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Airline Traffic and Urban Economic Development

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Summary. This paper provides new evidence on the link between airline traffic and employment in US metropolitan areas. The evidence confirms the common view that good airline service is an important factor in urban economic development. Frequent service to a variety of destinations, reflected in a high level of passenger enplanements, facilitates easy face-to-face contact with businesses in other cities, attracting new firms to the metro area and stimulating employment at established enterprises. The empirical results show that a 10 per cent increase in passenger enplanements in a metro area leads approximately to a 1 per cent increase in employment in service-related industries. However, airline traffic has no effect on manufacturing and other goods-related employment, suggesting that air travel is less important for such firms than for service-related businesses. These estimates are generated controlling for reverse causality between employment and traffic. The results imply that expansion of Chicago's O'Hare airport would raise service-related employment in the Chicago metro area by 185 000 jobs (this impact assumes that expansion raises traffic by 50 per cent). Thus, the expansion of O'Hare airport represents a powerful economic development tool, as argued by its proponents.

1. Introduction

Small-town business leaders and government officials sometimes complain that inadequate airline service is an obstacle to local economic development. It is alleged that poor service inhibits local employment growth by limiting the attractiveness of the city as a location for new businesses and by reducing the viability of existing firms. In Champaign–Urbana, Illinois, for example, airline service quality has been viewed as a potential impediment to an attempt by the University of Illinois to stimulate high-tech employment through creation of a research park.

The quality of airline service matters to firms because it affects the cost of achieving face-to-face contact with business collaborators in other cities. This contact, which is achieved through business travel by the firm's employees, is more costly in terms of time and money when airline service is poor. While raising the cost of production, these higher travel costs may also limit the volume of face-to-face contacts that the firm undertakes. This limitation may in turn impair the viability of the enterprise, especially in high-tech industries where exchange of information is critical.

In effect, by facilitating easy face-to-face contacts with collaborators in other cities, good airline service fosters *intercity* agglom-

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eration economies. These intercity effects complement the agglomeration economies that occur among firms within a given city, whose importance is now firmly established following a rebirth of empirical work on agglomeration (see, for example, Glaeser *et al.*, 1992; Rosenthal and Strange, 2001). By demonstrating the significance of agglomeration effects, this new literature suggests that intercity agglomeration economies, which are fostered by air travel, may also be important. Because poor airline service limits the extent of these economies, it could constitute an impediment to urban economic development.[1]

The geographer Allan Pred commented on these issues back in 1977, when air travel was arguably less critical for businesses than it is today. He noted that

> There are tremendous savings in time, and hence costs, that accrue from the clustering of organizational head offices and ancillary business services in major metropolitan areas. The time and cost savings available in large urban centers are compounded by the superior air-transport connections those places possess … Centers which do not have a wide variety and great number of daily nonstop flights to the leading metropolitan complexes with a given system of cities are not particularly attractive … because they do not permit nonlocal personal contacts … to be carried out … efficiently (Pred, 1977, p. 24).

In discussing the success of Boise, Idaho, as a corporate headquarters location, Pred makes the following additional observations:

> The functioning of major headquarters office units in Boise has also been made viable by the commercial airline service available to that geographically isolated metropolitan area … The Boise evidence indicates that lesser metropolitan [areas] … possess the potential to house … divisional headquarters … and research and development units … Good air travel connections would have to be available, and the organizations would have to … internalize some business services (Pred, 1974, pp. 205–206).

Despite its plausibility and potential importance, the link between airline service and economic development has been the focus of only a few research studies. To study this link, Brueckner (1982) assumed that employment growth in a metropolitan area over a multi-year period depends on the level of airline traffic in the period's base year. High traffic, indicative of frequent airline service to many destinations, was presumed to stimulate employment growth by attracting new firms and helping existing firms to prosper. Unfortunately, the hypothesised relationship emerged only weakly in the chosen sample, which consisted of 75 small and medium-sized metropolitan areas. The more recent study of Button *et al.* (1999) related the level of high-technology employment in a sample of over 300 metro areas to a number of explanatory variables, including a dummy variable indicating whether the area's airport is one of the nation's 56 largest. The study confirmed the anticipated connection between high-tech employment and airport size. Finally, Green (2002) took an approach similar to that of Brueckner (1982), regressing employment as well as population growth in a metro area on base-year airline traffic. Green's study represents an improvement over earlier efforts because it includes a rich list of additional explanatory variables and it attempts to control for the potential endogeneity of airline traffic. While the study shows the anticipated positive connection between growth and base-year traffic, the results are marred by the unexpectedly weak performance of many of the other explanatory variables.

In attempt to improve further on previous work, the present study offers additional empirical evidence on the link between airline traffic and economic development. Following Button *et al.* (1999), and in contrast to Brueckner (1982) and Green (2002), this link is assumed to be contemporaneous rather than occurring with a lag. In other words, the level of airline traffic is assumed to affect metro-area employment *in the same year*, rather than boosting employment growth over subsequent years. Part of this contemporaneous employment effect counts the jobs of airport workers, which obviously grow in number as traffic expands, as well as the usual multiplier effects of such job growth. But airline traffic's employment effect also has an additional component, which captures the stimulative effect of the intercity agglomeration economies created by good airline service.

Given a contemporaneous relationship between employment and airline traffic, the endogeneity of traffic becomes a more serious issue than in the studies that use a base-year value to explain subsequent employment growth. In other words, while airline traffic may affect employment, traffic itself depends partly on the contemporaneous level of employment in a metro area, which helps to determine the volume of business travel. In order to prevent the empirical results from being contaminated by this potential reverse causality, satisfactory instruments, which are variables that affect airline traffic without being strongly correlated with employment, must be used. While including a number of exogenous variables that help to explain employment, the study also makes use of several plausible instruments. The sample, which pertains to the year 1996, consists of 91 US metropolitan areas covering a wide range of population sizes. The paper's empirical findings confirm the hypothesised link between employment and airline traffic.

The next section of the paper presents the empirical framework and discusses the variables it contains. Section 3 presents the empirical results and section 4 uses the results to predict the employment impact of expansion of Chicago's O'Hare airport. Section 5 offers conclusions.

2. Empirical Framework and Data

Letting E denote employment in a metro area and T denote airline traffic, the estimating equation has the form

$$E = f(T, \mathbf{X}; \boldsymbol{\theta}) + u \qquad (1)$$

where $\mathbf{X}$ is a vector of exogenous variables that influence employment; $\boldsymbol{\theta}$ is a parameter vector; and u is an error term.

The relationship in equation (1) can be viewed as a 'quasi reduced-form' relationship in that, aside from airline traffic, all potentially endogenous variables that help to determine employment have been eliminated by appropriate substitution from other structural equations. For example, although the wage level might be viewed as a demand-side determinant of employment, the wage is endogenous, being jointly determined along with E, and it is therefore suppressed in equation (1). Only those variables that can reasonably be viewed as exogenous determinants of employment appear in $\mathbf{X}$.

In a separate structural equation determining airline traffic, T depends on E, on other endogenous variables such as incomes (and hence wages) and on a set of exogenous variables. Through solution of the structural system, T ultimately depends on a collection of exogenous variables that is potentially broader than the set contained in $\mathbf{X}$. In order for equation (1) to be identified, allowing the effect of T on employment to be measured, this set of exogenous variables must include at least one variable (instrument) that does not already appear as part of $\mathbf{X}$. A challenge is to find such instruments, which should be highly correlated with T but uncorrelated (or weakly correlated) with the error term u. Once the instruments are selected, equation (1) can be estimated by two-stage least squares (2SLS).

To enumerate the actual variables that are used in the empirical model, the discussion first focuses on those appearing in equation (1), with the choice of instruments discussed last. The employment variable E is total non-farm employment in the metropolitan area for 1996, denoted *EMP*. Other versions of the estimating equation use the disaggregated employment measures *GDSEMP* and *SVCEMP*, which represent goods-related employment (manufacturing, construction and mining) and service-related employment, respectively. The latter measure includes wholesale and retail trade, FIRE (finance, insurance and real estate), services, government, transport and public utilities employment.

The first variable in **X** is the metro area's population, denoted *POP*. Because the contemporaneous 1996 population may be jointly determined along with *EMP* and hence endogenous, the metro area's 1990 population is used instead as the *POP* variable. The predicted sign of this variable's coefficient in equation (1) is obviously positive. Since, conditional on *POP*, the age distribution of the metro area's population is likely to affect employment, the variables *YOUNG* and *OLD* appear as part of **X**. These variables measure the 1996 shares of the population with ages 14 years and under and 65 years and over, respectively, and the effects of both variables on *EMP* are expected to be negative. To measure the possible lure of sunbelt locations, the climate variable *HEATING*, which equals average heating degree days for the metro area over the 1971–2000 period, appears as part of **X**. With a high value of *HEATING* indicating a 'rust-belt' location, the traditional view would predict a negative sign for its coefficient. A metro area with a high level of human capital is presumably an attractive location for employers and this level is measured by the variable *COLGGRAD*, which equals the percentage of the 1990 population over age 25 with a college degree. *COLGGRAD*'s coefficient is likely to be positive.

Following Green (2002), union influence is measured by the dummy variable *RTW*, which equals one if the metro area is located in a state with a 'right-to-work' law, which inhibits the organising efforts of unions. The expected sign of *RTW*'s coefficient is positive. Finally, again following Green (2002), **X** includes variables designed to capture the personal and corporate tax burdens in the state containing the metro area. *PERSTAX* equals the maximum marginal rate for the state's personal income tax in 1996, while *CORPTAX* equals the maximum marginal rate for the state's corporate tax. Assuming that a high tax burden deters employment (both from the demand and supply sides), the coefficients of the tax variables should be negative.

Airline traffic *T* is measured by total 1996 passenger enplanements (the number of passengers boarding aircraft) in the metro area, denoted *TRAFFIC*. In metro areas with multiple airports, such as New York, Los Angeles and Chicago, *TRAFFIC* is computed by summing enplanements across the relevant airports. It should be noted that for these multiple-airport cities and other large urban centres, construction of the sample relies on the most-encompassing definition of a metro area. Thus, when a Consolidated Metropolitan Statistical Area (CMSA) is defined for a metro area (embracing several smaller units), the CMSA is used as the unit of observation. For example, in the case of New York, the unit of observation is the New York–Northern New Jersey–Long Island CMSA and the relevant airports are La Guardia, John F. Kennedy, Newark, Islip, White Plains and Newburgh (NY). The Appendix provides a list of the 91 metro areas in the sample, indicating the multiple airport cases. Note that for smaller metro areas, the unit of observation is the MSA.[2]

Turning to the choice of instruments, these variables should again be strongly correlated with *TRAFFIC* but uncorrelated or weakly correlated with the error term in equation (1). The model relies on four instruments, which are used as a group in the 2SLS estimation.

The first instrument, *HUB*, indicates whether the metro area contains a hub airport.[3] In the case of a single-airport metro area, *HUB* is simply a dummy variable equal to one if that airport is a hub and zero otherwise. When a metro area has multiple airports and one is a hub, the *HUB* variable equals the share of that airport in the metro area's total enplanements. In effect, *HUB* then equals the zero–one dummy scaled down by the hub airport's enplanement share. In case of New York, for example, Newark is a hub airport, so that *HUB* equals Newark's share of the New York metro area's total enplanements.

To see that *HUB* has some features of a suitable instrument, observe that traffic at a hub airport consists of local passengers plus a typically larger volume of connecting passengers, whose trip begins and ends elsewhere. Since both types of passenger generate enplanements, the *TRAFFIC* measure for a hub will be much larger than for a non-hub airport located in a similar-size city, which has little or no connecting traffic. Thus, the *HUB* variable will be an important determinant of *TRAFFIC*, satisfying one requirement of a suitable instrument.

As for the other requirement, lack of correlation with u in equation (1), the suitability of *HUB* can be questioned. Since the advantage of a large local passenger base means that hubs tend to be located in large metro areas, it follows that the raw correlation between *HUB* and *EMP* is positive. However, the above correlation requirement says that an increase in any of the *unobserved* determinants of *EMP* (which are contained in u) should not affect the *HUB* status of a metro area's airport(s). Since *POP*, an observed determinant of *EMP*, is implicitly held fixed in this thought experiment, the correlation condition reduces to the following requirement: an increase in an unobserved variable that tends to raise a metro area's *EMP* above *the typical level for areas of its size* will not affect the hub status of the airport. If hub locations are chosen more on the basis of a metro area's population than its employment level, this requirement may be satisfied. On the other hand, the importance of business travel suggests that, among metro area with a particular population, those with abnormally high employment levels might be more attractive as hub locations, in which case the correlation requirement would be violated. Even in this instance, however, the correlation between *HUB* and u may not be substantial.

Recognising the potential drawbacks of *HUB* as an instrument, a variable that may be an exogenous determinant of an airport's hub status can be substituted in its place. This variable is suggested by the geography of airline networks, which dictates that the best US hub locations lie in the centre of the country, facilitating both east–west and north–south travel. Of course, many hub airports (Newark, Miami, Washington–Dulles, Philadelphia, San Francisco, among others) constitute exceptions to this central tendency. Nevertheless, the effect of centrality is measured by the distance from the given airport to the US population centre of gravity for the year 1990, which lies in Missouri.[4] A decrease in this variable, which is denoted *CENTRALITY*, may raise the likelihood that an airport is a hub, thus increasing *TRAFFIC*. However, holding the elements of **X** fixed, *CENTRALITY* is unlikely to affect *EMP*, thus being uncorrelated with u.

A second instrument attempts to capture the traffic diversion effect of proximity to a large airport. For cities that are relatively close to a metro area containing a large airport, passengers may drive to it rather than flying out of their local airport, reducing local enplanements. The variable *PROXIMITY*, which captures this traffic diversion effect, is set equal to one for smaller metro areas (those with enplanements outside the top 26) that are within 150 miles of a metro area containing a large airport (metro areas within the top 26).[5] A negative correlation between *PROXIMITY* and *TRAFFIC* is likely, but the variable is unlikely to be correlated with u in equation (1).

Two additional instruments capture the special features of particular airports and metro areas. The variable *SLOT* indicates whether the metro area has a slot-controlled airport. Such airports, which operate at capacity and are thus closed to new traffic, should have *TRAFFIC* levels below those of otherwise comparable airports that are not capacity-constrained. Since each of the slot-controlled airports (Chicago–O'Hare, New York–La Guardia, New York–JFK and Washington–National) is in a multiple-airport metro area, construction of the slot variable follows that of *HUB*. The variable is set equal to the metro-area enplanement share of the slot-controlled airport(s) for those areas containing such an airport and zero otherwise. *SLOT* should be negatively correlated with *TRAFFIC* but uncorrelated with u.

Finally, two metro areas, Las Vegas and Orlando, have abnormally high traffic levels because of the special leisure attractions that they offer. To capture the effect of such outliers, the dummy variable *LEISURE* is set equal to one for these two metro areas and zero otherwise. While *LEISURE* should show a strong positive correlation with *TRAFFIC*, the variable should not exhibit any particular relationship to employment and hence u (affecting its composition rather than its level).

Table 1 presents definitions and summary statistics for all of the variables of the model.

3. Empirical Findings

Table 2 presents the regression results when *HUB* is used as an instrument along with *PROXIMITY*, *SLOT* and *LEISURE*; and Table 3 presents the results when *CENTRALITY* replaces *HUB*. In the regressions, *TRAFFIC*, *POP* and the employment variables appear in natural log form. In addition, the t-statistics in the regressions are based on robust standard errors (White, 1980) to account for possible heteroscedasticity in the error structure. Once the estimates have been discussed, the results of diagnostic tests for endogeneity of *TRAFFIC* and the suitability of the instruments are presented.

The first column of Table 2 presents the first-stage regression of the 2SLS procedure, where *TRAFFIC* is regressed on the **X** variables and the instruments. Focusing first on the instruments, the *HUB* and *LEISURE* variables both have positive coefficients, as predicted, and the estimates are highly significant. Thus, metro areas that contain hub airports or are prominent leisure destinations have higher *TRAFFIC* levels. The *PROXIMITY* coefficient is negative and significant, indicating that small and medium-sized metro areas close to a large airport experience a diversion of traffic, which lowers local enplanements. While *SLOT*'s coefficient has the predicted negative sign, the coefficient is not significantly different from zero, indicating that the slot-control status of airports has no effect on *TRAFFIC*, holding its other determinants constant.

Among the **X** variables, only *POP* and *COLGGRAD* have significant effects on *TRAFFIC*. A larger population naturally raises enplanements and the coefficient estimate of 0.979 indicates that the elasticity is virtually unitary, with a 1 per cent increase in *POP* raising *TRAFFIC* by 1 per cent. The positive coefficient of *COLGGRAD* shows that a highly educated metro-area generates more airline traffic than a less-educated area. This result partly reflects the fact that highly educated workers are likely to be employed in occupations that require business travel. In addition, *COLGGRAD*'s coefficient is likely to capture the effect on leisure travel of an increase in income, which is suppressed from the empirical framework (see above) but correlated with education. In addition, high education may increase the propensity for leisure air travel, holding income constant. The lack of significance of the remaining coefficients shows that the airline traffic does not depend on the age distribution of a metro area's population (*YOUNG*, *OLD*), on its climate (*HEATING*) or level of union activity (*RTW*), or on its income-tax burden (*PERSTAX*, *CORPTAX*).[6]

The second column of Table 2 presents the 2SLS estimates of the coefficients of equation (1), while the third column presents OLS estimates for comparison. As expected, the results show that airline traffic exerts a significantly positive effect on total employment in a metro area. The point estimate shows that the elasticity of this effect is 0.09, indicating that a 10 per cent increase in *TRAFFIC* raises *EMP* by 0.9 per cent. This effect, which shows that a *TRAFFIC* increase translates into higher employment in approximately a 10:1 ratio, is substantial in size. Its magnitude shows that employment gains extend far beyond the airport itself, where higher traffic directly generates more jobs. While these outside employment gains partly reflect the usual multiplier effect of new jobs, the gains are also consistent with the existence of intercity agglomeration economies,

Table 1. Variable definitions and summary statistics

Variable	Definition	Mean	Minimum	Maximum
TRAFFIC	Total 1996 passenger enplanements at metro area airport(s)	5 638 982	285 585	34 937 810
EMP	Total metro-area non-farm employment for 1996 (in 1000s)	880.5	92.2	8 893.0
GDSEMP	Total metro-area goods-related employment for 1996 (in 1000s)	162.8	11.5	1 298.3
SVCEMP	Total metro-area service-related employment for 1996 (in 1000s)	717.7	77.6	7 595.3
POP	Metro-area population for 1990	1 742 861	139 236	19 480 012
YOUNG	Percentage of 1996 metro-area population of age 14 or younger	21.6	15.7	28.5
OLD	Percentage of 1996 metro-area population of age 65 or older	12.3	7.4	30.9
RTW	Dummy variable equal to one if metro area's state has right-to-work law	0.57	0	1
HEATING	Average heating degree days for metro area	3 914	155	7 976
COLGGRAD	Percentage of metro area's 1990 population over 25 with a college degree	22.0	12.0	34.8
CORPTAX	Maximum 1996 marginal corporate income tax rate for metro area's state	6.54	0	12.0
PERSTAX	Maximum 1996 marginal personal income tax rate for metro area's state	4.73	0	11.0
HUB	Enplanement share of any hub airports in metro area	0.19	0	1
CENTRALITY	Mileage from the metro area's largest airport to the US population centre of gravity	736.6	76.6	1 721.8
LEISURE	Dummy variable equal to one for Las Vegas and Orlando	0.02	0	1
PROXIMITY	Dummy variable equal to one for smaller metro areas within 150 miles of large airport	0.33	0	1
SLOT	Enplanement share of any slot-controlled airports in metro area	0.02	0	0.87

Data sources; *EMP*, *GDSEMP*, *SVCEMP*, *POP*, *YOUNG*, *OLD*: US Bureau of the Census, *State and Metropolitan Area Data Book, 1997–98*. *TRAFFIC*: Bureau of Transportation Statistics, *Airport Activity Statistics of Certificated Air Carriers*, 1997. *HEATING*: National Oceanic and Atmospheric Administration website (http://lwf.noaa.gov/oa/climate/online/ccd/nrmhdd.html). *CORPTAX*, *PERSTAX*: Council of State Governments, *Book of the States*, 1996–97 edition. *RTW*: National Right to Work Legal Defense Foundation website (http://www.nrtw.org/rtws.htm). *HUB*, *CENTRALITY*, *LEISURE*, *PROXIMITY*, *SLOT*: author's calculations.

Table 2. Regression results with *HUB* as instrument

Independent variables	*TRAFFIC* (OLS)	*EMP* (2SLS)	*EMP* (OLS)	*GDSEMP* (2SLS)	*GDSEMP* (OLS)	*SVCEMP* (2SLS)	*SVCEMP* (OLS)
INTERCEPT	−0.887	−6.246	−6.304	−7.532	−7.668	−6.509	−6.552
	(0.41)	(16.60)	(16.79)	(8.58)	(8.56)	(16.95)	(17.86)
POP	0.979	0.889	0.903	0.992	1.023	0.858	0.868
	(11.63)	(24.24)	(35.39)	(11.82)	(14.54)	(21.56)	(35.60)
TRAFFIC		0.0886	0.0782	0.0168	−0.00768	0.110	0.102
		(3.15)	(4.34)	(0.29)	(0.16)	(3.52)	(5.60)
YOUNG	0.0437	−0.0469	−0.0460	−0.0639	−0.0619	−0.0429	−0.0423
	(0.86)	(5.72)	(5.53)	(3.07)	(2.84)	(4.92)	(4.87)
OLD	0.0223	−0.0235	−0.0233	−0.0400	−0.0396	−0.0204	−0.0202
	(0.74)	(4.82)	(4.28)	(3.39)	(3.06)	(4.43)	(3.99)
RTW	0.0176	0.114	0.118	0.157	0.164	0.0968	0.0991
	(0.11)	(4.36)	(4.25)	(1.95)	(1.96)	(3.16)	(3.07)
HEATING	−0.0000128	0.0000328	0.0000332	0.0000732	0.0000741	0.0000221	0.0000224
	(0.32)	(5.51)	(5.30)	(4.25)	(4.14)	(3.44)	(3.28)
COLGGRAD	0.0540	0.00157	0.00202	−0.0145	−0.0135	0.00549	0.00583
	(3.63)	(0.48)	(0.62)	(1.69)	(1.50)	(1.54)	(1.60)
CORPTAX	−0.0637	−0.00141	−0.00214	−0.0174	−0.0192	0.00390	0.00336
	(1.78)	(0.21)	(0.31)	(1.13)	(1.21)	(0.59)	(0.47)
PERSTAX	−0.00908	0.00135	0.00107	0.0178	0.0172	−0.00356	−0.00377
	(0.42)	(0.34)	(0.26)	(1.66)	(1.53)	(0.81)	(0.83)
HUB	0.922						
	(5.76)						
LEISURE	1.653						
	(3.92)						
PROXIMITY	−0.315						
	(1.96)						
SLOT	−0.338						
	(0.82)						
R^2	0.872		0.992		0.947		0.991

Notes: TRAFFIC, *POP*, *EMP*, *GDSEMP*, *SVCEMP* in logs; absolute *t*-statistics in parenthesis, based on robust standard errors; observations = 91.

as discussed above. In other words, a high level of *TRAFFIC*, reflecting frequent airline service to many destinations, stimulates employment at established firms and attracts new employers to the metro area.

The estimates also confirm a number of other expectations. Employment is higher in large metro areas, with the significant *POP* elasticity of 0.89 indicating that *EMP* increases slightly less rapidly than population itself. The significantly negative *YOUNG* and *OLD* coefficients indicate that a metro area has relatively low employment when a larger than average share of the population is outside the working years. The significantly positive coefficient of *RTW* shows, as expected, that metro areas in states with union-inhibiting right-to-work laws have higher employment than those in states with more union influence. With *RTW* being a dummy variable, its coefficient shows that a right-to-work law boosts a metro area's employment by 11 per cent.

Contrary to expectations, however, *PERSTAX*, *CORPTAX* and *COLGGRAD* have insignificant coefficients, indicating that a metro area's income tax burden and its human capital level have no effect on employment. Finally, the significantly positive coefficient of *HEATING* shows that metro areas in the rustbelt region of the country have *higher* employment, other things equal, than metro areas in the warmer sunbelt.

Inspection of estimates in the third column of Table 2 shows that the OLS results are very similar to the 2SLS estimates of column two. While *TRAFFIC*'s coefficient declines from 0.09 to 0.08, the rest of the significant coefficients are very close in magnitude to the values in column two. This pattern is discussed further below once the entire set of results has been considered.

The fourth column of Table 2 presents the 2SLS estimates when *EMP* is replaced by total goods-related employment, *GDSEMP*. While many of the coefficients mirror the *EMP* results, a striking change is the lack of significance, as well as the small magnitude, of the *TRAFFIC* coefficient. This coefficient estimate implies that airline traffic has no effect on employment in manufacturing and other goods-related industries. But this finding conforms well to intuition regarding the nature of intercity agglomeration economies. Given the routine nature of much manufacturing and construction activity, firms in these industries have less need for face-to-face contact with businesses in other cities than do firms engaged in more information-intensive pursuits. As a result, good airline service would constitute much less of an attractive force for goods-related firms than for firms in other industries, implying the absence of a link between *GDSEMP* and *TRAFFIC*.

By contrast, the estimates in column six show that employment in service-related industries, *SVCEMP*, does respond to the level of airline traffic in a metro area. The significant elasiticity estimate equals 0.11, indicating that a 10 per cent increase in *TRAFFIC* raises *SVCEMP* by 1.1 per cent. Thus, the positive overall impact of *TRAFFIC* on *EMP* arises through the channel of service-related employment, a finding that is consistent with the presumed nature of intercity agglomeration economies. Note that the *SVCEMP* elasticity is naturally larger than the overall elasticity of 0.09 from column two, a consequence of the fact that *TRAFFIC* has a zero impact on the goods-related component of *EMP*.

Returning to the other coefficients in column four, *POP*, *YOUNG*, *OLD*, *RTW* and *HEATING* have the same qualitative effects on *GDSEMP* as in the *EMP* equation. Note, however, that a right-to-work law reduces *GDSEMP* by a larger 16 per cent. While the tax and education coefficients are again insignificant, *COLGGRAD*'s negative impact is marginally significant, plausibly indicating that highly educated metro areas are not favoured locations for manufacturing and other goods-related firms. By contrast, *COLGGRAD*'s coefficient in the *SVCEMP* regression in column six is positive and marginally significant, suggesting that educated metro areas may attract service-related firms.

The remaining **X** coefficients in the *SVCEMP* equation mirror the qualitative

Table 3. Regression results with *CENTRALITY* as instrument

Independent variable	*TRAFFIC* (OLS)	*EMP* (2SLS)	*GDSEMP* (2SLS)	*SVCEMP* (2SLS)
INTERCEPT	− 4.001	− 6.338	− 8.428	− 6.416
	(1.66)	(14.71)	(9.50)	(16.11)
POP	1.220	0.910	1.197	0.836
	(14.78)	(15.84)	(11.19)	(15.64)
TRAFFIC		0.0720	− 0.145	0.127
		(1.56)	(1.90)	(2.94)
YOUNG	0.0311	− 0.0455	− 0.0508	− 0.0443
	(0.50)	(5.07)	(2.68)	(4.98)
OLD	0.00755	− 0.0231	− 0.0370	− 0.0207
	(0.21)	(4.72)	(3.31)	(4.40)
RTW	0.280	0.119	0.204	0.0919
	(1.24)	(4.30)	(2.44)	(2.93)
HEATING	0.0000681	0.0000335	0.0000794	0.0000215
	(1.23)	(5.50)	(4.62)	(3.32)
COLGGRAD	0.0456	0.00229	− 0.00754	0.00476
	(2.50)	(0.62)	(0.86)	(1.28)
CORPTAX	− 0.0338	− 0.00257	− 0.0287	0.00507
	(0.96)	(0.37)	(2.00)	(0.69)
PERSTAX	− 0.0401	0.000900	0.0135	− 0.00311
	(1.64)	(0.23)	(1.25)	(0.72)
CENTRALITY	0.000240			
	(1.10)			
LEISURE	1.335			
	(3.32)			
PROXIMITY	− 0.412			
	(2.49)			
SLOT	− 0.621			
	(0.80)			
R^2	0.840			

Notes: *TRAFFIC*, *POP*, *EMP*, *GDSEMP*, *SVCEMP* in logs; absolute *t*-statistics in parenthesis, based on robust standard errors; observations = 91.

results from the other regressions, although *RTW*'s smaller coefficient suggests a weaker right-to-work effect for service industries. Finally, the OLS versions of the *GDSEMP* and *SVCEMP* regressions, reported in columns five and seven, are similar to the 2SLS equations.

Table 3 presents an equivalent set of regressions where the *CENTRALITY* variable replaces *HUB*. Recall that concerns about the suitability of *HUB* as an instrument suggested the use of this alternate variable. The first column of Table 3, which contains the first-stage regression of *TRAFFIC* on **X** and the instruments, shows an insignificant coefficient for *CENTRALITY*, indicating that, contrary to expectations, a central location for a metro area does not boost airline traffic. Recall that such an effect was anticipated because a central location was expected to increase the likelihood that an airport serves as a hub. Evidently, the numerous exceptions to a hub centrality pattern mask the anticipated effect of this variable on traffic.[7] Although the remaining coefficients in the regression are similar to those in Table 2, a noteworthy change is the rise in *POP*'s coefficient, which now indicates that *TRAFFIC* rises faster than population.

Turning to the 2SLS *EMP* results in column 2, a notable change is the loss of significance of *TRAFFIC*'s coefficient. The magnitude of the coefficient, however, is similar to that in Table 2 and the remaining results mirror the earlier ones. In the *GDSEMP* regression in column three, the *TRAFFIC* coefficient is again insignificant, but its sign is now negative and its *t*-statistic is in the marginally significant range. Despite these divergences from the results of Table 2, the *SVCEMP* regression in column four again shows a strongly significant impact of *TRAFFIC* on employment in service-related industries. The estimated elasticity of 0.13 is close to the value of 0.11 from Table 2, indicating that a 10 per cent increase in *TRAFFIC* raises service employment by 1.3 per cent. The remaining results from the *GDSEMP* and *SVCEMP* regressions are similar to those in Table 2. Use of a different instrument, of course, has no effect on the OLS estimates of the three employment equations.

The magnitudes of *TRAFFIC*'s estimated effects on employment are highly robust to changes in the composition of the sample. For example, if the two largest metro areas, New York and Los Angeles, are dropped from the sample, the elasticities of *EMP* and *SVCEMP* with respect to *TRAFFIC* in the specification using *HUB* as an instrument remain at 0.09 and 0.11, respectively. When metro areas with 1996 populations below 1 million are deleted, reducing the sample to 38 observations, the above elasticities are 0.09 and 0.09, respectively. These findings suggest that *TRAFFIC*'s employment effects are stable across a broad range of metro-area populations.

The similarity of the 2SLS and OLS estimates in Tables 2 and 3 suggests that concerns about the endogeneity of *TRAFFIC* may be unwarranted despite their strong intuitive basis. The Hausman–Wu specification test can be used to investigate this issue (see Davidson and MacKinnon, 1993). To carry out the test, the fitted values of *TRAFFIC* are included as an additional variable (along with the actual *TRAFFIC* variable) in an OLS regression based on equation (1). If the coefficient of the fitted *TRAFFIC* variable is insignificant, then the null hypothesis of zero correlation between *TRAFFIC* and the error term u cannot be rejected, implying that the OLS estimates in Tables 2 and 3 are consistent. When this test is carried out, an insignificant coefficient does indeed emerge, with the *t*-statistics well below unity in both the *EMP* and *SVCEMP* regressions, using either set of instruments. While this conclusion indicates that the OLS estimates in Tables 2 and 3 may be satisfactory, the usual danger involved in accepting a null hypothesis (the unknown probability of doing so incorrectly) suggests that the 2SLS estimates are preferable.[8] In any event, the similar magnitudes of the OLS and 2SLS point estimates mean that choice between them is not a critical issue.[9]

4. Applying the Results to Predict the Impact of O'Hare's Expansion

Many cities view improved airline service as a path to economic development. However, since the existing level of service is an equilibrium outcome produced by a structural equation system that includes equation (1), the desired service increase (and its attendant employment effect) can only be achieved through government intervention that changes the parameters of the system. For example, one type of intervention consists of government subsidies for airline service provided to small cities. Such subsidies boost traffic in an exogenous fashion as airlines reduce small-city fares and increase flights, and the empirical model predicts a resulting impact on local employment.

In another intervention, the government can invest resources to increase the size of a capacity-constrained airport. At such an airport, the desired level of airline operations exceeds capacity and expansion of the airport allows extra flights to be accommodated, leading to an exogenous increase in traffic.

Chicago's O'Hare airport is a prominent example of such a capacity-constrained airport and plans for its expansion have been formulated. These plans, which involve a hard-won agreement between the mayor of Chicago and the governor of Illinois, call for an approximate doubling of the airport's flight capacity. Despite the agreement, virulent opposition to the expansion still exists. This opposition comes mainly from residents living near the airport (and their elected representatives), who point to the increase in noise and other environmental damage that will result from a greater volume of flights.

Proponents argue that O'Hare's expansion will greatly stimulate the economy of the Chicago metropolitan area, arguing that the airport's role as a major economic engine in the region will be strengthened. However, quantitative predictions regarding the possible magnitude of such an impact are scarce. The current empirical results can be used to generate such a prediction, as follows.

First, observe that, if a capacity-constrained airport is still constrained after expansion, then the increase in traffic corresponds exactly to that allowed by the expansion. To understand this point, note that, by raising metro-area employment, the traffic increase facilitated by greater capacity will itself produce a further traffic stimulus. However, since the capacity constraint remains binding, the airport cannot accommodate the additional desired traffic. As a result, the traffic gain consists only of the exogenous initial increase made possible by greater capacity.

On the other hand, if the capacity constraint ceases to bind after expansion, then the airport can accommodate a second-round traffic gain, which is stimulated by the employment increase following the initial gain in traffic. Progressive rounds of feedback between traffic and employment ultimately achieve new equilibrium levels of these variables. However, predicting these levels requires a deeper knowledge of the parameters of the full equation system governing the variables.

Given the magnitude of the proposed capacity increase at O'Hare, it is doubtful that the new airport will be capacity-constrained, at least initially. As a result, the relevant scenario is likely to be the second one above, where the employment/traffic feedbacks affect the outcome. While it is difficult to predict the resulting level of traffic, a reasonable guess can serve as a basis for estimating the magnitudes of the employment effect of the expansion.

To this end, suppose that the new equilibrium level of traffic at O'Hare is 50 per cent above the current level, a seemingly conservative estimate given the proposed doubling of flight capacity. Then, the new equilibrium level of employment must satisfy equation (1), with the value of *TRAFFIC* raised by 50 per cent. Rounding the estimated *SVCEMP* elasticity from Table 2 down to 0.1 for simplicity, so that percentage changes are in a 10:1 ratio, this 50 per cent traffic increase is associated with a 5 per cent increase in service-related employment. In 2001, such employment equalled 3 698 000 jobs for the Chicago CMSA (see Bureau of Labor Statistics, 2002). Five per cent of this value corresponds to approximately 185 000 jobs. Thus, if O'Hare expansion raises traffic by 50 per cent, service-related employment in the Chicago CMSA is predicted to rise by almost 200 000 jobs. With a zero elasticity for manufacturing employment, the results predict no effect on the level of such jobs. The service-related job impact is obviously substantial in magnitude, testifying to the power of O'Hare expansion as an economic development tool. Of course, a smaller equilibrium traffic increase would be associated with a smaller employment gain. For example, the service employment gain would be somewhat more that 90 000 jobs if O'Hare's traffic increased by only 25 per cent following expansion.

Given that Chicago already has excellent airline service, it is natural to ask how additional traffic could possibly lead to a further strengthening in intercity agglomeration economies and thus more service-related employment. One important avenue for such an effect is through international airline service, whose growth is currently restrained by O'Hare's capacity limit. In addition, one can imagine that the already-long list of domestic destinations served from Chicago would grow with an expansion of the airport, as would the frequency of service to existing destinations.

5. Conclusion

This paper has provided new evidence on the link between airline traffic and employment in a metro area. The evidence confirms the common view that good airline service is an important factor in urban economic development. Frequent service to a variety of destinations, reflected in a high level of passenger enplanements, facilitates easy face-to-face contact with businesses in other cities, attracting new firms to the metro area and stimulating employment at established enterprises.

The empirical results show that a 10 per cent increase in passenger enplanements in a metro area leads approximately to a 1 per cent increase in employment in service-related industries. However, airline traffic has no effect on manufacturing and other goods-related employment, suggesting that air travel is less important for such firms than for service-related businesses. These estimates are generated controlling for reverse causality between employment and traffic.

The results can be used to predict the employment effects of expansion of Chicago's O'Hare airport. Assuming that expansion would generate a 50 per cent increase in traffic, service-related employment in the Chicago metro area would grow by 185 000 jobs. Thus, the expansion of O'Hare airport represents a powerful economic development tool, as argued by its proponents.

Notes

1. Another related literature studies the effect of public capital (which includes airport infrastructure) on the productivity of private firms (for the seminal paper, see Aschauer, 1989, and, for a recent contribution, see Pereira and Flores de Frutos, 1999; a survey is provided by Munnell, 1992). Since the studies in this literature are based on aggregate capital measures, none shows explicitly the effect of investment in airports.
2. Selection of the sample metro areas was carried out as follows. The starting-point was a list of the 120 US metro areas with the largest airline traffic volumes, contained in Bureau of Transportation Statistics (1997). Metro areas outside the continental US were deleted from this list, as were metro areas lacking data for any of the variables of the empirical model (usually employment). Finally, some of the listed metro areas were consolidated to match the CMSA definitions, yielding a sample size of 91.
3. Hub airports (and the associated airlines) are as follows: Atlanta (Delta), Charlotte, NC (US Airways), Cleveland (Continental), Chicago–O'Hare (United, American), Cincinnati (Delta), Dallas/Fort Worth (American), Denver (United), Detroit (Northwest), Houston (Continental), Miami (American), Memphis (Northwest), Minneapolis/St Paul (Northwest), Newark (Contintental), Philadelphia (US Airways), Phoenix (America West), Pittsburgh (US Airways), Salt Lake City (Delta), San Francisco (United), St Louis (TWA), Washington–Dulles (United).
4. For multiple-airport cities, the distance from the largest airport to the centre of gravity is used to compute *CENTRALITY*.
5. These metro areas are designated as 'large hubs' by the Bureau of Transportation Statistics (1997). (In their terminology, 'hub' refers to airport size and not to the existence of hub-and-spoke operations.)
6. Brueckner (1985) estimated a regression like that in column one for a sample of small and medium-sized metro areas. Among other things, the results show a similar kind of proximity effect on traffic.
7. In a regression of *HUB* on *POP* and *CENTRALITY*, the latter variable's coefficient is negative, as expected, but only marginally significant.
8. An intuitive explanation for the evident exogeneity of *TRAFFIC* is not readily apparent. On the one hand, *TRAFFIC* may be determined more by population than by employment, limiting the extent of simultaneity between *TRAFFIC* and employment. Moreover, the substantial variation of *TRAFFIC* across hub and non-hub airports generates a large, mostly exogenous, variation in this variable that may overwhelm any feedback effects from employment.
9. Although the outcome of the Hausman–Wu test suggests that the use of instruments in estimating equation (1) may be unnecessary, it is useful nevertheless to carry out a test for overidentifying restrictions, which indicates whether the chosen instruments are valid. In this test (see Davidson and MacKinnon, 1993), the 2SLS residuals are regressed on the **X** variables and the instruments. Since these residuals are analogous to the error term u, the explanatory power of this regression should be low if the instruments are

indeed uncorrelated with u (such correlation is absent for the X variables by assumption). The test thus relies on the R^2 value for this regression, rejecting the null hypothesis of zero correlation if the value is high. When this test is carried out using the instrument set that includes *CENTRALITY*, the null hypothesis cannot be rejected for both the *EMP* and *SVCEMP* regressions. However, when *HUB* replaces *CENTRALITY*, the null hypothesis is rejected for the *EMP* regression, while the test-statistic lies just on the margin of rejection for the *SVCEMP* regression. While the overidentification test thus favours *CENTRALITY* as an instrument, the similarity of the estimates in Tables 2 and 3 makes this choice mostly a matter of indifference.

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Appendix

Table A1. Sample metro areas

Albany	Fort Myers	Oklahoma City
Albuquerque	Grand Rapids	Omaha
Allentown/Bethlehem/Easton	Green Bay	Orlando
Amarillo	Greensboro	Pensacola
Atlanta	Greenville, SC	Philadelphia
Austin	Harrisburg	Phoenix
Baton Rouge	Houston[c]	Pittsburgh
Birmingham	Huntsville	Portland
Boise	Indianapolis	Raleigh/Durham
Boston	Jackson, MS	Reno
Brownsville	Jacksonville	Richmond
Buffalo	Kansas City	Rochester, NY
Cedar Rapids	Knoxville	Sacramento
Charleston, SC	Las Vegas	Salt Lake City
Charlotte	Lexington	San Antonio
Chicago[a]	Little Rock	San Diego

Table A1.—*continued*

Cincinnati	Los Angeles[d]	San Francisco[g]
Cleveland	Louisville	Sarasota
Colorado Springs	Lubbock	Savannah
Columbia, SC	Madison	Seattle
Columbus, OH	Melbourne, FL	Sioux Falls
Corpus Christi	Memphis	South Bend
Dallas/Fort Worth[b]	Miami[e]	Spokane
Dayton	Milwaukee	St Louis
Daytona Beach	Minneapolis/St Paul	Syracuse
Denver	Mobile	Tampa/St Petersburg
Des Moines	Nashville	Tucson
Detroit	New Orleans	Tulsa
El Paso	New York[f]	Washington, DC[h]
Eugene	Norfolk	West Palm Beach
		Wichita

[a]Airports are Chicago–O'Hare and Midway.

[b]Airports are DFW and Love Field.

[c]Airports are Houston Intercontinental and Hobby.

[d]Airports are Los Angeles International, John Wayne, Burbank, Long Beach and Ontario.

[e]Airports are Miami International and Fort Lauderdale.

[f]Airports are La Guardia, John F. Kennedy, Newark, White Plains, Islip and Newburgh.

[g]Airports are San Francisco, Oakland and San Jose.

[h]Airports are Washington–National, Dulles and Baltimore–Washington.