Title
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Publication Date
1995-04-01

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Working Paper
UCTC No. 85

The University of California Transportation Center

University of California
Berkeley, CA 94720

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Highways and Intrametropolitan Employment Growth

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Working Paper
April 1995

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HIGHWAYS AND INTRAMETROPOLITAN EMPLOYMENT GROWTH

Abstract

This paper examines the link between highways and employment growth within two metropolitan areas. Most studies of the land use impacts of transportation focus on residential location. Yet in decentralized urban areas, the relationship between the highway network and intrametropolitan employment location is an important one. This paper uses an econometric model of local employment growth to examine the effect of highways on employment changes within northern New Jersey and Orange County, California. Within both urban areas, highway proximity has a statistically significant and positive effect on employment growth. There is also evidence that other location specific amenities (such as agglomeration economies and surrounding population growth) are possibly more important for local employment growth than highway location.

Acknowledgements: I am grateful to Richard Crepeau for research assistance in collecting the data for Orange County and Genevieve Giuliano for comments on an earlier draft. Support for collecting some of the initial data for New Jersey was provided by the U.S. Department of Transportation and the New Jersey Department of Transportation. This research was also supported by the University of California through an allocation of computer time and through an Irvine Faculty Fellowship. I alone am responsible for the analysis that is presented here.

HIGHWAYS AND INTRAMETROPOLITAN EMPLOYMENT GROWTH

As urban areas have decentralized, the pattern of employment location appears to be linked to the highway network. Some suburban employment centers, such as Route 1 in New Jersey or the Route 128 corridor in Massachusetts, even bear the name of the highway that traverses the area. Yet empirical evidence on the link between highways and employment location is somewhat sparse, and the available evidence suggests that a large number of non-transportation factors influence the intrametropolitan distribution of jobs. This paper provides new evidence on the link between highways and employment location, based on an econometric model of employment location that is tested on two urban areas -- northern New Jersey and Orange County, California.

I. Background: The Land Use Impacts of Transportation

Economic theory, most notably the monocentric urban model, gives clear predictions regarding transportation improvements and land use. Simple applications of the monocentric model yield the result that decreases in transportation costs lead to decentralization of residential settlement (Alonso, 1964; Fujita, 1989).[1] More complex treatments, with beltways or street grids, give the result that residential bid-rents and, to the extent that bid-rents are the market rent, residential densities are higher near streets or highways (Yinger,

[1] More specifically, for a closed city (no in- or out-migration), decreases in marginal transportation costs will pivot the household bid-rent curve, such that the population density gradient decreases. For a derivation of this result, see Fujita (1989), pp. 78-81.

1993; Alonso, 1964 pp. 130-134; White 1976). In short, locations with better accessibility to an employment center have higher residential bid-rents and thus more intense land use (higher densities.)

Yet these predictions pertain to residential land use and usually assume an exogenous concentration of employment, typically in a central business district (CBD). Given the monocentric model's focus on residential location, predictions linking transportation and employment are more elusive. Port city models predict that firms will bid-up the price of land that is accessible to a shipping node, and, for those types of firms, the model can yield higher concentrations near the port (Mills, 1972, chapter 5; Henderson, 1985, pp. 28-30; White, 1976; Koide, 1990). Other location models, such as central place theories, predict that firms will locate to serve local markets (Losch, 1954; von Boventer, 1976).

Overall, theory suggests something similar to the result for residential location: Where transportation access is high, ceteris paribus, one would expect larger concentrations of economic activity.[2] This is consistent with the concern in the policy community that highways influence employment location, and can, in the extreme, become growth corridors. Empirical research on this topic also suggests a link, although the link is often weaker than theory would suggest, and past empirical work has shortcomings, as discussed below.

[2] Giuliano (1989) reviewed the literature on the land-use impacts of transportation and came to a similar conclusion regarding the theoretical literature on this topic. Yet Giuliano (1989) notes some contradictions across the theories. For example, while transportation improvements in a port city model imply that employment will decentralize, central place theory can give the result that transportation improvements will centralize employment.

II. Empirical Approaches in Examining Highways and Employment Location

There are, broadly speaking, two ways that empirical research can look for a link between transportation and land use. The first focuses on price impacts, while the second focuses on land use intensities. In a simple monocentric model, changes in bid-rent relate to changes in market rents, which in turn are related to the intensity of land use. Thus the basic monocentric prediction that there is a link between transportation and land use can be tested either by examining prices or quantities (where quantities are land use intensities.)[3] Consider the empirical evidence on both.

Land price studies have typically focused on the effect of transportation access on the value of residential land. Mohring (1961) argued that land price increases near highways represent travel time savings to commuters, and are not independent benefits. Mohring (1961) also documented, using data from 1948 to 1955, that the construction of a freeway connecting Mercer Island to Seattle increased residential land values. Czamanski (1966) found that land values in Baltimore were positively associated with a measure of accessibility to major activity centers.[4] Time series studies by Langley (1976a and 1976b) show both an increase in residential land values in the vicinity of highways and land price decreases for locations that are closest to highways (and are affected by highway noise and other

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[3] Of course, with more than one household type, the market rent is the upper envelope of bid-rent curves (Fujita, 1989, p. 102), and the relationship between observed market rents and densities can be more complicated. Still, one would expect that land in places with lower transportation costs will be both more expensive and settled at higher densities.

[4] Czamanski studied several different land uses, not just residential.

disamenities.)

The land price approach, while having shown some success for residential land, is a less fruitful approach for employment location. For firms, unlike residents, location specific amenities can be capitalized into two price variables -- wages and rents (Sivitanidou and Wheaton, 1992). This complicates the situation, leaving land prices as a more ambiguous measure of location specific amenities experienced by firms. Furthermore, data on commercial and office space, while available, are less common than house price data. Lastly, for both firms and residences, one must separate the value of land from the value of the structure. A common technique for doing this is hedonic regression. Yet there has been much less research into hedonic price analysis of commercial structures, which leaves a thinner literature on which to base estimates of commercial or office land values.[5]

Probably for the reasons described above, most studies of economic activity and highways have focused on a measure of land use intensity -- usually employment location. A landmark study in the late 1970s examined the land use and development impacts of beltways in several U.S. urban areas (Payne-Maxie, 1980). The authors examined a sample of 54 metropolitan areas -- 27 with beltways and 27 without beltways. They found few consistent, statistically significant relationships between the presence of a beltway and the distribution of population or employment growth within the metropolitan area. The effects that were documented seemed related to the characteristics of the beltway and metropolitan area, including the beltway location, distance from the CBD, density of interchanges, and the age,

[5] An exception is Peiser (1987), who studied the determinants of commercial land values. Yet Peiser examined hedonics for vacant land, and as such did not use the hedonic to separate the value of the structure from the value of the land.

income, and past growth rates of the urban area. The conclusion was that beltway impacts on the distribution of employment were often modest and secondary to other factors.

Later studies by Eagle and Stephanedes (Eagle and Stephanedes, 1987; Stephanedes and Eagle, 1987; Stephanedes, 1988) used data on Minnesota counties to test the relationship between highway spending and employment growth. With time series data, they conducted Granger causality tests and concluded that highway spending did not cause employment growth in most Minnesota counties. The exception was in the urbanized counties, where highways did Granger cause employment. Their results also suggested that the employment growth due to highways in urban counties was largely at the expense of job losses in neighboring (next-to-urban) counties.

Both the studies by Eagle and Stephanedes and Payne-Maxie (1980) yield results that are consistent with the view that highways have a relatively small impact on employment location, although both suggest that the impact varies depending on the nature of the highway and the metropolitan area. This is consistent with Giuliano's (1989) summary of the literature on the land use impacts of transportation. She concludes that most modern transportation improvements, highways included, have a small impact on relative accessibility within an urban area. Giuliano (1989) further suggests that the often small change in relative accessibility explains the typically small land use impacts from modern highway projects.

Yet the past studies, most notably those by Payne-Maxie (1980) and Eagle and Stephanedes, were limited in some important respects. In the case of Payne-Maxie (1980), three issues are most important. First, the geographic scale of the study was restricted to the central city/suburban ring dichotomy. This obscures effects that exist for very small areas within either the central city or the suburban ring. Second, while the study tried to control for non-transportation factors in analyzing land use (and employment location) impacts, it did not do this within the context of a formal location model. This obscures the relationship between highways and other factors that affect employment location. Third, the relatively low degrees of freedom (based on 54 observations) could be part of the reason why many variables were insignificant, especially since the independent variables in the study were often correlated with each other.

The Eagle and Stephanedes studies were also limited in their use of county data, which could obscure employment growth impacts that are realized in small, localized areas. The Granger causal tests used in the Eagle and Stephanedes studies also do little to illuminate the relative role of transportation and non-transportation factors in intrametropolitan employment growth.

The most straightforward solution to these problems is to study employment location using intrametropolitan data for geographic observations that are much smaller than counties. The empirical technique should also use a well-specified employment location model to control for non-transportation factors that influence employment location.

The model used here is an adaptation of the Carlino and Mills simultaneous population and employment location model. Carlino and Mills (1987) fit their model on data for U.S. counties. They found that employment growth within a county was positively related to the density of interstate highway miles within the county. That suggests that highways have an impact on employment location. Yet any intra-county effects of highways cannot be illuminated by the Carlino and Mills study. This paper uses intrametropolitan data to examine in detail the effect of highway access on employment location within two urban areas.

III. Study Goals and Empirical Model

This study uses an intrametropolitan employment location model, fit on data for northern New Jersey municipalities and Orange County, California census tracts. The primary goal of this work is to test the hypothesis that employment growth clusters near highways, once other relevant factors have been controlled. In other words, is the common perception that highways facilitate employment growth corridors correct?

The empirical model is a simultaneous population and employment location model. The derivation of the model is described in Boarnet (1994), so only a brief description will be given here.

The model starts with a description of equilibrium population and employment levels at locations within a metropolitan area. Equilibrium population and employment are assumed to be functions of transportation access at the location, other locational amenities, and each other, as shown below.

$$POP^*_{i,t} = f(T_{i,t}, E_{i,t}, \overline{EMP}^*_{i,t}) \tag{1}$$

$$EMP^*_{i,t} = g(\tau_{i,t}, \varepsilon_{i,t}, \overline{POP}^*_{i,t}) \tag{2}$$

where $POP^*_{i,t}$ = equilibrium population

$EMP^*_{i,t}$ = equilibrium employment

$T_{i,t}$ = measures of transportation access relevant to residents

$\tau_{i,t}$ = measures of transportation access relevant to firms

$E_{i,t}$ = measures of local environmental amenities relevant to residents

$\epsilon_{i,t}$ = measures of local environmental amenities relevant to firms

$\overline{POP}^*_{i,t}$ = equilibrium population in the labor market centered on municipality or census tract "i" in time "t"

$\overline{EMP}^*_{i,t}$ = equilibrium employment in the labor market centered on municipality or census tract "i" in time "t"

"i" subscripts refer to the geographic unit of observations (municipalities in New Jersey or census tracts in Orange County)

"t" subscripts refer to time

Following Carlino and Mills (1987), the equilibrium relations are related to dynamic changes through the use of a lagged adjustment model, as shown below.

$$POP\Delta_{i,t} = POP_{i,t} - POP_{i,t-1} = \lambda_p(POP^*_{i,t} - POP_{i,t-1}) \tag{3}$$

$$EMP\Delta_{i,t} = EMP_{i,t} - EMP_{i,t-1} = \lambda_e(EMP^*_{i,t} - EMP_{i,t-1}) \tag{4}$$

where $POP_{i,t}$ = actual population at "i" in time period "t"

$EMP_{i,t}$ = actual employment at "i" in time period "t"

$POP^*_{i,t}$ = equilibrium population at "i" in time period "t"

$EMP^*_{i,t}$ = equilibrium employment at "i" in time period "t"

$\lambda_p \in [0,1]$; $\lambda_e \in [0,1]$

The equilibrium relationships in (1) and (2) are assumed to be linear, with a normally distributed error term. This gives the model shown below.

$$POP\Delta_{i,t} = \alpha_0 + \boldsymbol{T}_{i,t}\boldsymbol{\alpha}_1 + \boldsymbol{E}_{i,t}\boldsymbol{\alpha}_2 + \alpha_3\overline{EMP}^*_{i,t} - \lambda_p POP_{i,t-1} + u_{i,t} \quad (5)$$

$$EMP\Delta_{i,t} = \beta_0 + \tau_{i,t}\boldsymbol{\beta}_1 + \varepsilon_{i,t}\boldsymbol{\beta}_2 + \beta_3\overline{POP}^*_{i,t} - \lambda_e EMP_{i,t-1} + v_{i,t} \quad (6)$$

where $\mathbf{T}_{i,t}$ = a vector of transportation access variables for residents
$\tau_{i,t}$ = a vector of transportation access variables for firms
$\mathbf{E}_{i,t}$ = a vector of local environmental amenity variables for residents
$\epsilon_{i,t}$ = a vector of local environmental amenity variables for firms

α_1, α_2, β_1, and β_2 are column vectors of parameters

u and v are normally distributed error terms

The unobservable equilibrium labor market variables, $\overline{POP}^*_{i,t}$ and $\overline{EMP}^*_{i,t}$, were related to actual values by assuming that labor market values of population and employment adjust toward equilibrium according to the same lag process specified in (3) and (4) . Specifying such a lag process for labor market variables, and rearranging terms, gives the relationship shown below.

$$\overline{POP}^*_{i,t} = \overline{POP}_{i,t-1} + \frac{1}{\lambda_p}(\overline{POP}_{i,t} - \overline{POP}_{i,t-1}) \quad (7)$$

$$\overline{EMP}^*_{i,t} = \overline{EMP}_{i,t-1} + \frac{1}{\lambda_e}(\overline{EMP}_{i,t} - \overline{EMP}_{i,t-1}) \quad (8)$$

where overbars denote labor market values
"*" denotes an equilibrium value
other values are actual values

Substituting (7) and (8) into (5) and (6) gives a two equation model for population and employment changes. Carlino and Mills (1987) suggest lagging most independent variables to a base year to identify the resulting regression system. For this model, the transportation access and local amenity variables (**T**, τ, **E**, and ϵ) were lagged to the base year "t-1". The resulting model is shown below.

$$POP\Delta_{i,t} = \alpha_0 + T_{i,t-1}\alpha_1 + E_{i,t-1}\alpha_2 + \alpha_3\overline{EMP}_{i,t-1} + \frac{\alpha_3}{\lambda_e}(\overline{EMP}_{i,t} - \overline{EMP}_{i,t-1}) - \lambda_p POP_{i,t-1} + u_{i,t} \tag{9}$$

$$EMP\Delta_{i,t} = \beta_0 + \tau_{i,t-1}\beta_1 + \varepsilon_{i,t-1}\beta_2 + \beta_3\overline{POP}_{i,t-1} + \frac{\beta_3}{\lambda_p}(\overline{POP}_{i,t} - \overline{POP}_{i,t-1}) - \lambda_e EMP_{i,t-1} + v_{i,t} \tag{10}$$

This is a simultaneous system for municipal (in northern New Jersey) or census tract (in Orange County) population and employment change from time "t-1" to time "t". The independent variables are measures of municipal transportation access and other local amenities in the base year of time "t-1".

The labor market variables, $\overline{POP}_t$, $\overline{EMP}_t$, $\overline{POP}_{t-1}$, and $\overline{EMP}_{t-1}$ are measured using potential variables, as shown below.

$$\overline{POP}_i = \sum_{j \neq i} \frac{POP_j}{(d_{i,j})^{\alpha}} + POP_i \tag{11}$$

$$\overline{EMP}_i = \sum_{j \neq i} \frac{EMP_j}{(d_{i,j})^{\alpha}} + EMP_i \tag{12}$$

where $d_{i,j}$ = the distance between municipalities "i" and "j"[6]

The parameter α in (11) and (12) describes how labor market relationships damp with distance. Since the size of labor market areas is based on commuting relationships, the damping parameter, α, was estimated from commuting data before the regression analysis for

[6] For municipalities that were less than one mile apart, $d_{i,j}$ was set equal to one to avoid inflating the influence of those municipalities in the potential variable.

population and employment changes was performed. The estimation technique interprets the potential variables in (11) and (12) as defining commuter-sheds, and then estimates α from 1979 census journey to work data. That technique is described in Boarnet (1993). The value of α used in the regressions is 0.67.

The potential variables in (11) and (12) imply a spatial structure for the regression model. Given the definition of the potential variables, the regressions in (9) and (10) can be rewritten in matrix notation as shown below.

$$\begin{aligned} \boldsymbol{POP\Delta}_t = {} & \alpha_0 + \boldsymbol{T}_{t-1}\alpha_1 + \boldsymbol{E}_{t-1}\alpha_2 + \alpha_3(\boldsymbol{I} + \boldsymbol{W})\boldsymbol{EMP}_{t-1} \\ & + \frac{\alpha_3}{\lambda_e}(\boldsymbol{I} + \boldsymbol{W})\boldsymbol{EMP\Delta}_t - \lambda_p \boldsymbol{POP}_{t-1} + \boldsymbol{u} \end{aligned} \quad (13)$$

$$\begin{aligned} \boldsymbol{EMP\Delta}_t = {} & \beta_0 + \tau_{t-1}\beta_1 + \varepsilon_{t-1}\beta_2 + \beta_3(\boldsymbol{I} + \boldsymbol{W})\boldsymbol{POP}_{t-1} \\ & + \frac{\beta_3}{\lambda_p}(\boldsymbol{I} + \boldsymbol{W})\boldsymbol{POP\Delta}_t - \lambda_e \boldsymbol{EMP}_{t-1} + \boldsymbol{v} \end{aligned} \quad (14)$$

where **POPΔ**$_t$ is an (n x 1) vector of observations of
$POP\Delta_{i,t} = POP_{i,t} - POP_{i,t-1}$
EMPΔ$_t$ is an (n x 1) vector of observations of $EMP\Delta_{i,t} = EMP_{i,t} - EMP_{i,t-1}$
$\underline{I}$ is an (n x n) identity matrix
$\underline{W}$ is an (n x n) matrix of weights, where each element is $1/(d_{i,j})^{\alpha}$, as was used to derive the potential variables
POP$_{t-1}$ is an (n x 1) vector of observations of $POP_{i,t-1}$, which is municipal or tract population in the base year
EMP$_{t-1}$ is an (n x 1) vector of observations of $EMP_{i,t-1}$, which is municipal or tract employment in the base year

n is the number of observations (358 for New Jersey and 315 for Orange County)

the subscript "i" refers to the geographic observations (municipalities or tracts) and has been dropped from equations (13) and (14) since those regressions are expressed in matrix and column vector notation

as before, the subscripts "t" and "t-1" refer to time periods

The variables $\underline{W}\mathbf{POP\Delta}_t$ and $\underline{W}\mathbf{EMP\Delta}_t$ are spatial lags of the dependent variables. (For a definition and discussion of the concept of a spatial lag, see Anselin, 1988, Chapter 3.) Since least squares yields biased and inconsistent estimates when spatial lags of dependent variables appear on the right-hand side (Anselin, 1980 and 1988), traditional two-stage least squares was not used to estimate (13) and (14). Instead, an instrumental variables technique was used that treats $\mathbf{POP\Delta}_t$, $\mathbf{EMP\Delta}_t$, and the spatial lags of both those variables as endogenous. In particular, $\mathbf{POP\Delta}_t$ and $\mathbf{EMP\Delta}_t$ were instrumented by the exogenous variables in the vectors **T**, **E**, τ, and ϵ plus the predetermined variables $(\underline{I}+\underline{W})\mathbf{POP}_{t-1}$, $(\underline{I}+\underline{W})\mathbf{EMP}_{t-1}$, $\mathbf{POP}_{t-1}$, and $\mathbf{EMP}_{t-1}$. Following Anselin (1980), pp. 83-86 and Anselin (1988), pp. 81-86, the resulting instrumental variables (IV) estimator for equation (14) is

$$\hat{\delta}_2 = (Z_2^{*\prime} Z_2)^{-1} (Z_2^{*\prime} EMP\Delta_t) \qquad (15)$$

where $\delta_2' = (\beta_3/\lambda_p \mid \beta_0 \mid \beta_1' \mid \beta_2' \mid \beta_3 \mid -\lambda_e\}$ = the vector of parameters for equation (14)

$\mathbf{Z}_2 = ((\underline{I}+\underline{W})\mathbf{POP\Delta}_t) \mid \mathbf{X}_2)$

$\mathbf{Z}^*_2 = ((\underline{I}+\underline{W})\mathbf{PO\hat{P}\hat{\Delta}}_t \mid \mathbf{X}_2) = ((\underline{I}+\underline{W})\mathbf{P}_X\mathbf{POP\Delta}_t \mid \mathbf{X}_2)$

$\mathbf{P}_X = \mathbf{X}(\mathbf{X'X})^{-1}\mathbf{X'}$

$\mathbf{X} = (\mathbf{X}_1 \mid \mathbf{X}_2)$

$\mathbf{X}_1 = (\mathbf{T}_{t-1} \mid \mathbf{E}_{t-1} \mid (\underline{I} + \underline{W})\mathbf{EMP}_{t-1} \mid \mathbf{POP}_{t-1})$

$\mathbf{X}_2 = (\tau_{t-1} \mid \epsilon_{t-1} \mid (\underline{I} + \underline{W})\mathbf{POP}_{t-1} \mid \mathbf{EMP}_{t-1})$

The interest here is on equation (14), but the IV estimator for equation (13) is defined analogously.

IV. Data

Equation (14) was estimated on two sets of data. One dataset consisted of the 365 municipalities in the northern thirteen counties of New Jersey and the other was the 319 census tracts in Orange County, California.[7] Both northern New Jersey and Orange County, California are well suited to an intrametropolitan study of employment growth. Both are suburban areas, located next to the nation's two largest cities. The observations (municipalities in New Jersey and census tracts in Orange County) are quite small, allowing the analysis to give a fine level of geographic detail.[8] Furthermore, both New Jersey and Orange County are home to several suburban employment centers (Garreau 1991; Giuliano and Small 1992).

For each study area, the most recent data available were used. For northern New Jersey, this included data on employment changes from 1980 to 1988. For Orange County, this included data on employment changes from 1970 to 1980. Thus, for New Jersey data, the year subscripts shown in equation (14) correspond to 1980 for time "t-1" and 1988 for time "t". For Orange County, 1970 is time "t-1" and 1980 is time "t". Note that for both New Jersey and Orange County, equation (14) amounts to regressing employment change on a large number of independent variables that are lagged to a base year (the τ and ϵ

[7] Due to missing data, the regression results reported in Section V use 358 observations for northern New Jersey and 315 observations for Orange County.

[8] The average size of the New Jersey municipalities is 10.42 square miles, while Orange County census tracts average 2.48 square miles. Descriptive statistics on the municipal and tract observations are given in Table 1.

variables), a simultaneous measure of population change in a surrounding labor market, and other variables that are measured in the base year (time "t-1") and that are required by the theoretical structure of the model.

The variables used to measure transportation access (τ) and other local amenities (ϵ) are listed in Table 2. Table 2 describes how each independent variable was measured and lists the data sources used to construct each variable.

For both New Jersey and Orange County, transportation access was measured by HIGHWAY, which is a dummy variable that equaled one if the observation (municipality or census tract) was traversed by one or more of the region's major highways. For Orange County, only limited access highways (namely the 5, 22, 55, 57, 73, 91, and 405 freeways) were included in the HIGHWAY variable. Since New Jersey has a less extensive network of limited access highways, the five longest U.S. highways, whether limited access or not, were also included in the New Jersey HIGHWAY variable. The major highways in New Jersey were thus Interstates 78, 80, 195, 287, 280, the limited access portion of Interstate 95, the New Jersey Turnpike, the Garden State Parkway, and U.S. highways 1, 9, 46, 202, and 206. For New Jersey, a dummy variable for rail transit stations (called NJTRNSIT) was also included to control for the transportation accessibility provided by that region's commuter rail system.

The vector ϵ measures non-transportation amenities that can affect the intrametropolitan distribution of employment. The variables used to measure ϵ were based on firm location theory and previous similar studies (e.g. Bradbury, Downs, and Small, 1982; Carlino and Mills, 1987; Palumbo, Sacks, and Wasylenko, 1990). For northern New

Jersey, those variables measured agglomeration economies, fiscal policy, crime rates, and land available for development.

For northern New Jersey, agglomeration economies were measured by two potential variables, one which described access to manufacturing employment (AGGMANU) and the other which measured access to retail employment (AGGRET). Both are defined formally in Table 2. Crime rates in each northern New Jersey municipality were measured by the violent crime rate per 1,000 municipal residents (VIORAT) and the property crime rate per 1,000 municipal residents (PRPRAT). Land available for development was proxied by the number of farm property parcels in the municipality (FRMPAR). Local fiscal policy was measured by the per employee public expenditures on selected infrastructure and public safety functions (PEBUSEXP) and the equalized property tax rate in the municipality (EQZDTX). The variables $AGGPOP_{1980}$, $AGGPOP\Delta_{1988}$, and EMP_{1980} are required by the structure of the model, and measure, respectively, the $(\underline{I}+\underline{W})\mathbf{POP}_{t-1}$, $(\underline{I}+\underline{W})\mathbf{POP}\Delta_t$, and $\mathbf{EMP}_{t-1}$ in equation (14).

The land area of each municipality (LANDAREA) is included as an independent variable. Two variables that measure distance from the urban core are also included. Those variables measure employment growth effects that are related to distance from the central business district. The variables are NYCDIST (distance from Manhattan Island) and NYCDSTSQ (distance from Manhattan Island, squared). For a detailed discussion of the choice of independent variables for the New Jersey dataset, see Boarnet (1992) and Boarnet (1994).

The model in equation (14) was estimated with variables that were as similar as possible for the two study areas. The results for the regression estimated with New Jersey data are reported on the left side of Table 3, and the results for the regression estimated with Orange County data are reported on the right side of Table 3.

The differences between the variables used in the New Jersey and Orange County regressions are due to data availability and differences in the character of the two study areas. Since the Orange County observations are census tracts, fiscal variables are both harder to obtain and less meaningful, given that fiscal policy varies across government boundaries, not census tracts. Similarly, crime rates are more difficult to obtain in Orange County, since the observations do not correspond to the government entities that tabulate crime data. For that reason, in Orange County, the fiscal and crime variables are replaced by dummy variables showing what municipality contains the tract. Note that census tracts can cross municipal boundaries, such that some tracts in the Orange County dataset have more than one municipal dummy variable equal to one. Also note that municipal dummy variables can potentially measure local land use regulations, business climate, and other advantages or disadvantages associated with particular cities.

The variable that measures agglomeration potential in retail employment, AGGRET, is replaced by AGGTRADE in Orange County. AGGTRADE is constructed in the same way as AGGRET, but uses data for both retail and wholesale employment, which was the closest comparable data in Orange County. The variable FRMPAR, which measures farm parcels in each New Jersey municipality, was not available for Orange County census tracts. The variable for commuter rail stations, NJTRNSIT, is only included in New Jersey, since Orange County had no commuter rail during the 1970s. The variables that measure distance from the urban core are based on distance from downtown Los Angeles (LADIST and LADISTSQ) for Orange County.

Lastly, note that the estimator in (15) includes variables that appear in the population change regression specified in equation (13). Those variables (the $\mathbf{X}_1$ matrix) are, effectively, the instruments for the portion of $(\underline{\mathbf{I}}+\underline{\mathbf{W}})\mathbf{POP}\boldsymbol{\Delta}_t$ that is endogenous. For the New Jersey municipalities, the variables in the $\mathbf{X}_1$ matrix are the proportion of residents who were black, proportion hispanic, poverty rate, proportion of housing built before 1940, per capita municipal expenditures on selected categories, and per capita tax burdens. For Orange County census tracts, the variables in the $\mathbf{X}_1$ matrix are the proportion of residents who were black, proportion hispanic, and the census tract poverty rate.

Our attention here focuses on the highway access variable, HIGHWAY. That variable is a dummy that equals one if the municipality (in New Jersey) or census tract (in Orange County) contains or borders on a major highway. Thus HIGHWAY represents a simple measure of transportation access. If locations near highways experience more employment growth, the coefficient on HIGHWAY should be positive and statistically significant.

V. Results

The coefficient on the HIGHWAY variable is statistically significant at the 99% level in both the New Jersey and Orange County regressions. Highways clearly have a role in shaping the intrametropolitan distribution of employment in both study areas.

Other variables are also significant in the two models. The population change in a surrounding labor market (AGGPOPΔ) is statistically significant and positive in the New Jersey regression. The same variable was not significant in Orange County, although AGGPOPΔ is significant in Orange County when LADIST and LADISTSQ are omitted from the model. This suggests that the difference in the performance of the AGGPOPΔ variable is due to differences in the geography of the two study regions.

In Orange County, the locations that are most distant from Los Angeles are on the quickly growing urban fringe. The same is not as true for New Jersey, where some of the far western counties are among the most distant from New York City. Those counties in northwestern New Jersey (e.g. Sussex and Warren) are agricultural areas with relatively little employment growth during the 1980s.

In New Jersey, the agglomeration variables AGGMANU and AGGRET are significant, with AGGMANU negative and AGGRET positive. Locations with access to manufacturing employment in 1980 lost jobs, and those with access to retail employment in 1980 gained jobs. This is consistent with a shift out of manufacturing employment and into service and retail industries.

Somewhat surprisingly, the agglomeration variables are not significant in Orange County. During the period under study (the 1970s), Orange County was quickly expanding its manufacturing employment base (Scott, 1988). This could explain why the sign pattern of AGGMANU and AGGTRADE is the reverse of that found in New Jersey. More surprising is that neither variable is significant in Orange County. It is possible that the agglomeration benefits in Orange County were at a finer level of detail than manufacturing and trade jobs can measure. Another possibility is that the agglomeration benefits in Orange County were tied to aggregate employment, and thus picked up by the EMP70 variable, which is significantly positive.[9]

In New Jersey, access to a commuter rail station (NJTRNSIT) is associated with increased job growth. Higher violent crime rates (VIORAT) are associated with less employment growth, while higher property crime rates (PRPRAT) are associated with more job growth. This latter relationship likely reflects simultaneity between property crime and economic activity which is not completely eliminated by lagging the property crime variable to a base year. The number of farm parcels in a municipality (FRMPAR) are negatively associated with employment growth.

In Orange County, the dummy variables for the cities of Anaheim, Costa Mesa, Fullerton, and Santa Ana are significantly negative. With the exception of Costa Mesa, these cities are older cities that grew rapidly in the 1950s and 1960s. By the 1970s, the most rapid employment growth had shifted to the central and southern part of the county. Much of that area was unincorporated as of 1970.

Given that variables other than HIGHWAY also affect employment growth, it is interesting to compare the magnitudes of the statistically significant coefficients. Standardized regression coefficients allow a quick comparison of the magnitudes of

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[9] According to the theoretical model (Boarnet, 1994), the coefficient on EMP70 measures an adjustment parameter that should be between 0 and -1. Thus the positive coefficient on EMP70 suggests that variable is measuring more than adjustment speed. One possibility is that in Orange County during the 1970s, unlike New Jersey in the 1980s, agglomeration benefits were linked to the total number of jobs in an area, rather than the number of jobs in specific industries.

coefficients for variables that are measured in different units. The standardized coefficient for an independent variable, x, is shown below.

$$\beta_{std}(x) = \beta \frac{se(x)}{se(y)} \tag{16}$$

where $\beta_{std}(x)$ = standardized coefficient of the variable x
β = regression coefficient
se(x) = standard error of x
se(y) = standard error of the dependent variable, y

Independent variables with larger standardized coefficients have a larger effect on the dependent variable, given a one standard deviation change in the independent variable. The standardized coefficients for the statistically significant variables from Table 3 are shown in Table 4. Note that in both New Jersey and Orange County, the standardized regression coefficient for HIGHWAY has the same value, and in both regressions HIGHWAY has among the smallest of all standardized coefficients for statistically significant variables.

The most important factor in employment location in New Jersey is the agglomeration benefits measured by AGGMANU and AGGRET. In Orange County, the most important factor in employment location is census tract employment in 1970, which, as mentioned earlier, might also measure agglomeration benefits. In New Jersey, the variable $AGGPOP\Delta_{1988}$, which measures population change in a surrounding labor market area, also has a larger standardized coefficient than the HIGHWAY variable. Also in New Jersey, the violent crime rate (VIORAT) has a larger standardized coefficient than the HIGHWAY variable. Overall, while HIGHWAY access has some effect on intrametropolitan employment growth, it appears to be less influential than existing agglomeration benefits, the pattern of population changes, and possibly other locational amenities within urban areas.

VI. Interpretation and Conclusion

The implication of the results in Tables 3 and 4 is similar, but more precise, than the findings of the Payne-Maxie (1980) study. Payne-Maxie (1980) concluded that there were many factors other than beltways which influenced the distribution of economic activity within an urban area. In many regressions in the Payne-Maxie (1980) study, the variable that measured whether the metropolitan area had a beltway was not statistically significant. This work, using both a more refined measure of highway access and a more detailed employment location model, shows that highways are associated with nearby employment growth. While the effect of highways might be smaller than that of other variables, highways do have an independent and statistically significant effect on intrametropolitan employment growth in both northern New Jersey and Orange County, California.

Based on these results, the intuition that new highway projects will facilitate employment growth corridors has some basis in truth, but one must be cautious with that interpretation. Highway location is not the only factor that influences intrametropolitan job growth, and in areas with mature highway networks, it might be less influential than other variables.

This finding is, of course, only as good as the model used in Section V. While the performance of the employment location model has been discussed elsewhere (Boarnet, 1994), a few points are worth mentioning. First, data limitations constrained the implementation of the model in both New Jersey and Orange County. In both areas, land price data, had it been available, could have helped proxy for unobservable or unmeasured locational amenities that influence employment location. Second, zoning and other local land use and business regulations, while important, are not measured directly in either New Jersey or Orange County. Still, the municipal dummy variables in Orange County can help proxy for that portion of the local regulatory environment (land use regulations included) that varies across municipalities. It is thus encouraging that the HIGHWAY variable was statistically significant in the Orange County sample.

Lastly, the fact that the HIGHWAY variable is significant, with approximately the same coefficient and standardized coefficient, in both the New Jersey and Orange County samples is especially intriguing. While care was taken to implement the model with the same data in both regions, that was not precisely possible. Yet even with differences in variables and model performance across the two urban areas, the influence of highways on intrametropolitan employment growth is remarkably similar in both regions. Overall, the evidence presented here strongly suggests that highways play an important, although not dominant, role in the geographic distribution of employment growth within urban areas.

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Table 1: Descriptive Statistics

New Jersey Municipalities (365 observations):

Variable	Mean	Standard Deviation	25th Percentile	Median	75th Percentile
EMP_{1980}	6,492	10,692	674	2,123	6,233
$EMP\Delta_{1988}$	1,067	2,639	60	357	1,323
POP_{1980}	15,096	26,046	3,971	7,987	16,699
LANDAREA (square miles)	10.42	13.45	1.7	4	15.7

Orange County Census Tracts (319 observations):

Variable	Mean	Standard Deviation	25th Percentile	Median	75th Percentile
EMP_{1970}	1,345	1,947	351	713	1,472
$EMP\Delta_{1980}$	1,228	4,132	48	366	1,026
POP_{1970}	4,452	1,738	3,366	4,178	5,307
LANDAREA (square miles)	2.48	13.04	0.504	0.759	1.23

Table 2: Variables

New Jersey Municipalities:

variable name	description	source
$EMP\Delta_{1988}$	employment change from 1980 to 1988, $EMP_{1988} - EMP_{1980}$	NJDOL Covered Employment
EMP_{1980}	employment in 1980	NJDOL Covered Employment
NYCDIST	distance in miles from Manhattan Island	calculated using Atlas-Graphics software
NYCDSTSQ	NYCDIST squared	
HIGHWAY	dummy variable = 1 if municipality lies on any one of: I78, I80, I195, I287, I280, limited access portion of I95, New Jersey Turnpike, Garden State Parkway, US1, US9, US46, US202, US206	various New Jersey roadmaps
NJTRNSIT	dummy variable = 1 if municipality has NJ Transit commuter rail station	NJ Transit schedules
LANDAREA	land area in square miles	NJDCA Annual Report
AGGMANU	potential variable measuring manufacturing agglomeration in 1982, constructed as $AGGMANU_i = \sum_{j=i}^{N} \frac{MANU_{j,1982}}{(d_{i,j})^2}$ where $MANU_j$ = manufacturing employment in muni. "j" $d_{i,j}$ = distance in miles from "i" to "j" $d_{i,i} = 1$	NJDOL Annual Municipality Report
AGGRET	potential variable measuring retail agglomeration in 1982, constructed similarly to AGGMANU	NJDOL Annual Municipality Report
$AGGPOP_{1980}$	$\sum_{j\neq 1}^{N} \frac{POP_{j,1980}}{d_{i,j}^{\alpha}} + POP_{i,1980} \;;\; d_{i,i} = 1 \;;\; \alpha = 0$	NJDCA Annual Report
$AGGPOP\Delta_{1988}$	$\sum_{j\neq 1}^{N} \frac{POP\Delta_{j,1988}}{d_{i,j}^{\alpha}} + POP\Delta_{i,1988} \;;\; d_{i,i} = 1 \;;\; \alpha$	NJDCA Annual Reports

Table 2: Variables (continued)

New Jersey Municipalities (continued):

variable name	description	source
VIORAT	violent crimes per 1,000 municipality residents, 1980	NJ Uniform Crime Reporting Program, 1980
PRPRAT	property crimes per 1,000 municipality residents, 1980	NJ Uniform Crime Reporting Program, 1980
FRMPAR	number of farm parcels in the municipality in 1980	NJDCA 1980 Annual Report
PEBUSEXP	per employee expenditures on streets and drainage and sewage	constructed from NJDCA 1980 Annual Report
EQZDTX	equalized property tax rate in 1980 (includes all overlying jurisdictions below the state level)	NJDCA 1980 Annual Report

NJDOL is the New Jersey Department of Labor
NJDCA is the New Jersey Department of Community Affairs

Table 2: Variables (continued)

Orange County Census Tracts:

variable name	description	source
$EMP\Delta_{1980}$	employment change from 1970 to 1980; EMP_{1980} - EMP_{1970}	office of the OC Demographer
EMP_{1970}	employment in 1970	OC Demographer
LADIST	distance in miles from downtown Los Angeles	calculated using ARC-Info software
LADISTSQ	LADIST squared	
HIGHWAY	dummy variable = 1 if census tract lies on any one of the following limited access freeways: 5, 22, 55, 57, 73, 91, 405	Calif. Dept. of Trans. "State Highway Routes" and census tract maps
LANDAREA	land area in square miles	calculated using Atlas-Pro mapping software
AGGMANU	potential variable measuring manufacturing agglomeration in 1970, constructed similarly to AGGMANU for New Jersey	data obtained from OC Demographer
AGGTRADE	potential variable measuring retail and wholesale trade agglomeration in 1970, constructed similarly to AGGMANU for New Jersey	data obtained from OC Demographer
$AGGPOP_{1970}$	constructed similarly to $AGGPOP_{80}$ for New Jersey	data obtained from OC Demographer
$AGGPOP\Delta_{1980}$	constructed similarly to $AGGPOP\Delta_{1988}$ for New Jersey	data obtained from OC Demographer
municipality dummy variables	dummy variables = 1 if census tract is wholly or partially contained in the following municipalities or census defined places: Anaheim (ANAHEIM), Buena Park (BPARK), Costa Mesa (CMESA), Cypress (CYPRESS), Fountain Valley (FVALLEY), Fullerton (FULLTON), Garden Grove (GGROVE), Huntington Beach (HBEACH), La Habra (LHABRA), Newport Beach (NBEACH), Orange (ORANGE), Santa Ana (STANA), Tustin Foothills (TFOOT), Westminster (WESTMIN), or unincorporated area (UNINC)	census tract maps

OC Demographer is the Orange County Demographer's office

Table 3: Results of Regression Model, Dependent Variable = $EMP\Delta$

NEW JERSEY MUNICIPALITIES:
Dependent variable = $EMP_{1988} - EMP_{1980}$.
All independent variables measured in 1980 unless otherwise noted.

Variable	Coefficient
NYCDIST	-112.08
	(-1.75)
NYCDSTSQ	1.12
	(1.36)
HIGHWAY	768.15 **
	(2.96)
NJTRNSIT	744.56 **
	(2.71)
LANDAREA	50.84 **
	(3.26)
AGGMANU	-0.26 **
	(-4.92)
AGGRET	0.62 **
	(6.44)
$AGGPOP_{1980}$	-0.001
	(-0.77)
$AGGPOP\Delta_{1988}$ †	0.10 **
	(3.16)
VIORAT	-261.26 **
	(-4.75)
PRPRAT	15.98 *
	(2.28)
FRMPAR	-2.44 *
	(-2.01)
PEBUSEXP	-0.24
	(-0.90)
EQZDTX	62.75
	(0.39)
EMP_{1980}	0.02
	(0.97)
INTERCEPT	955.90
	(0.54)
N	358
R^2	0.3847
R^2_{adj}	0.3577

ORANGE COUNTY CENSUS TRACTS:
Dependent variable = $EMP_{1980} - EMP_{1970}$.
All independent variables measured in 1970 unless otherwise noted.

Variable	Coefficient	Variable	Coefficient
LADIST	426.08	ANAHEIM	-1737.26 *
	(0.50)		(-2.16)
LADISTSQ	-5.48	BPARK	1384.49
	(-0.50)		(1.169)
HIGHWAY	1286.11 **	CMESA	-2540.38 *
	(2.64)		(-2.344)
		CYPRESS	967.85
			(0.723)
LANDAREA	26.02	FVALLEY	-912.38
	(1.54)		(-0.593)
AGGMANU	0.08	FULLTON	-2217.62 **
	(0.69)		(-2.44)
AGGTRADE	-0.24	GGROVE	-580.71
	(-1.25)		(-0.60)
$AGGPOP_{1970}$	0.007	HBEACH	-1254.90
	(0.41)		(-1.35)
$AGGPOP\Delta_{1980}$ †	0.05	LHABRA	1364.79
	(0.57)		(0.89)
		NBEACH	-902.98
			(-0.57)
		ORANGE	-1266.43
			(-1.34)
		STANA	-2234.15 *
			(-2.24)
		TFOOT	-793.99
			(-0.55)
		WESTMIN	-1058.57
			(-1.02)
EMP_{1970}	0.86 **	UNINC	807.93
	(7.86)		(1.51)
INTERCEPT	-14789.79		
	(-1.40)		
N	315		
R^2	0.3342		
R^2_{adj}	0.2791		

t-statistics in parentheses
† instrumented in spatial autocorrelation fit

* significant using .05 two-tailed test
** significant using .01 two-tailed test

Table 4: Standardized Coefficients

New Jersey Municipalities		Orange County Census Tracts	
Variable	Stand. Coef.	Variable	Stand. Coef.
HIGHWAY	0.15	HIGHWAY	0.15
NJTRNSIT	0.13	EMP_{1970}	0.41
LANDAREA	0.26	ANAHEIM	-0.15
AGGMANU	-0.55	CMESA	-0.14
AGGRET	0.64	FULLTON	-0.15
$AGGPOP\Delta_{1988}$	0.31	STANA	-0.19
VIORAT	-0.35		
PRPRAT	0.14		
FRMPAR	-0.17		