
**Airport Specific Parameter Estimates**

Dependent Variable: ln ($GMP_{it}$)

| Variable | Estimate | Approx Std Err | Approx Pr > \|t\| |
|---|---|---|---|
| $Atlanta_{t-1}$ | -0.0055 | 0.007 | 0.4155 |
| $Boston_{t-1}$ | 0.0242 | 0.006 | 0.0002 |
| $Cleveland_{t-1}$ | -0.0017 | 0.009 | 0.8505 |
| $Cincinnati_{t-1}$ | -0.0324 | 0.008 | <.0001 |
| $Denver_{t-1}$ | -0.0261 | 0.011 | 0.0188 |
| $Detroit_{t-1}$ | -0.0268 | 0.011 | 0.0143 |
| $Orlando_{t-1}$ | 0.0201 | 0.014 | 0.1450 |
| $Minneapolis_{t-1}$ | -0.0001 | 0.006 | 0.9868 |
| St. $Louis_{t-1}$ | 0.0001 | 0.006 | 0.9846 |
| # observations | 198 | | |
| Adjusted $R^2$ - 0.9986 | | | |

Authors' calculations. Except for (Additional $Runway)_{t-1}$, the other variables in this model are robust relative to those reported in Table 4. See note below Table 4 for sample information.

us to determine whether an additional runway reduced $GMP_{it}$ for all MSAs or whether there were differential effects across the MSAs. Because the results for the other variables are qualitatively similar to those reported in Table 4, we present only the airport specific variables in Table 5.

9 airports added runways during the 2001 – 2007 period and the results in Table 5 indicate that the effect of an additional runway was not uniform across airports. Although the average effect

in Table 4 indicated that adding an additional runway decreased $GMP_{it}$, all else constant, the more detailed results in Table 5 indicate that the effect on $GMP_{it}$ was specific to the airport and varied from a significant negative effect to no effect to a significant positive effect. Orlando and Boston experienced similar positive $GMP_{it}$ effects, amounting to a 2.01% and 2.42% increase in GMP from an additional runway. The additional runway in Atlanta, Cleveland, Minneapolis, and St. Louis, on the other hand, had neither an appreciable positive nor negative effect on gross metropolitan product. In each of these cases, we could not reject the null hypothesis, at any reasonable level of significance, that the additional runway substantively affected GMP. For Cincinnati, Denver, and Detroit, on the other hand, the effect of the additional runway was negative and statistically significant and whose effect ranged between -3.2% to -2.6%. Excepting Boston, the absence of an effect or the weaker positive effect of an additional runway was not sufficient to offset the estimated negative sign reported in Table 4.

These results are important for their suggestion that the addition of a runway per se may have unintended consequences whose net effect may hinder rather than spur economic development. The results presented in Tables 4 and 5 raise interesting questions on what specific factors are most important in determining whether investing in an additional airport will generate net costs or net benefits to the metropolitan area.

### *V.1.ii A Probit Analysis of Increased Capacity*

In Table 6, we use probit analysis to explore what factors are associated with increased airport landing capacity. For this analysis, our dependent variable for each airport-year equals 0 if no additional runways were added in the 1991 – 2007 period and equals 1 if additional runways were added.[26]

The likelihood ratio statistic strongly rejects the null hypothesis that all estimated coefficients equal 0 and the results are generally consistent with expectations. There has been an increasing trend toward more runways throughout the sample period. And additional runways are more likely to exist in the Great Lakes, Southern, and Western Pacific Regions relative to other parts of the country.

[26] Denver, for example, added a runway in 2003 so that the dependent variable for Denver equals 0 for 1991 – 2002, a period of no new capacity and 1 in 2003 through 2007 when new capacity was available.

**Table 6**
**Probit Analysis of Runway Additions**
**1991 - 2007**

| Variable | Estimate | Approx Std Err | Approx Pr > \|t\| |
|---|---|---|---|
| Constant | -221.8 | 31.72 | <.0001 |
| Passengers, Annual Growth (%) | 0.4562 | 0.704 | <.0001 |
| Passengers per Runway | -0.2628 | 0.052 | <.0001 |
| Freight Shipped per Runway | 0.0060 | 0.002 | 0.0052 |
| Airport Area (square miles) | 0.0235 | 0.007 | 0.0006 |
| Great Lakes Region | 0.5086 | 0.189 | 0.0070 |
| Southern Region | 0.2358 | 0.1703 | 0.1661 |
| Western Pacific Region | 0.3925 | 0.222 | 0.0772 |
| Year | 0.1105 | 0.016 | <.0001 |
| # observations | 561 | | |
| Log-likelihood at Convergence | 229.79 | | |
| Log-likelihood at Intercept Only | 309.57 | | |
| Likelihood Ratio Statistic | 159.55 | | |
| $\chi^2_{05 \text{ critical value}}$ (9) | 16.92 | | |

An increase in the rate of growth of passenger travel and freight shipped per runway increases the probability of having more runways, all else constant. On the other hand, growth in passengers per runway has a negative and significant effect upon additional runway capacity. This suggests that, holding constant the growth of air passenger traffic, increasing passengers per runway more efficiently uses existing capacity and reduces the need for additional runways.
These results, however, are exploratory and more research is required to fully understand the relationships that exist between runway capacity and the various runway demands.[27]

Having the space to grow is also an important determinant of additional runway capacity. Airports located on larger parcels of land are more likely to have additional runways. The metropolitan unemployment rate reflects the economic environment and its positive sign suggests that

[27] A number of passenger and freight variables (e.g. passengers, freight shipped, passengers per runway, freight per runway, domestic departures) were included in preliminary estimations and consistently, as reported in Table 6, there appeared trade-offs in that all signs were not uniformly positive, reinforcing the need to better understand the underlying relationships.

major expansions at airports, including runways, have job-related economic benefits for the metropolitan area.

*V.2 Average Product of Labor Estimates*

Table 4 reported the results of a dynamic metropolitan production function that included labor, a proxy for private capital, and various measures of airport public capital. In addition to determining the importance of these variables to real $GMP_{it}$, it is also useful to analyze whether the same variables are important determinants of a metropolitan area's labor productivity, output per labor, and defined here as the (Real $GMP_{it}$/$Employment_{it}$). Table 7 reports the estimation results for a dynamic metropolitan labor productivity model. Overall, the data fit the model well, explaining 99.7% of the variance in the dependent variable and the results are generally consistent with expectations.

Past labor productivity is a stronger predictor of current productivity and, all else constant, increases in employment decrease labor productivity which is consistent with profit maximizing behavior.[28] And to the extent that the number of establishments is a proxy for private capital, the positive and statistically significant coefficient is consistent with expectations that increases in private capital, all else constant, increases labor productivity. Lane miles and the road congestion index have no impact on labor productivity. Also, during the sample period, labor productivity in these single airport metropolitan areas decreased, on average, .35%.

Turning to the airport related variables, the results in Table 7 indicate that neither an additional runway, nor runway length, has a direct effect on labor productivity. However, consistent with expectations, Average Flight Delay significantly reduces labor productivity. All else constant, a 1% increase in average delay reduces labor productivity 1.31%. Given an average product of labor equal to $78, 557, average delays reduce productivity $1,029. Further, labor productivity in metropolitan areas with large hubs, relative to MSAs with medium hub airports, significantly increases (1.12% or $885), suggesting that at least part of the increased

[28] Profit maximization requires that firms hire labor up to the point where the revenue generated from the marginal product of the last laborer hired just equals the resources expended to hire the individual. When this occurs, employers are effectively on the downward sloping portion of their labor demand curves and in this area the marginal product of labor and average product of labor are falling with increases in employment.

**Table 7**
**Metropolitan Average Product of Labor Estimation Results**
**2002 - 2007**

Dependent Variable: $GMP_{it}/Employment_{it}$

| Variable | Estimate | Approx Std Err | Approx Pr > \|t\| |
|---|---|---|---|
| Constant | 6.724 | 1.699 | 0.0001 |
| ln $(APL)_{t-1}$ | 0.9535 | 0.021 | <.0001 |
| ln $(Employment)_{t-1}$ | -0.0320 | 0.018 | 0.0780 |
| ln $(Establishments)_{t-1}$ | 0.0423 | 0.018 | 0.0188 |
| ln $(Lane Miles)_{t-1}$ | -0.0014 | 0.008 | 0.8549 |
| ln (Road Congestion Index | 0.0095 | 0.016 | 0.5430 |
| $(New Runway)_{t-1}$ | -0.0034 | 0.004 | 0.3784 |
| ln $(Average Flight Delay)_{t-1}$ | -0.0131 | 0.007 | 0.0738 |
| ln (Maximum Runway Length) | 0.0150 | 0.017 | 0.3842 |
| Hub Size (1 if large hub; 0 otherwise) | 0.0112 | 0.005 | 0.0185 |
| Eastern Region | 0.0098 | 0.005 | 0.0626 |
| Great Lakes Region | 0.0054 | 0.005 | 0.3136 |
| New England Region | 0.0202 | 0.009 | 0.0268 |
| Northwest Mountain Region | 0.0010 | 0.006 | 0.1015 |
| Southern Region | 0.0080 | 0.005 | 0.1360 |
| Southwest Region | 0.0028 | 0.009 | 0.7465 |
| Western Pacific Region | 0.0140 | 0.007 | 0.0415 |
| Year | -0.0035 | 0.001 | <.0001 |
| # observations | 198 | | |
| Adjusted $R^2$ 0.9977 | | | |

Authors' calculations.
The model does not include Jacksonville, FL. and Charlotte, NC due to the absence of data on some variables. 2001 data were not included due to a one-period lag.

$GMP_{it}$ associated with a larger scale of airport activities at large hubs occurs through increased worker productivity.

To explore airport specific results, the model in Table 7 was estimated where $(New Runway)_{t-1}$ was replaced by a set of dummy variables associate with the specific airport that added a new runway. Similar, although not identical to the results for $GMP_{it}$, adding a new runway reduced labor productivity 0.94%, 1.8%, and 1.4% in Atlanta, Cincinnati, and Denver, respectively. The new runway increased labor productivity in Boston 1.6%.

## VI Additional Results

Based upon a metropolitan production function framework, the primary focus of previous sections has been on the effect that the number of runways has had upon metropolitan output. There are other measures of economic development and this section summarizes additional estimation results that explore the extent to which airport runway capacity affects alternative measures of development.

Specifically, we focus four attributes of economic development: Wage and Salary Compensation, Urban Size, Population Density, and Delay to the Peak Period Traveler. Panel data for this analysis include the same cross sections as in previous analyses but extends the sample back to 1992. Table 8 presents the two-way fixed effects dynamic model estimation results. In addition to a lagged dependent variable, the model includes two explanatory variables,

**Table 8**
**Other Economic Development Measures**
**1992 - 2007**

| | Dependent Variable | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *Wages and Salary Compensation* | | *Urban Size* | | *Population Density* | | *Delay to Peak Period Traveler* | |
| | Estimate | p-value | Estimate | p-value | Estimate | p-value | Estimate | p-value |
| Independent Variable | | | | | | | | |
| Wage and Salary Compensation$_{t-1}$ | 0.8832 | <0.0001 | - | - | - | - | - | - |
| Urban Size$_{t-1}$ | - | - | 0.8873 | <.0001 | - | - | - | - |
| Delay to Peak Period Traveler$_{t-1}$ | - | - | - | - | - | - | 0.8129 | <.0001 |
| Population Density$_{t-1}$ | - | - | - | - | 0.9310 | <.0001 | - | - |
| Runway$_{t-1}$ | -0.0058 | 0.2522 | 0.0112 | 0.4256 | -0.0252 | 0.0466 | -0.0953 | 0.0340 |
| Unemployment Rate | -0.0056 | <.0001 | -0.0008 | 0.4675 | 0.0006 | 0.6032 | -0.0143 | 0.0004 |
| # observations | 528 | | 528 | | 528 | | 528 | |
| $R^2$ | 0.9971 | | 0.9991 | | 0.9967 | | 0.9752 | |

Authors' calculations. Two way fixed effects models and all standard errors are heteroskedastic consistent covariance matrix standard errors. All variables except Runway$_{t-1}$ are in logarithms.

the number of runways in the previous period and the unemployment rate. The model fits the data well with all $R^2$s over 0.97. From these exploratory results, the unemployment rate does not have an impact on the spatial form of a city. We cannot reject the null hypothesis that its coefficient in the Urban Size and Population Density equations equals 0. However, the unemployment rate does affect the economic character of a metropolitan area. The coefficient for unemployment is statistically significant in the Wage and Salary Compensation and Delay to Peak Period Travel equations. In each of these cases, the coefficient for Unemployment is statistically significant and has the expected sign, with increasing unemployment rates decreasing wages and compensation and decreasing travel delays during peak periods.

Turning to the number of runways, Table 8 presents mixed results. Increasing the number of runways has no impact upon labor compensation or upon urban size. But it does have an effect on population density and traveler delays during the peak period. All else constant, an additional runway reduces population density 2.5% and peak period delays over 9%. These results are intriguing and reinforce the notion that runway capacity has a number of direct and indirect effects upon metropolitan areas that are not well understood.

### *VI.1 Atlanta Hartsfield-Jackson International Airport*

In comparison with other MSAs with only one airport in this analysis, the scale of operations at Atlanta's Hartsfield-Jackson International Airport (ATL) is significantly higher. Because of this, in preliminary estimations, we included a number of Atlanta specific interaction variables to test whether there was a differential airport public capital effect associated with ATL. Consistently, these interaction effects were not determining factors at any reasonable level of statistical significance. Also, in Section V.1.i, Table 5, we saw that the new runway at Hartsfield-Jackson had no appreciable impact upon gross metropolitan product. Here, we can ask a similar question and explore whether there are differential effects when considering other alternative measures of economic development. The results in Table 8 identified an effect associated with more runways. Table 9 re-estimates the model in Table 8 but adds a new variable, Atlanta*$\text{Runway}_{t-1}$ , that interacts Atlanta with (the logarithm of) $\text{Runway}_{t-1}$. In Table 9, the results for $\text{Runways}_{t-1}$ are similar to its effect in Table 8, i.e. no impact upon compensation and urban size but a decreasing effect upon population density and peak period delays. Increasing the number of runways at Hartsfield-Jackson has no differential impact upon urban size or peak period traveler delays. But there is a differential effect on Wage and

Salary Compensation and Population Density. In particular, increasing the number runways at Hartsfield-Jackson increases compensation and the effect is sufficiently large (0.0222) that it which more than offsets the general effect of runways (-0.0061), although this latter effect was

**Table 9**
**Other Economic Development Measures**
**1992 - 2007**

| | Dependent Variable | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *Wages and Salary Compensation* | | *Urban Size* | | *Population Density* | | *Delay to Peak Period Traveler* | |
| Independent Variable | Estimate | p-value | Estimate | p-value | Estimate | p-value | Estimate | p-value |
| $Runway_{t-1}$ | -0.0061 | 0.2370 | 0.0112 | 0.4271 | -0.0265 | 0.0372 | -0.0955 | 0.0353 |
| $Atlanta*Runway_{t-1}$ | 0.0222 | 0.1037 | -0.0054 | 0.8205 | 0.1209 | <.0001 | -0.0165 | 0.7929 |
| $R^2$ | 0.9971 | | 0.9991 | | 0.9967 | | 0.9752 | |

Authors' calculations. Two way fixed effects models and all standard errors are heteroskedastic consistent covariance matrix standard errors. Other variables in the model are the same as those in Table 8. All variables except $Runway_{t-1}$ are in logarithms.

not statistically significant. In addition, increasing the number of runways increases population density in Atlanta and the effect again more than offsets the general decreasing impact upon population density, 0.1209 versus -0.0265. To the extent that larger airports and more runways reflect and, to a greater or lesser degree generate, more economic activities and metropolitan travel, this result suggests that the net impact may be more urbanization of firms and households.

## VII Concluding Considerations

This study explored the economic impact that additional runway capacity has upon a metropolitan growth and economic development. In order to better establish the link between economic development and runway capacity, the sample for this study included MSAs with only one medium or large hub airport. Depending upon the specific analysis the sample period was 2001 – 2007 or a longer period from 1992 – 2007.

Based upon a metropolitan production function framework, a panel data analysis of 33 airports over the 7 year period 2001 – 2007 found that that adding a new runway increased annual gross metropolitan product as long as the maximum length of the runway present is not longer than

9,900 feet and had no effect on labor productivity. Average flight delays were an important determinant of economic development, decreasing gross metropolitan product as well as labor productivity, decreasing GMP by 2.9% ($1.5 billion) and labor productivity by 1.31% ($1,029) on average. In addition, increasing maximum runway length increased GMP.

A more detailed analysis revealed that an additional runway had differential effects. In particular, a new runway increased gross metropolitan product in Boston and Orlando; had no appreciable effect in Atlanta, Cleveland, Minneapolis, and St. Louis; and decreased gross metropolitan product in Cincinnati, Denver, and Detroit. And in an analysis of labor productivity, adding a new runway significantly increased productivity in Boston but reduced productivity in Atlanta, Cincinnati, and Denver.

From a probit analysis of new runway additions for the period 1991 – 2007, annual passenger growth rate, freight shipped per runway, and land area of the airport increase the likelihood of a new runway; and given the passenger growth rate, passengers per runway reduce the likelihood, suggesting more efficient use of runway capacity. Additional results found that airports with more runways are associated with MSAs that have lower population densities and lower average delays for the peak period highway traveler.

Specific results for the Atlanta-Sandy Springs–Marietta MSA and Atlanta's Hartsfield-Jackson International Airport found that, during the period 2001 – 2007, Atlanta's fifth runway had no appreciable impact upon gross metropolitan product but decreased the average product of labor 0.94%. Over the longer period 1992 – 2007, an increased number of runways at Hartsfield-Jackson increased labor compensation as well as population density.

As one of the busiest airports in the nation during the sample period, Atlanta's Hartsfield-Jackson scale of operations is unlike that of other MSA's with one large hub and no medium hubs airports. An area for future research is to determine whether the results obtained in this analysis are robust if one considers larger MSAs that have multiple airports.

Many of the results in this analysis are new and suggestive of the effects that public capital, in the form of airports and, specifically, runways, have upon MSA economic development. Yet, there needs to be considerably more research in order to better understand the linkages that exist between airport capacity and economic development. The finding that a new runway significantly increases GMP and labor productivity in some areas, significantly decreases these measures in other areas, and has no effect on yet other areas indicates that airports and runway capacity are having diverse effects on metropolitan areas that are not at all well understood.

Last, and related, is a need to improve understanding of those factors that increase the likelihood that a MSA will add a new runway. Certainly, increases in the demand for air travel are influential. At the same time, associated with increased capacity are congestion and other effects that may deter economic development. It is important for policy makers to understand the direct and indirect effects of increasing airport capacity if the nation's systems of airports are to be engines of economic development. And, as a corollary, an area for future study is to explore the conditions and factors that determine whether new runways or extending existing runways offers the best alternative for increasing capacity.

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