

UC Irvine

Working Paper Series

Title

Transportation Access, Urban Problems, and Intrametropolitan Population and Employment Changes

Permalink

<https://escholarship.org/uc/item/9v732838>

Author

Boarnet, Marlon G.

Publication Date

1992-07-01

UCI-ITS-WP-92-5

**Transportation Access, Urban
Problems and Intrametropolitan
Population and Employment Changes**

UCI-ITS-WP-92-5

Marlon G. Boarnet

Graduate Program in Urban and Regional Planning
School of Social Ecology and
Institute of Transportation Studies
University of California, Irvine

July 1992

Institute of Transportation Studies
University of California, Irvine
Irvine, CA 92697-3600, U.S.A.
<http://www.its.uci.edu>

Abstract

This study examines the competing roles of transportation access and urban problems in the continuing suburbanization of American metropolitan areas. In particular, the paper asks whether suburbanization is primarily an adjustment to existing transportation networks, as predicted by the monocentric urban model, or whether decentralization is the result of persons and firms fleeing a host of central city problems, as is more consistent with a Tiebout model. This question is empirically tested by examining the determinants of population and employment changes for 365 northern New Jersey municipalities in the 1980s. The findings suggest that both transportation access and intra-metropolitan differences in local characteristics are important determinants of municipal population and employment changes. Furthermore, transportation access and local characteristics have roughly equal policy importance. This suggests that policies aimed at controlling land use patterns should be cognizant of both transportation networks and local characteristics such as fiscal policy and crime rates.

Section I: Introduction

The nature and causes of the decentralization of American urban areas have often been debated. After several decades, the argument still comes down to one of two perspectives. One viewpoint is informed by the monocentric urban model, and casts suburbanization as a natural (and possibly optimal) response to broad economic factors. The other perspective is more in the Tiebout tradition, and focuses on the effect that local characteristics have in shaping urban development patterns. This paper shows that both perspectives are relevant in explaining the changing population and employment settlement patterns in American urban areas, and furthermore that both perspectives are of arguably equal policy importance.

The debate between the monocentric and Tiebout paradigms can be illustrated by the articles written by Bradford and Kelejian and by Mills and Price.¹ Bradford and Kelejian found that local characteristics, and in particular central city problems such as fiscal disparities and poverty concentrations, contributed to suburbanization. Mills and Price later took issue with those results, claiming that what they called "basic economic variables" had the more important role in explaining changes in metropolitan density gradients. Those basic economic variables were factors suggested by the monocentric urban model, such as metropolitan income and population levels.

¹ David F. Bradford and Harry H. Kelejian, "An Econometric Model of the Flight to the Suburbs," in Journal of Political Economy, 1973, and Edwin S. Mills and Richard Price, "Metropolitan Suburbanization and Central City Problems," in Journal of Urban Economics, 1984.

This debate on the causes of decentralization is not purely academic, since the policy orientations of the monocentric and Tiebout paradigms differ. The policy variables of interest in monocentric (and also multicentric) models are those that affect transportation access, since that is of vital importance for the predicted settlement pattern. On the other hand, the policy variables of interest in Tiebout models are those local characteristics that presumably influence residential and business location decisions. Those factors include many central city characteristics that persons are assumed to flee -- notably concentrations of minority or poor populations, high tax burdens, high crime rates, and low levels of public service provision. Thus the policy debate that parallels the intellectual debate is whether patterns of transportation access or various central city problems are the more important focus of policy attention.²

This paper will show that the decentralization of population and employment in one metropolitan area is explained by both the pattern of transportation access and the spatial distribution of local characteristics. Furthermore, those two groups of variables, and thus the monocentric and Tiebout traditions that they respectively represent, are of roughly equal policy importance. In short, the question of whether transportation access or urban problems are more important in shaping metropolitan development is a false dichotomy. Both are influential, and policy-makers should give attention to both groups of variables. The rest of this paper develops and presents the results of an empirical test that demonstrates that point.

² This, of course, assumes that policy attention is appropriate. Technically, only a welfare analysis can suggest whether intervention in private land markets is sound. Such a welfare analysis is beyond the scope of this paper. The question asked here is how policy might effectively influence urban development, assuming such influence was shown to be appropriate.

Section I. Background

This work tests the relative importance of transportation access and local characteristics by analyzing how both sets of factors affected population and employment changes in the 365 municipalities in the northern half of New Jersey from 1980 to 1988. The test is structured around a regression analysis of the determinants of population and employment change. Municipal population and employment changes are regressed on variables that measure transportation access and other local characteristics. Since this is a study of the determinants of population and employment change, it is similar to many past studies that have examined metropolitan population and employment settlement patterns.³

Those past studies examined cross sections of metropolitan areas, and divided each metropolitan area into a central city and a suburban ring. While this allowed an analysis of decentralization, that analysis was arguably crude in its measure of local characteristics. Transportation access was often left unmeasured, which is understandable since the variations of interest involved links to highways or public transit that were often obscured by a focus on entire central cities and suburban rings. Local characteristics, such as tax burdens, poverty levels, or demographic composition of the population, were usually measured by ratios of those variables in the central city and the suburban ring. While this captured broad

³ For studies of this sort, see, e.g., Bradford and Kelejian, W. Norton Grubb, "The Flight to the Suburbs of Population and Employment, 1960 - 1970," in Journal of Urban Economics, 1982, Edwin S. Mills, "Metropolitan Central City Population and Employment Growth During the 1970's," in M. H. Peston and R. E. Quandt, eds., Prices, Competition, and Equilibrium, Philip Alan Publishers, 1986, Mills and Price, and George Palumbo, Seymour Sacks, and Michael Wasylenko, "Population Decentralization within Metropolitan Areas: 1970 - 1980," in Journal of Urban Economics, 1990.

variations, it provided limited information on local differences that might be important in determining where in central and suburban areas businesses and residences locate.

This study examines 365 municipalities within one urban area, thereby measuring detailed intrametropolitan differences in both transportation access and local characteristics. The transportation access variables in this study measure the presence of major highways and commuter rail lines in the municipality. The community characteristics include tax burdens, local expenditures, poverty rates, proportion black, proportion hispanic, and crime rates, all measured at the municipality level. In terms of both sets of variables, fine intrametropolitan variations can be measured, since the dependent variables are municipalities that are small and that are in the same urban area.⁴

At this point, one should also note that the tests reported here examine both population and employment changes within the study region. The discussion in the introduction juxtaposed explanations of suburbanization that are often used to describe household location. Yet both theory and empirical evidence suggest that household and firm locations are

⁴ The municipalities in the dataset are from thirteen counties, eleven of which are in the New York consolidated metropolitan statistical area (CMSA). The influence of New York City is considerable throughout the study region. Of the 365 municipalities in the dataset, over 100 are less than two square miles in area, two-thirds are less than ten square miles, and fewer than forty are larger than thirty square miles. This is based on land area data from the New Jersey Department of Community Affairs, Annual Report, 1988. Note that municipal borders did not change in the study region during the 1980's.

simultaneously determined in an urban area.⁵ A study of metropolitan structure must examine both population and employment.

Section II: Specification

A. Equilibrium Relationships

A regression specification for municipal population and employment changes can be based on the equilibrium relationships shown below. Those relationships can be derived from simple bid-rent models of household and firm location.⁶

⁵ See, e.g., Donald N. Steinnnes and Walter D. Fisher, "An Econometric Model of Intraurban Location," in Journal of Regional Science, 1974, for a theoretical discussion of the simultaneous nature of intra-metropolitan population and employment levels and some empirical evidence. Also see, e.g., Donald N. Steinnnes, "Causality and Intraurban Location," in Journal of Urban Economics, 1977, and Edwin S. Mills, "Urban Density Functions," in Urban Studies, 1970.

⁶ For a complete discussion how bid-rent models yield the relationships in (1) and (2), see Marlon G. Boarnet, Intra-Metropolitan Growth Patterns: The Nature and Causes of Population and Employment Changes within an Urban Area, unpublished Ph.D. dissertation, Princeton University, 1992, Chapter 3, or Marlon G. Boarnet, "An Empirical Model of Intrametropolitan Population and Employment Growth," paper presented at the 1992 Symposium of the Commission on Mathematical Models of the International Geographical Union, at Princeton University, Princeton, NJ, August 5-7, 1992.

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

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

where $POP_{i,t}^*$ = equilibrium population
 $EMP_{i,t}^*$ = equilibrium employment
 $T_{i,t}$ = measures of transportation access for residents
 $\tau_{i,t}$ = measures of transportation access for firms
 $E_{i,t}$ = measures of local environmental amenities for residents
 $\varepsilon_{i,t}$ = measures of local environmental amenities for firms
 $\overline{POP}_{i,t}^*$ = equilibrium population in the labor market centered on municipality
 "i" in time "t"
 $\overline{EMP}_{i,t}^*$ = equilibrium employment in the labor market centered on municipality
 "i" in time "t"

"i" subscripts refer to municipalities
 "t" subscripts refer to time

The equilibrium relationships assume that the simultaneity between population and employment works at the level of a labor market that may not be coterminous with municipalities. Since persons might commute across municipal boundaries, equilibrium population in a municipality depends on job opportunities in a surrounding labor market, $\overline{EMP}_{i,t}^*$, and likewise equilibrium municipal employment depends on the surrounding labor market population, $\overline{POP}_{i,t}^*$. These labor market variables are measured using potential variables, as is discussed later.

Also note that, since (1) and (2) are derived from bid-rent models, location specific characteristics are fully capitalized into land prices. The relationships in (1) and (2) reflect the fact that households and firms bid up prices for more desirable land, and then purchase less of the higher priced land at desirable locations. Thus population and employment densities (and, for equal land area, levels), are higher at locations with low transportation

costs and high environmental amenities. One implication of this technique is that prices for land need not appear on the right hand side of the regression equation. Since the bid-rent theory implies that location-specific characteristics are fully capitalized into land prices, if one measures the local characteristics, one has the information that is driving intrametropolitan variations in land prices. Thus the independent variables are the intrametropolitan variations in both transportation and other characteristics that affect land prices and, in turn, settlement patterns.

B. A Lagged Adjustment Model of Intrametropolitan Growth

While equations (1) and (2) describe a static equilibrium, the dependent variables in this study are changes in population and employment levels. Since the study assumes that those changes are largely driven by movements of persons and firms, the observed changes must be disequilibrium phenomena. Changes in municipal population and employment levels are assumed to be adjustments toward equilibria. Following work done by Mills and Price and by Carlino and Mills, the changes in population and employment are assumed to follow a lagged adjustment model, as shown below.⁷

$$POP\Delta_{it} = POP_{it} - POP_{it-1} = \lambda_p(POP_{it}^* - POP_{it-1}) \quad (3)$$

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

⁷ Mills and Price and Gerald A Carlino and Edwin S. Mills, "The Determinants of County Growth," in Journal of Regional Science, 1987.

$$EMPA_{i,t} = EMP_{i,t} - EMP_{i,t-1} = \lambda_e(EMP_{i,t}^* - EMP_{i,t-1}) \quad (4)$$

$EMP_{i,t}$ = 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 lagged adjustment model relates the equilibrium equations given in (1) and (2) to the disequilibrium phenomenon of differential municipal population and employment changes. Assuming that the equilibrium relationships (1) and (2) are linear, and substituting those relationships into (3) and (4), yields the model shown below.

$$POP\Delta_{i,t} = \alpha_0 + T_{i,t}\alpha_1 + E_{i,t}\alpha_2 + \alpha_3\overline{EMP}_{i,t}^* - \lambda_p POP_{i,t-1} + u_{i,t} \quad (5)$$

$$EMPA_{i,t} = \beta_0 + \tau_{i,t}\beta_1 + \varepsilon_{i,t}\beta_2 + \beta_3\overline{POP}_{i,t}^* - \lambda_e EMP_{i,t-1} + v_{i,t} \quad (6)$$

where $T_{i,t}$ = a vector of transportation access variables for residents

$\tau_{i,t}$ = a vector of transportation access variables for firms

$E_{i,t}$ = a vector of local environmental amenity variables for residents

$\varepsilon_{i,t}$ = a vector of local environmental amenity variables for firms

u and v are normally distributed error terms

The unobservable equilibrium quantities in (5) and (6), $\overline{POP}_{i,t}^*$ and $\overline{EMP}_{i,t}^*$, are related to observable quantities by assuming that the lagged adjustment model given in (3) and (4) also operates at the level of labor markets. This gives the relationships shown below.

where overbars denote labor market values

"*" denotes an equilibrium value

other values are actual values

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

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

Substituting (7) and (8) into (5) and (6) gives the model shown below.

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

$$\begin{aligned} EMP\Delta_{i,t} &= \beta_0 + \tau_{i,t}\beta_1 + e_{i,t}\beta_2 + \beta_3\overline{POP}_{i,t-1} \\ &+ \frac{\beta_3}{\lambda_p}(\overline{POP}_{i,t} - \overline{POP}_{i,t-1}) - \lambda_e EMP_{i,t-1} + v_{i,t} \end{aligned} \quad (10)$$

C. Measurement of the Labor Market Variables

The labor market variables in (9) and (10), $\overline{POP}_{i,t}$, $\overline{POP}_{i,t-1}$, $\overline{EMP}_{i,t}$, and $\overline{EMP}_{i,t-1}$, correspond to commuting relationships. They are measured using potential variables, as shown below.

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

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

where d_{ij} = the distance between municipalities "i" and "j"⁸

The parameter α in (11) and (12) describes how labor market relationships damp with distance. That parameter was estimated from commuting data before the regression analysis for population and employment changes was performed.⁹ The technique used to estimate α is described in Appendix A.

D. Model Identification

The model in (9) and (10) contains independent variables that are possibly endogenous. The labor market population and employment variables are constructed in such a way that municipal values of population and employment change are both endogenous in the estimation. This amounts to using a technique which is similar to two-stage least squares

⁸ For municipalities that were less than one mile apart, d_{ij} was set equal to one to avoid inflating the influence of those municipalities in the potential variable.

⁹ The commuting data is on commuting patterns of persons living within SMSA's but outside central cities in the United States. The source is U.S. Bureau of the Census, Current Population Reports, Series P-23, No. 122, The Journey to Work in the United States: 1979, U.S. Government Printing Office, Washington, D.C., 1982, Table 5. The estimated value for α is 0.67.

(2SLS), but which allows for the spatial structure of the model, as discussed below. Yet many other independent variables, most notably local fiscal policy and demographic characteristics, are also endogenous to municipal population and employment changes. Thus (9) and (10) cannot be estimated as shown.

One alternative is to specify the full structural model for the system. In other words, one could specify the determinants of local fiscal policy, poverty rates, crime rates, black and hispanic population concentrations, and other endogenous variables. Once that is done, one could instrument the endogenous variables using 2SLS or other simultaneous system techniques. Unfortunately, specifying the determinants of factors such as fiscal policy, poverty rates, crime rates, and demographic composition is extremely difficult. Each equation would be, at a minimum, a paper by itself. Furthermore, it is not clear that there will be enough instruments once such a system is specified. For that reason, an alternative identifying restriction was used.

Many of the independent variables in (9) and (10) were lagged to a prior time period to lessen simultaneity problems.¹⁰ Thus the empirical model regresses population and employment changes from 1980 to 1988 on independent variables measured in 1980. The model that was estimated is shown below.¹¹

¹⁰ This technique was originally suggested by Carlino and Mills. It has become common in later work. See, e.g., Palumbo, Sacks, and Wasylenko, and Thomas F. Luce, "Local Taxes, Public Services, and the Intrametropolitan Location of Firms and Households," paper presented at the Twelfth Annual Research Conference of the Association of Public Policy Analysis and Management, San Francisco, California, October 18-20, 1990.

¹¹ This corresponds to assuming that the adjustment toward equilibrium closes the gap between the equilibrium and actual values at "t-1", as shown below.

$$\begin{aligned}
POP\Delta_{i,t} &= \alpha_0 + T_{i,t-1}\alpha_1 + E_{i,t-1}\alpha_2 + \alpha_3\overline{EMP}_{i,t-1} \\
&+ \frac{\alpha_3}{\lambda_e}(\overline{EMP}_{i,t} - \overline{EMP}_{i,t-1}) - \lambda_p POP_{i,t-1} + u_{i,t}
\end{aligned} \tag{13}$$

$$\begin{aligned}
EMP\Delta_{i,t} &= \beta_0 + \tau_{i,t-1}\beta_1 + e_{i,t-1}\beta_2 + \beta_3\overline{POP}_{i,t-1} \\
&+ \frac{\beta_3}{\lambda_p}(\overline{POP}_{i,t} - \overline{POP}_{i,t-1}) - \lambda_e EMP_{i,t-1} + v_{i,t}
\end{aligned} \tag{14}$$

While it is true that variables measured later in time cannot cause variables measured earlier, there is still the possibility that a spurious correlation could inject simultaneity bias into the specification with lagged independent variables. In the case of omitted independent variables, the omitted variable might cause a spurious correlation between an included independent variable and the error term. While lagging the independent variables lessens the chance of simultaneity bias, it does not eliminate it. For that reason, a method of moments test was conducted to examine whether the instruments for the endogenous variables (population and employment change) were orthogonal to the error in the reduced forms. The results were mixed. The instruments for population change were not correlated with the error

$$POP\Delta_t = POP_t - POP_{t-1} = \lambda_p(POP_{t-1}^* - POP_{t-1}) \tag{1}$$

$$EMP\Delta_t = EMP_t - EMP_{t-1} = \lambda_e(EMP_{t-1}^* - EMP_{t-1}) \tag{2}$$

Note that previously the model assumed that the gap between the equilibrium value at time "t" and the actual value at time "t-1" was closed by the partial adjustment process. While it seems more sensible that persons and firms would move with some foresight, as in (3) and (4), the lag structure shown above can be derived from a model in which actors view equilibrium values as random walks, such that the equilibrium value at "t-1" is the best predictor of the value at time "t". For more discussion of this, see Boarnet [1992 b].

in the employment change reduced form equation, but the instruments for employment change were correlated with the error in the population change reduced form equation.¹² While this is cause for concern, one should note that the results of the regression analysis are in agreement with theory and with many aspects of similar past studies. Furthermore, a detailed data analysis shows that the results are robust to theoretically appropriate changes in specification.¹³ Thus I suggest that these results provide compelling evidence for the importance of both transportation access and local characteristics, as reported in Section IV.

Section III: Study Region and Data

The study region is the 365 municipalities in the northern thirteen counties of the state of New Jersey. The region is shown in Maps 1 and 2. This region is largely part of the New York City metropolitan area. Map 3 shows that eleven of the thirteen counties are part of the New York metropolitan area.

The municipalities in the study region show considerable variation. Some, like Newark, Paterson, and Jersey City, are essentially old central cities. There are many inner suburbs that surround these old, central cities. The inner suburbs grew rapidly in the late 1940s and 1950s. A newer ring of outer suburbs stretches from northern Monmouth County, encompassing the high-growth Route 1 corridor between Princeton and New Brunswick, and

¹² See Boarnet [1992 a], Chapter 7, pp. 14-16, and Boarnet [1992 b] for a discussion of this.

¹³ See Boarnet [1992 a], Chapter 7 and Boarnet [1992 b].

continuing northward through Somerset and Morris Counties. At the fringe of the region, in Hunterdon, Sussex, and Warren Counties, there are small communities that still bear more similarity to farming towns than to suburbs.

The dependent variables in this study are the population and employment changes in the municipalities from 1980 to 1988. Both population and employment growth are most pronounced in the outer suburbs of the Route 1 corridor, Monmouth County, and Somerset and Morris Counties. The pattern of population and employment growth for the region during the last three decades is shown in Maps 4 and 5.

The independent variables are taken from a number of sources, including census data and data from the New Jersey Departments of Community Affairs and Labor. The independent variables measure transportation access and other local amenities.¹⁴ A complete list of all the variables, with mnemonic eight letter names and the source for the data, can be found in Table 1. A shorter list that highlights some important transportation access and local environmental amenity variables is shown below.¹⁵

Transportation Access Variables for Population and Employment Changes:

ANYHIWAY -- dummy variable that measures whether a municipality is on a limited access interstate highway, turnpike, or major U.S. highway

¹⁴ Many of the amenities are problems that persons or firms might flee. Thus the word amenity is used to represent a characteristic that might be either desirable or undesirable.

¹⁵ The list of variables in Table 1 shows which variables are expected to affect population changes and which are expected to affect employment changes. For a complete discussion of which variables affect population changes and which affect employment changes, see Boarnet [1992 a], Chapter 4. For a discussion of how the variables were constructed, see Boarnet [1992 a], Chapter 7, pp. 1-10.

NJTRANSIT -- dummy variable that measures whether a municipality is on the NJ Transit commuter rail network

INTERCHA -- dummy variable that measures whether municipality contains two or more of the highways used for the ANYHIWAY variable

Local Environmental Amenity Variables for Population Changes:

PCTAX -- per capita tax burden in the municipality

PCNECEXP -- per capita expenditures on programs likely to be necessary for all municipalities, such as fire, police and sewage expenditures

POVRAT80 -- poverty rate in the municipality in 1980

PRBLCK80 -- proportion black in the municipality in 1980

PRHISP80 -- proportion hispanic in the municipality in 1980

VIORAT80 -- violent crimes per 1,000 persons in the municipality in 1980

PRPRAT80 -- property crimes per 1,000 persons in the municipality in 1980

Local Environmental Amenity Variables for Employment Changes:

EQZDTX80 -- equalized property tax rate in the municipality in 1980

PEBUSEXP -- per employee expenditures on services likely to be useful to businesses, such as streets and drainage and sewage

VIORAT80 and PRPRAT80, as defined above

TOTMAN82 -- a potential variable that measures total manufacturing employment near the municipality. This variable is designed to measure agglomeration benefits. See the full variable list for a description of this and other agglomeration economy variables. Also see Appendix B for a discussion of the agglomeration economy variables.

TOTRET82 -- a potential variable that measures total retail employment near the municipality. This variable is also designed to measure agglomeration benefits.

The dependent variables in (13) and (14), $POP\Delta_{i,t}$ and $EMP\Delta_{i,t}$, are denoted by $POP8880$ and $EMP8880$, respectively. $POP8880 = POP88 - POP80$, where $POP88 =$ municipal population in 1988 and $POP80 =$ municipal population in 1980. $EMP8880$ is similarly defined as $EMP88 - EMP80$.

Section IV: Estimation and the Spatial Structure of the Model

One implication of the potential variables in (11) and (12) is that the model in (13) and (14) can be expressed in matrix notation, as shown below.¹⁶

$$\begin{aligned}
 POP8880 &= \alpha_0 + T_{80}\alpha_1 + E_{80}\alpha_2 + \alpha_3(\mathbf{I} + \mathbf{W})EMP80 \\
 &+ \frac{\alpha_3}{\lambda_e}(\mathbf{I} + \mathbf{W})EMP8880 - \lambda_p POP80 + u
 \end{aligned} \tag{15}$$

$$\begin{aligned}
 EMP8880 &= \beta_0 + \tau_{80}\beta_1 + \epsilon_{80}\beta_2 + \beta_3(\mathbf{I} + \mathbf{W})POP80 \\
 &+ \frac{\beta_3}{\lambda_p}(\mathbf{I} + \mathbf{W})POP8880 - \lambda_e EMP80 + v
 \end{aligned} \tag{16}$$

where $POP8880$ is a (365×1) vector of observations of $POP8880_i = POP\Delta_i$

¹⁶ Note that the spatial lag of a variable does not include the municipality's own value of that variable, since $d_{i,i} = 0$. Thus variables that are summed over all municipalities must be written as the municipal value plus the spatial lag. For example, $EMP_{i,80} = \mathbf{W}(EMP80) + EMP80_i$.

$EMP8880$ is a (365×1) vector of observations of $EMP8880_i = EMP\Delta_i$
 \mathbf{I} is a (365×365) identity matrix
 \mathbf{W} is a (365×365) matrix of weights, where each element is $1/(d_{ij})^\alpha$, as was used to derive the potential variables
 $POP80$ is a (365×1) vector of observations of $POP80_i$
 $EMP80$ is a (365×1) vector of observations of $EMP80_i$

the subscripts "t" refer to time periods and subscripts "i" refer to municipalities

For simplicity, note that (15) and (16) can be written as shown below.

$$POP8880 = \rho_1(\mathbf{I} + \mathbf{W})EMP8880 + X_1\beta_1 + u_1 \quad (17)$$

$$EMP8880 = \rho_2(\mathbf{I} + \mathbf{W})POP8880 + X_2\beta_2 + u_2 \quad (18)$$

where X_1 and X_2 are matrices of the exogenous variables in (15) and (16)

u_1 and u_2 are normally distributed errors

$$\rho_1 = \alpha_3/\lambda_e \ ; \ \rho_2 = \beta_3/\lambda_p$$

The variables $\mathbf{W}POP8880$ and $\mathbf{W}EMP8880$ are spatial lags of the dependent variables.¹⁷ If one assumed that $\mathbf{W}POP8880$ and $\mathbf{W}EMP8880$ were exogenous, (17) and (18) could be estimated by two-stage least squares (2SLS). Yet such a technique would give reduced forms with spatial lags of the dependent variables on the right hand side. OLS yields biased and inconsistent estimates when spatial lags of dependent variables appear as

¹⁷ For a definition and some discussion of the concept of a spatial lag, see Luc Anselin, Spatial Econometrics: Methods and Models, Kluwer Academic Publishers, 1988, Chapter 3.

independent variables.¹⁸ Since 2SLS, treating POP8880 and EMP8880 as the only endogenous variables, uses OLS to estimate the reduced form for the first stage, those first stage results will be biased and inconsistent. For that reason, the components of POP8880 and EMP8880 that appear both on their own and in the spatial lag were all treated as endogenous.

In particular, POP8880 and EMP8880 were instrumented by the exogenous variables in X_1 and X_2 . The resulting instrumental variables (IV) estimator is¹⁹

$$\hat{\delta}_1 = (Z_1^* Z_1)^{-1} (Z_1^* y_1) \quad (19)$$

where $\delta_1' = (\rho_1 \mid \beta_1')$

$$Z_1 = ((\mathbf{I} + \mathbf{W})y_2 \mid X_1)$$

$$Z_1^* = ((\mathbf{I} + \mathbf{W})\hat{y}_2 \mid X_1) = ((\mathbf{I} + \mathbf{W})P_X y_2 \mid X_1)$$

$$P_X = X(X'X)^{-1}X'$$

$$X = (X_1 \mid X_2)$$

$$y_2 = \text{EMP8880}$$

and

$$\hat{\delta}_2 = (Z_2^* Z_2)^{-1} (Z_2^* y_2) \quad (20)$$

where $\delta_2' = (\rho_2 \mid \beta_2')$

$$Z_2 = ((\mathbf{I} + \mathbf{W})y_1 \mid X_2)$$

¹⁸ See, e.g., Luc Anselin, Estimation Methods for Spatial Autoregressive Processes, Program in Urban and Regional Studies, Cornell University, Regional Science Dissertation and Monograph Series, number 8, 1980, pp. 41-44.

¹⁹ This follows a technique suggested by Anselin [1980], pp. 83-86 and Anselin [1988], pp. 81-86. It amounts to instrumenting POP8880 in the $(\mathbf{I} + \mathbf{W})\text{POP8880}$ variable and similarly instrumenting EMP8880 in $(\mathbf{I} + \mathbf{W})\text{EMP8880}$.

$$Z_2^* = ((\mathbf{I} + \mathbf{W})\hat{y}_1 \mid X_2) = ((\mathbf{I} + \mathbf{W})P_X y_1 \mid X_2)$$

$$P_X = X(X'X)^{-1}X'$$

$$X = (X_1 \mid X_2)$$

$$y_1 = \text{POP8880}$$

The results of the estimation are shown in Table 2, where variables with t-statistics less than 0.7 in magnitude were dropped. A Moran's I-test on the residuals from that regression suggested that the errors in (17) and (18) are spatially correlated.²⁰ Since spatial correlation in the error reduces the efficiency of the estimation and biases the standard errors, a model with a first order spatially autoregressive error was estimated.

That model is as shown in (17) and (18), but now the errors are spatially autoregressive, as shown below.

$$u_1 = \theta_1 \mathbf{W}u_1 + \varepsilon_1$$

$$u_2 = \theta_2 \mathbf{W}u_2 + \varepsilon_2$$
(21)

with $\varepsilon_1 \sim N(0, \sigma_1^2 \mathbf{I})$; $\varepsilon_2 \sim N(0, \sigma_2^2 \mathbf{I})$

For (17), the error term is now

²⁰ The Moran's I-test can be expressed as a variable that is distributed as a standard normal. The value of the variable was 99.89 for the POP8880 regression and -37.76 for the EMP8880 regression, both of which reject the null hypothesis of no spatial correlation in the errors. For a discussion of the Moran's I statistic, see, e.g., John Odland, Spatial Autoregression, Sage Publications, 1988, Daniel A. Griffith, Advanced Spatial Statistics, Kluwer Academic Publishers, 1988, Chapter 1, or Anne C. Case, "Spatial Patterns in Household Demand," in Econometrica, 1991.

$$u_1 = (\mathbf{I} - \theta_1 \mathbf{W})^{-1} \varepsilon_1 \quad (22)$$

Premultiplying (17) by the matrix $\underline{\mathbf{A}}_1$, where $\underline{\mathbf{A}}_1 = (\mathbf{I} - \theta_1 \mathbf{W})$, will give an equation with spherical errors. This is shown below.

$$\underline{\mathbf{A}}_1 y_1 = \underline{\mathbf{A}}_1 Z_1 \delta_1 + \varepsilon_1 \quad (23)$$

where y_1 , Z_1 , and δ_1 are as defined above

As with (17) and (18), EMP8880 was instrumented in $(\mathbf{I} + \mathbf{W})$ EMP8880. An instrumental variables estimator for (23) is

$$\hat{\delta}_1 = (Z_1^* \mathbf{A}_1' \mathbf{A}_1 Z_1)^{-1} (Z_1^* \mathbf{A}_1' \mathbf{A}_1 y_1) \quad (24)$$

where $Z_1^* = (X_1 \mid (\mathbf{I} + \mathbf{W})\hat{y}_2) = (X_1 \mid (\mathbf{I} + \mathbf{W})P_x y_2)$
 $\mathbf{X} = (X_1 \mid X_2)$
 $P_x = \mathbf{X}(\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'$
 $y_1 = \text{POP8880}$
 $y_2 = \text{EMP8880}$
 $\underline{\mathbf{A}}_1 = (\mathbf{I} - \theta_1 \mathbf{W})$

Since the matrix $\underline{\mathbf{A}}_1$ contains the parameter θ_1 , the parameters must be estimated using maximum likelihood.²¹ The log-likelihood function for (23) is

where $\det(\mathbf{A}_1)$ is the Jacobian of the transformation from ε
to $u_1 = \mathbf{A}_1^{-1}\varepsilon_1$
 N is the number of observations
 Z_1 , \mathbf{A}_1 , and δ_1 are as defined before

²¹ On the inconsistency of least squares for estimating θ_1 , see, e.g., Anselin [1980], pp. 41-44 and pp. 142-144.

$$\log L = -\frac{N}{2}\log(2\pi) - \frac{N}{2}\log(\sigma_1^2) - \frac{1}{2\sigma_1^2}[(y_1 - Z_1\delta_1)'A_1'A_1(y_1 - Z_1\delta_1)] + \log(\det(A_1)) \quad (25)$$

log denotes natural logarithm

Maximizing (25) with respect to δ_1 and σ_1^2 one gets

$$\hat{\delta}_1 = (Z_1'A_1'A_1Z_1)^{-1}(Z_1'A_1'A_1y_1) \quad (26)$$

$$\hat{\sigma}_1^2 = \frac{[(y_1 - Z_1\hat{\delta}_1)'A_1'A_1(y_1 - Z_1\hat{\delta}_1)]}{N} \quad (27)$$

Substituting (26) and (27) into (25) gives the concentrated likelihood function

$$\log L_c = -\frac{N}{2}\log(2\pi) - \frac{N}{2}\log(\hat{\sigma}_1^2) - \frac{N}{2} + \log(\det(A_1)) \quad (28)$$

The concentrated likelihood function was maximized by searching values of θ_1 from -1 to 1. For each θ_1 , \underline{A}_1 was defined. $\hat{\delta}_1$ was defined as in (24) to obtain an IV estimator that treats POP8880 and EMP8880 as endogenous. Given $\hat{\delta}_1$, the concentrated log-likelihood was calculated. The value of θ_1 that maximized the concentrated log-likelihood was used. The

estimator for the employment growth regression in (18) was obtained analogously. The results of this estimation are shown in Table 3.²²

Section IV: Results

The results in Table 3 show that both transportation access and environmental amenities affect municipal population and employment changes. This suggests that both monocentric and Tiebout explanations have validity. A comparison of standardized regression coefficients reinforces the sense that the monocentric and Tiebout models have roughly equally important insights.

The standardized regression coefficients are shown in Table 4 for the statistically significant variables in the model shown in Table 3. The variables are listed in descending order depending on the magnitude of the standardized coefficient. The standardized regression coefficients were used to get consistent comparisons of magnitudes for variables that were measured in different units. The standardized coefficient is the estimated regression coefficient divided by the ratio of the standard deviation of the dependent variable to the standard deviation of the independent variable. The standardized coefficients show how much the dependent variable will change for a one standard deviation change in the independent variable.

²² The asymptotic variance of the estimator is

$$avar(\hat{\delta}_1) = \sigma_1^2(Z_1^*A_1'A_1Z_1)^{-1}(Z_1^*A_1'A_1Z_1^*)(Z_1'A_1'A_1Z_1^*)^{-1}$$

which is obtained by simplifying the expression for $E[(\delta_1 - \hat{\delta}_1)(\delta_1 - \hat{\delta}_1)']$.

For population changes, the most influential variables are NYCDSTSQ and LANDAR80. (Note that NYCDIST, the linear term for distance from New York City, was insignificant at the 0.05 level but significant at the 0.10 level.) This suggests that basic geographic variables, including a distance measure related to the monocentric model, are most influential. While this is interesting, distance from the urban core and land area are not policy variables that can be easily altered. The significant variables that can more clearly be affected by policy are VIORAT80, ANYHIWAY, and PCTAX80.

For those variables, ANYHIWAY represents the monocentric focus on transportation access. VIORAT80 and PCTAX80 represent local characteristics (violent crime rates and per capita tax burdens, respectively.) Those variables have standardized coefficients that are roughly the same magnitude, suggesting that, from a policy perspective, a focus on highway location and local characteristics (either violent crime or tax burdens) would be equally effective.

The standardized coefficients from the employment regression, also shown in Table 4, give roughly the same results. The variables that can be affected by policy are VIORAT80, NJTRNSIT, ANYHIWAY, and PRPRAT80. Of those variables, VIORAT80 has the largest standardized coefficient. The magnitudes of the standardized coefficients for NJTRNSIT, ANYHIWAY, and PRPRAT80 are very similar. Only PRPRAT80 has an unexpected sign, and one might be reluctant to infer causality in the case of that variable, since there is a relationship between economic activity and property crime that has not been fully modelled. For employment changes, one could conclude that the role of violent crime rates is more important than the role of transportation access.

Overall, the fact that the transportation and environmental amenity variables have roughly equal standardized coefficients (with the exception of VIORAT80 in the employment growth regression) is striking. This suggests that policies aimed at affecting metropolitan development should give attention to both highway and public transit locations and intrametropolitan variations in local characteristics.

Returning to Table 4, another trend is apparent. The policy variables in both regressions tend to have the smallest standardized coefficients. The most important variables for population growth are distance from New York City and the land area of the municipality. The most important variables for employment growth are the potential variables that measure retail and manufacturing employment. Thus, for population changes, basic geographic factors that are related to the monocentric model are most important. For employment changes, agglomeration variables that are most likely related to the transition away from a manufacturing economy are most important. In both cases, growth patterns are predominantly affected by factors that are exogenous to local policy makers. Thus the conclusion offered by Mills and Price that "basic economic variables" exert the most influence on metropolitan development is correct. Intrametropolitan growth patterns are most sensitive to geographic factors and national economic trends that are largely outside the grasp of local policy-makers. Yet having said that, one should note that policy variables do have some effect, and that the relative influence of transportation and local characteristics is approximately equal.

This insight can be used to inform recent attempts to regulate land use and growth control at a regional or state level. The first point is that policy variables in general are of secondary importance to the geographic and economic variables that influence metropolitan

development. The second point is that, among the available policy variables, attention should be directed both toward transportation access and local characteristics. Both the monocentric development and the "flight from blight" schools of thought are relevant to a policy analysis of intrametropolitan growth. The third point is that the task of regional planning agencies is a formidable one. Certainly the transportation access variables require long time horizons. More importantly, the above results suggest that effective regional planning should focus not only on traditional planning functions such as transportation, but also on intrametropolitan variations in crime rates and tax burdens. These are areas in which localities might be less inclined to surrender jurisdictional authority, and regional cooperation could involve difficult political problems.

Overall, policy-makers should be evenhanded in focusing both on transportation access and on urban problems as causes of the decentralization of urban areas. While one implication of this is that the role of policy potentially becomes more difficult, the point is that to the extent that urban development can be shaped, it is best shaped by a perspective that is informed by both the monocentric and Tiebout models.

Acknowledgements:

I have benefitted from discussions with James R. Hines, Jr., Mark Alan Hughes, and Julian Wolpert. Seminar participants at Princeton University, The University of Pennsylvania, and The University of California at Irvine also provided helpful suggestions. Support for some of the initial data collection was provided by the U.S. Dept. of Transportation and the New Jersey Dept. of Transportation. This research was also supported in part by the University of California through an allocation of computer time. Of course, I alone am responsible for the analysis that is presented here.

Appendix A: Estimation of α in Labor Market Variables

One interpretation of the labor market variables in (11) and (12) is that $1/(d_{ij})^\alpha$ of the residents at "j" are in the labor market centered on "i".²³ This suggests that $1/(d_{ij})^\alpha$ of the residents at "j" commute the distance d_{ij} . Thus, for the residents at "j", the number who commute less than some distance a is

$$\int_0^a \frac{POP_j}{r^\alpha} dr = POP_j \left[\frac{r^{(1-\alpha)}}{(1-\alpha)} \right]_0^a \quad (29)$$

$$= POP_j \left[\frac{a^{(1-\alpha)}}{1-\alpha} \right]$$

where r is the distance from "j" to the end of the commute

Thus the proportion of persons commuting less than some distance "a" is

$$y = \frac{a^{(1-\alpha)}}{1-\alpha} \quad (30)$$

Census journey-to-work data for 1979 gives information on the proportion of persons who commute less than a particular distance. Table A-1 below shows the percent of persons commuting less than a given distance (one-way) to work. The data are for persons living

²³ Equivalently, (11) and (12) suggest that $1/(d_{ij})^\alpha$ of the jobs at "j" are available to or perceived by residents who live at "i".

within SMSA's but outside of central cities.²⁴ The data in the last column of Table A-1 was used for y in equation (30), and the parameter α was estimated by maximum likelihood, since the relationship in (30) is non-linear.²⁵ The estimation was performed using a grid search for values of α that ranged from -3 to 3. The log-likelihood function was maximized for $\alpha = 0.67$, and that value was used in the labor market variables, as defined in (11) and (12).

²⁴ Of the various classifications offered in the census journey-to-work reports, residence inside an SMSA but outside central cities seemed closest to northern New Jersey. The other categories for which data were reported were "In SMSA Central Cities", and "Outside SMSA's". A chi-square test of the hypothesis that each of those categories gives the same commuting pattern as the "In SMSA, Outside Central City" category fails to reject the hypothesis at the 0.1 level for "In SMSA Central Cities" ($\chi^2_9 = 13.64$) but rejects the hypothesis at the 0.05 level for "Outside SMSA's" ($\chi^2_9 = 25.07$).

²⁵ This assumes that the proportion of persons commuting less than some distance includes a normally distributed error term, as shown below.

$$y_i = \frac{a_i^{(1-\alpha)}}{1-\alpha} + u_i$$

Table A-1: Data on Journey to Work for Persons Living in SMSA's, Outside Central Cities, 1979²⁶

Distance to Work Categories	% Commuting to Work	Distance to Work	Proportion of Persons Commuting < Distance
< 1 mile	6.20%	1	0.0620
1-2 miles	9.54%	2	0.1574
3-4 miles	10.85%	4	0.2659
5-9 miles	24.08%	9	0.5067
10-14 miles	18.47%	14	0.6914
15-19 miles	11.56%	19	0.8070
20-29 miles	11.80%	29	0.9250
30-49 miles	6.32%	49	0.9882
50-74 miles	0.95%	74	0.9977
>= 75 miles	0.24%		

²⁶ Adapted from U.S. Bureau of the Census, Current Population Reports, Series P-23, No. 122, The Journey to Work in the United States: 1979, U.S. Government Printing Office, Washington, D.C., 1982, Table 5: Distance to Work, by Family Income and Metropolitan-Nonmetropolitan Residence.

Appendix B: Construction of Agglomeration Economy Variables

The four variables TOTMAN82, TOTRET82, TOTFIR82, and TOTSER82 measure agglomeration economies in four important employment sectors -- manufacturing (TOTMAN82), retailing (TOTRET82), financial, insurance, and real estate (TOTFIR82), and services (TOTSER82). These data are obtained from the New Jersey Department of Labor, which reports employment by one digit SIC code for each of the ninety-six municipalities in the state that have the largest private sector employment.²⁷ Using data on the eighty-four of those municipalities that are in the study area, potential variables in employment, by sector, were constructed as shown below.

$$TOTMAN82_i = \sum_{j \neq i} \frac{MANU_{j,1982}}{(d_{i,j})^2} + MANU82_i \quad (1)$$

where $MANU_i$ = manufacturing employment in municipality "i"
 $d_{i,j}$ = distance in miles from "i" to "j"

TOTRET82, TOTFIR82, and TOTSER82 were constructed similarly. For each employment agglomeration variable, municipalities for which no employment by SIC code was reported were excluded from the summation. Thus, the employment agglomeration variables only measure employment potential using the eighty-four largest employment centers.

²⁷ New Jersey Employment and Wages, 1982 Annual Municipality Report, Private Sector, New Jersey Department of Labor, Trenton, New Jersey, 1982. The data include at least one municipality in each county in the state. Otherwise, the municipalities are those with the largest private sector employment.

An additional variable was included to measure agglomeration economies in marketing. This variable was constructed as shown below.²⁸

$$TRSALE82_i = \sum_{j \neq i} \frac{RETSAL82_{j,1982}}{(d_{i,j})^2} + RETSAL82_i \quad (2)$$

where $RETSAL_i$ = total retail sales (in dollars) in municipality "i"

$d_{i,j}$ = distance in miles from "i" to "j"

Only the TOTMAN82 and TOTRET82 variables were statistically significant in the regressions, so the other three variables were dropped from the specifications reported in Tables 2 and 3 of the text.

²⁸ Data on retail sales in 1982 was available for urban areas in New Jersey with a population of 2,500 or greater. This includes 239 of the municipalities in the study. As with the employment data, municipalities with no reported retail sales were set to zero in the potential variable shown below. The data is from United States Bureau of the Census, 1982 Census of Retail Trade, Geographic Area Series, New Jersey, report number RC82-A-31, 1982.

Bibliography

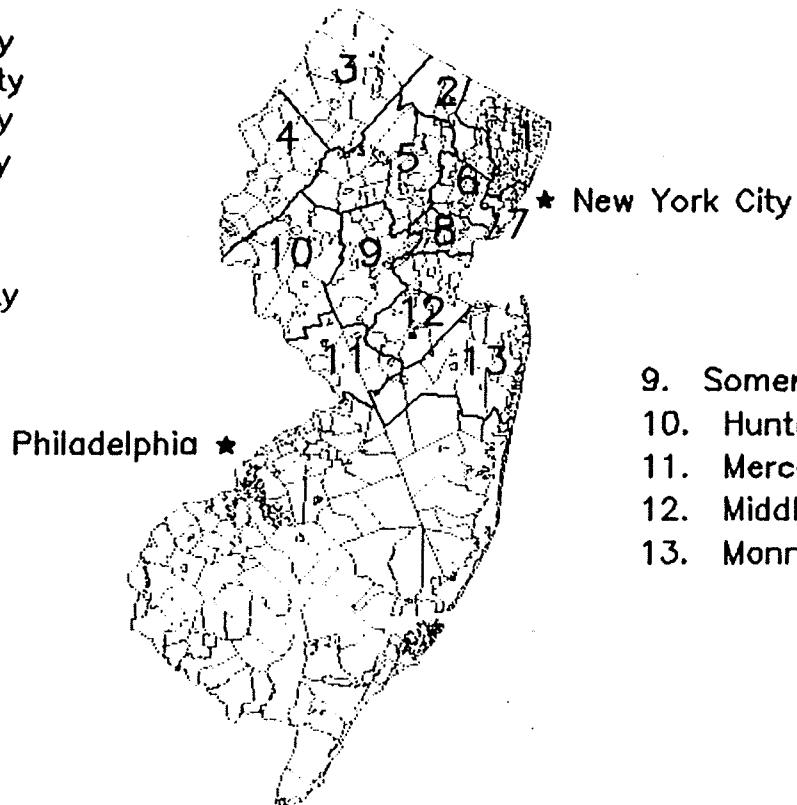
- Anselin, Luc. (1980). Estimation Methods for Spatial Autoregressive Structures: A Study in Spatial Econometrics. Cornell University Program in Urban and Regional Studies, Regional Science Dissertation and Monograph Series Number 8. Ithaca, NY: Cornell University, Program in Urban and Regional Studies.
- _____. (1988). Spatial Econometrics: Methods and Models. Dordrecht, The Netherlands: Kluwer Academic Publishers.
- Boarnet, Marlon G. (1992 a). "Intra-Metropolitan Growth Patterns: The Nature and Causes of Population and Employment Changes within and Urban Area." Unpublished Ph.D. dissertation, Princeton University, 1992.
- _____. (1992 b). "An Empirical Model of Intrametropolitan Population and Employment Growth." Paper presented at the 1992 Symposium of the Commission on Mathematical Models of the International Geographical Union, Princeton, New Jersey, August 5-7, 1992.
- Bradford, David F. and Kelejian, Harry H. (1973). "An Econometric Model of the Flight to the Suburbs," Journal of Political Economy, 81, 566-589.
- Carlino, Gerald A. and Mills, Edwin S. (1987). "The Determinants of County Growth," Journal of Regional Science, 27, 39-54.
- Case, Anne C. (1987). "Spatial Patterns in Household Demand," Econometrica, 59, 953-965.
- Griffith, Daniel A. (1988). Advanced Spatial Statistics. Dordrecht, The Netherlands: Kluwer Academic Publishers.
- Grubb, W. Norton. (1982). "The Flight to the Suburbs of Population and Employment, 1960 - 1970," Journal of Urban Economics, 11, 348-367.
- Luce, Thomas F., Jr. (1990). "Local Taxes, Public Services, and the Intrametropolitan Location of Firms and Households," presented at Twelfth Annual Research Conference of the Association of Public Policy Analysis and Management, San Francisco, California, October 18-20, 1990.
- Mills, Edwin S. (1970). "Urban Density Functions," Urban Studies, 7, 5-20.
- _____. (1986). "Metropolitan Central City Population and Employment Growth During the 1970's." In Peston, M. H. and Quandt, R. E., eds., Prices, Competition, and Equilibrium. Oxford, England: Philip Alan Publishers, Ltd.

- _____ and Price, Richard. (1984). "Metropolitan Suburbanization and Central City Problems," Journal of Urban Economics, 15, 1-17.
- New Jersey Department of Community Affairs. (1960, 1970, 1980, and 1988.) Annual Report of the New Jersey Department of Community Affairs. Trenton, NJ: New Jersey Dept. of Community Affairs.
- New Jersey Department of Labor. (1960, 1970, 1980, and 1988). Covered Employment Trends. Trenton, NJ: New Jersey Dept. of Labor.
- _____. (1982). New Jersey Employment and Wages: 1982 Annual Municipality Report, Private Sector. Trenton, NJ: New Jersey Dept. of Labor.
- New Jersey Division of State Police. (1980). Crime in New Jersey: Uniform Crime Report, 1980. Trenton, NJ: Division of State Police, Uniform Crime Reporting Unit.
- Odland, John. (1988). Spatial Autocorrelation. Newbury Park, CA: Sage Publications.
- Palumbo, George, Sacks, Seymour, and Wasylenko, Michael. (1990). "Population Decentralization within Metropolitan Areas: 1970-1980," Journal of Urban Economics, 27, 151-167.
- Steinnes, Donald N. (1977). "Causality and Intraurban Location," Journal of Urban Economics, 4, 69-79.
- _____ and Fisher, Walter D. (1974). "An Econometric Model of Intraurban Location," Journal of Regional Science, 14, 65-80.
- United States Bureau of the Census. (1980.) 1980 Census of Population and Housing. Washington, D.C.: U.S. Government Printing Office.
- _____. (1984.) 1982 Census of Retail Trade. Geographic Areas Series, New Jersey, Report No. RC82-A-31. Washington, D.C.: U.S. Government Printing Office.
- _____. (1982.) The Journey to Work in the United States: 1979. Current Population Reports, Series P-23, No. 122. Washington, D.C.: U.S. Government Printing Office.

Map 1

The Study Region

1. Bergen County
2. Passaic County
3. Sussex County
4. Warren County
5. Morris County
6. Essex County
7. Hudson County
8. Union County

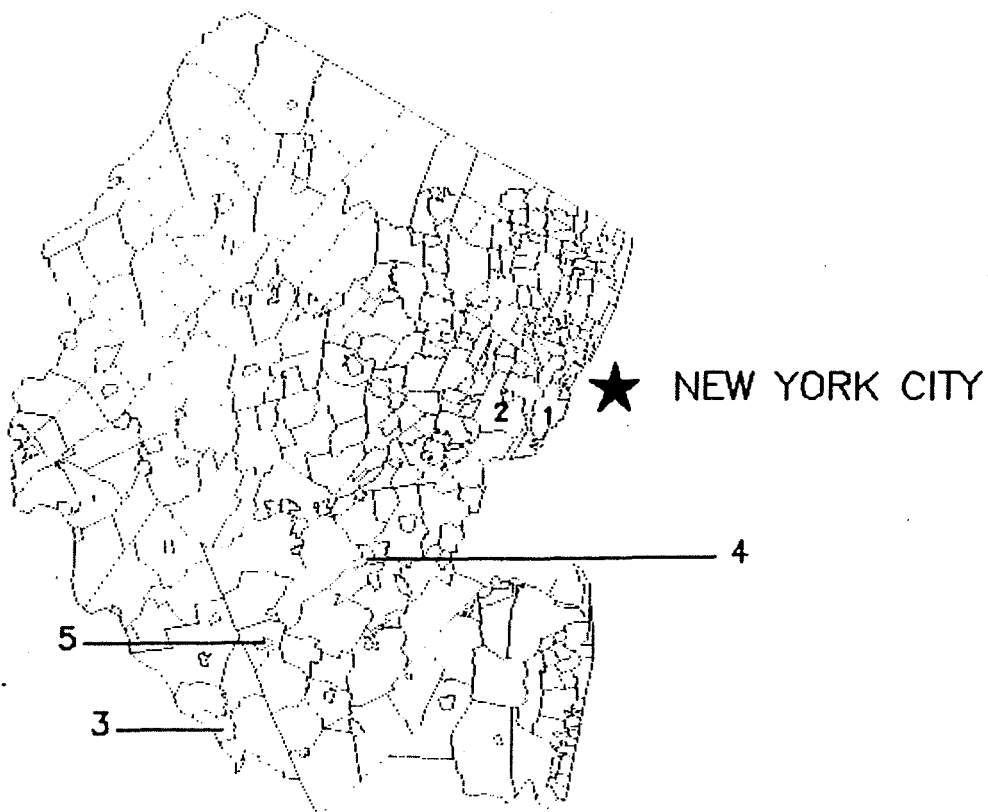


9. Somerset County
10. Hunterdon County
11. Mercer County
12. Middlesex County
13. Monmouth County

Map 2

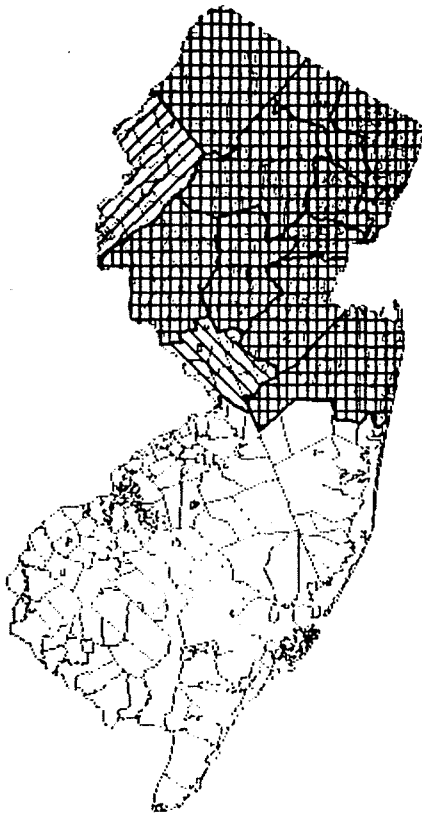
The Study Region

1. Jersey City
2. Newark
3. Trenton
4. New Brunswick
5. Princeton Boro



Map 3

The Study Region



Legend

 New York City CMSA

 Philadelphia CMSA

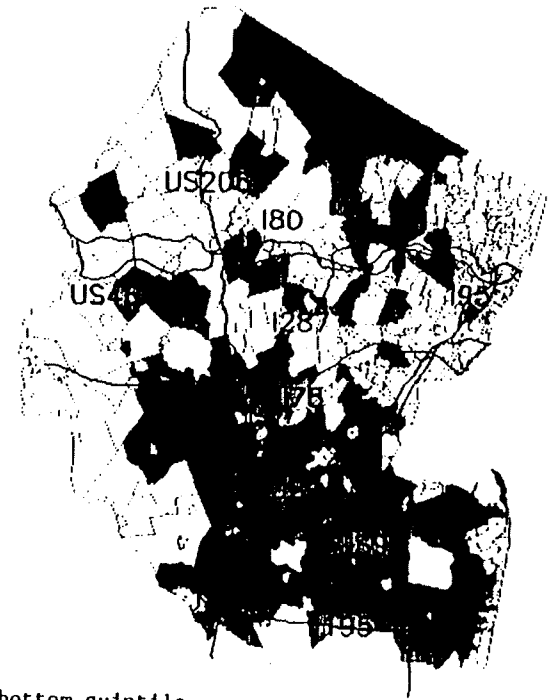
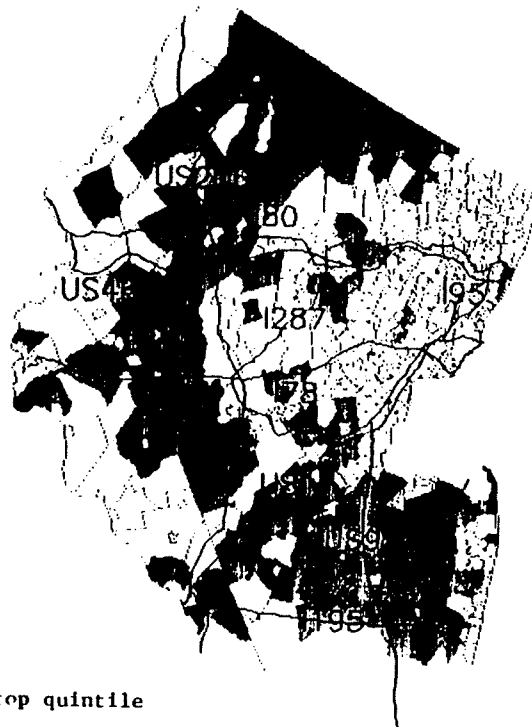
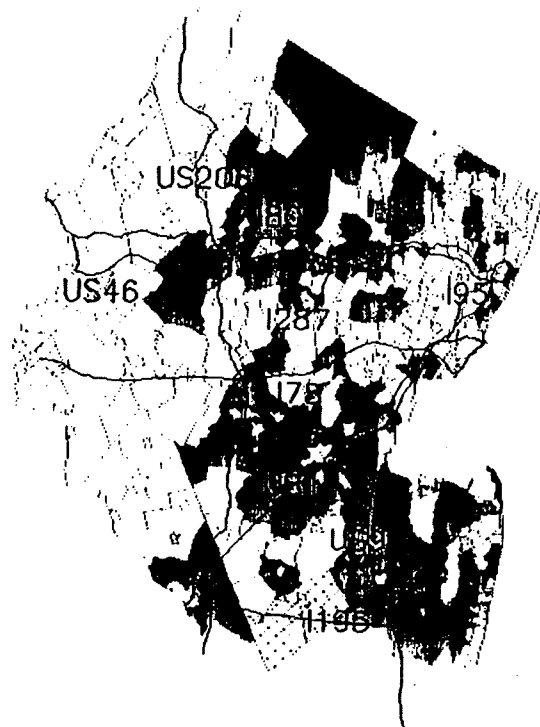
 Allentown SMSA

Map 4: Change in Population,
by municipality

1960-1970

1970-1980

1980-1988



top quintile

bottom quintile

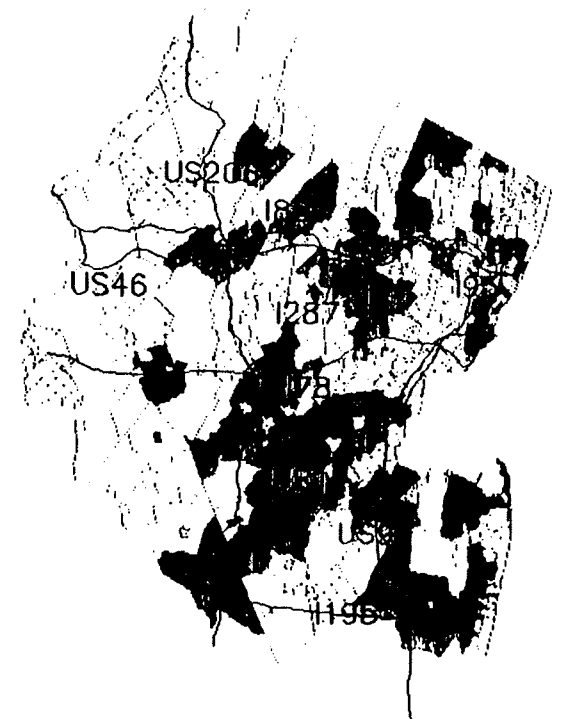
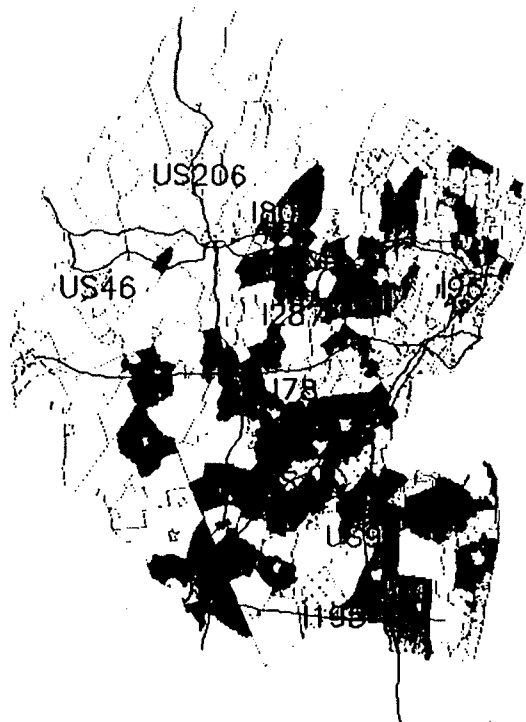
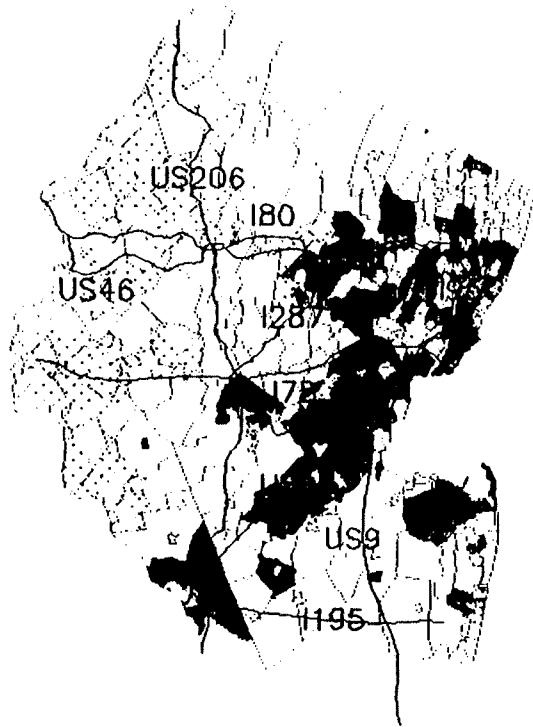
source: adapted from N.J. Dept. of Community Affairs Annual Report, 1960, 1970, 1980, and 1988

Map 5: Change in Employment,
by Municipality

1960-1970

1970-1980

1980-1988



top quintile



bottom quintile

source: adapted from Covered Employment Trends, N.J. Dept. of Labor, 1960, 1970, 1980, and 1988

Table 1: Variable Names

Accessibility Variables for Population and Employment, T and τ :

<u>variable name</u>	<u>description</u>	<u>source</u>
ANYHIWAY	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
NJTRANSIT	dummy variable = 1 if municipality has an NJ Transit commuter rail station	NJ Transit schedules
NYCDIST	distance in miles from the municipality to the geographic centroid of Manhattan Island	calculated using ATLAS DRAW mapping software
NYCDSTSQ	NYCDIST squared	
INTERCHA	dummy variable = 1 if municipality lies on two or more of the highways in HIGHWAY variable	

Amenity Variables for Population, E:

<u>variable name</u>	<u>description</u>	<u>source</u>
PRBLCK80	proportion of muni. population that is black, 1980	1980 Census of Pop.
PRHISP80	proportion of muni. population that is hispanic, 1980	1980 Census of Pop.
POVRAT80	muni. poverty rate (as a proportion), 1980	1980 Census of Pop.
PCI80	muni. per capita income, 1980	1980 Census of Pop.
PCTAX80	per capita local tax payments, 1980 (includes all overlying jurisdictions other than state and federal)	NJDCA 1980 Annual Report
PCPOVEXP	1980 per capita municipal expenditures on human resources, health, welfare, and hospitals	NJDCA 1980 Annual Report

Table 1 (cont.)

Amenity Variables for Population, E (cont.):

<u>variable name</u>	<u>description</u>	<u>source</u>
PCNECEXP	1980 per capita municipal expenditures on fire dept's., police, streets and drainage, sewage, garbage collection, and courts	NJDCA 1980 Annual Report
PCRCHEXP	1980 per capita municipal expenditures on parks and recreation, libraries	NJDCA 1980 Annual Report
EDPUP80	total educational expenditures per pupil, 1980 (includes state transfers to municipality)	N.J. Dept. of Education
VIORAT80	violent crimes per 1,000 municipality residents, 1980	N.J. Uniform Crime Reporting Program, 1980
PRPRAT80	property crimes per 1,000 muni. residents, 1980	N.J. Uniform Crime Reporting Program, 1980
HOUPRE40	proportion of 1980 municipality housing stock built before 1940	1980 Census of Pop. and Housing
FRMPAR80	number of farm property parcels in the municipality, 1980	N.J. Dept. of Community Affairs (NJDCA), 1980 Annual Report
AVGRADON	average radon reading (in pCi/L) in homes in the muni. that were tested between 1986 and early 1991	unpublished data from N.J. Dept. of Env. Protection, Radon Section

Table 1 (cont.)

Amenity Variables for Employment, ϵ :

<u>variable name</u>	<u>description</u>	<u>source</u>
TOTMAN82	potential variable measuring manufacturing employment agglomeration in 1982 (see text for details)	N.J. Employment and Wages, Annual Municipality Report, N.J. Dept. of Labor (NJDOL)
TOTRET82	potential variable measuring retail employment agglomeration, 1982 (see text)	NJDOL 1982 Annual Municipality Report
TOTFIR82	potential variable measuring employment agglomeration in financial, real estate, and insurance, 1982 (see text)	NJDOL 1982 Annual Municipality Report
TOTSER82	potential variable measuring service employment agglomeration, 1982 (see text)	NJDOL 1982 Annual Municipality Report
TRSALE82	potential variable measuring retail sales agglomeration, 1982 (see text)	1982 Census of Retail Trade
EQZDTX80	equalized property tax rate, 1980 (includes all overlying jurisdictions other than state and federal)	NJDCA 1980 Annual Report
PEBUSEXP	per employee expenditures on streets and drainage and sewage	NJDCA 1980 Annual Report
VIORAT80	violent crimes per 1,000 municipality residents, 1980	N.J. Uniform Crime Reporting Program, 1980

Table 1 (cont.)

Amenity Variables for Employment, e (cont.):

<u>variable name</u>	<u>description</u>	<u>source</u>
PRPRAT80	property crimes per 1,000 muni. residents, 1980	N.J. Uniform Crime Reporting Program, 1980
HOUPRE40	proportion of 1980 municipality housing stock built before 1940	1980 Census of Pop. and Housing
FRMPAR80	number of farm property parcels in the municipality, 1980	NJDCA 1980 Annual Report

Labor Market Variables:

<u>variable name</u>	<u>description</u>	<u>source</u>
POP80	municipal population in 1980	NJDCA 1980 Annual Report
EMP80	municipal private sector employment in 1980	NJDOL Covered Emp. by Muni., 1980
POP8070	(POP80 - POP70)	NJDCA '70 and '80 Annual Reports
EMP8070	(EMP80 - EMP70)	NJDOL Covered Emp. by Muni., 1970 and '80

Table 1 (cont.)

Labor Market Variables (cont.):

<u>variable name</u>	<u>description</u>	<u>source</u>
TOTPOP70	potential variable for population, 1970	NJDCA 1970 Annual Report

$$\sum_{j \neq i} \frac{POP_{j,1970}}{(d_{i,j})^\alpha} + POP_{i,1970}$$

TOTEMP70	potential variable for employment, 1970	NJDOL Covered Employment by Muni., 1970
----------	---	---

$$\sum_{j \neq i} \frac{EMP_{j,1970}}{(d_{i,j})^\alpha} + EMP_{i,1970}$$

TOTPOP80	potential variable for population, 1980	NJDCA 1980 Annual Report
----------	---	--------------------------

$$\sum_{j \neq i} \frac{POP_{j,1980}}{(d_{i,j})^\alpha} + POP_{i,1980}$$

TOTEMP80	potential variable for employment, 1980	NJDOL Covered Emp. by Muni., 1980
----------	---	-----------------------------------

$$\sum_{j \neq i} \frac{EMP_{j,1980}}{(d_{i,j})^\alpha} + EMP_{i,1980}$$

Table 1 (cont.)

Labor Market Variables (cont.):

<u>variable name</u>	<u>description</u>	<u>source</u>
PPOT8070	potential variable for population change, 1970 to 1980	NJDCA 1970 and 1980 Annual Reports

$$\sum_{j \neq i} \frac{POP_{j,1980} - POP_{j,1970}}{(d_{i,j})^a}$$

EPOT8070	potential variable for employment change, 1970 to 1980	NJDOL Covered Emp. by Muni., 1970 and 1980
----------	--	--

$$\sum_{j \neq i} \frac{EMP_{j,1980} - EMP_{j,1970}}{(d_{i,j})^a}$$

PPOT8880	potential variable for population change, 1980 to 1988	NJDCA '80 and '88 Annual Reports
----------	--	----------------------------------

$$\sum_{j \neq i} \frac{POP_{j,1988} - POP_{j,1980}}{(d_{i,j})^a}$$

EPOT8880	potential variable for employment change, 1980 to 1988	NJDOL Covered Emp. by Muni., 1980 and 1988
----------	--	--

$$\sum_{j \neq i} \frac{EMP_{j,1988} - EMP_{j,1980}}{(d_{i,j})^a}$$

Table 1 (cont.)

Control Variables:

<u>variable name</u>	<u>description</u>	<u>source</u>
LANDAR80	municipality land area in square miles, 1980	NJDCA 1980 Annual Report
POPDEN80	population density in persons per square mile	data from NJDCA 1980 Annual Report
PDEN80SQ	POPDEN80 squared	

Dependent Variables:

<u>variable name</u>	<u>description</u>	<u>source</u>
POP8880	change in municipal population from 1980 to 1988 (POP88 - POP80)	NJDCA '80 and '88 Annual Reports
EMP8880	change in municipal private sector employment, 1980 to 1988 (EMP88 - EMP80)	NJDOL Covered Emp. by Muni., 1980 and 1988

Table 2: Model without Spatially Autoregressive Error

dependent variable: <u>POP8880</u>		<u>EMP8880</u>	
NYCDIST	80.093 (1.905)	NYCDIST	-115.205 (-1.772)
NYCDSTSQ	-1.079 (-1.911)	NYCDSTSQ	1.242 (1.526)
ANYHIWAY	713.641 ** (3.439)	ANYHIWAY	696.494 ** (2.672)
LANDAR80	63.729 ** (4.693)	NJTRANSIT	863.776 ** (3.032)
POPDEN80	0.038 (1.070)	LANDAR80	39.846 * (2.442)
PRBLCK80	3030.450 (1.911)	POPDEN80	-0.035 (-0.950)
PRHISP80	3159.729 (1.376)	VIORAT80	-236.641 ** (-4.107)
POVRAT80	-1.07(10) ^{4*} (-2.411)	PRPRAT80	13.216 (1.812)
VIORAT80	-106.472 (-1.793)	HOUPRE40	-1573.951 (-1.878)
PRPRAT80	10.506 (1.870)	FRMPAR80	-2.127 (-1.766)
HOUPRE40	-1.33(10) ³ (-1.896)	PEBUSEXP	-0.268 (-0.998)
FRMPAR80	0.947 (1.005)	EQZDTX80	149.985 (0.839)
AVGRADON	-70.787 (-1.839)	TOTMAN82	-0.246 ** (-4.388)
PCNECEXP	2.691 (1.189)	TOTRET82	0.605 ** (5.775)
PCTAX80	-0.815 (-1.492)	TOTFIR82	-0.342 (-1.497)
TOTEMP80	-2.33(10) ⁻³ (-0.508)	TOTSER82	0.134 (1.407)
(<u>I</u> + <u>W</u>)*	9.59(10) ⁻³	TOTPOP80	-1.6(10) ⁻³
EMP8880 ††	(0.316)	(<u>I</u> + <u>W</u>)*	-0.819
POP80	-0.020 ** (-3.638)	POP8880 ††	0.086 ** (2.912)
INTERCEPT	-435.555 (-0.333)	EMP80	0.024 (0.958)
		INTERCEPT	1810.562 (0.908)
N	358	N	358
R ²	0.4342	R ²	0.3959
R ² _{adj}	0.4041	R ² _{adj}	0.3619

t-statistics in parentheses

†† instrumented in spatial autocorrelation fit

* significant using .05 two-tailed test

** significant using .01 two-tailed test

Table 3: Model with Spatially Autoregressive Error

	<u>POP8880</u>		<u>EMP8880</u>
NYCDIST	112.458 (1.777)	NYCDIST	-96.230 (-1.697)
NYCDSTSQ	-2.053 * (-2.350)	NYCDSTSQ	1.022 (1.436)
ANYHIWAY	615.631 ** (3.045)	ANYHIWAY	729.454 ** (2.946)
LANDAR80	78.228 ** (5.914)	NJTRANSIT	846.740 ** (3.083)
POPDEN80	0.023 (0.694)	LANDAR80	41.280 ** (2.635)
PRBLCK80	2533.707 (1.700)	POPDEN80	-0.025 (-0.707)
PRHISP80	3506.826 (1.602)	VIORAT80	-244.891 ** (-4.384)
POVRAT80	-7.74 (10) ³ (-1.889)	PRPRAT80	14.406 * (2.067)
VIORAT80	-111.323 * (-2.006)	HOUPRE40	-1485.802 (-1.837)
PRPRAT80	10.513 (1.953)	FRMPAR80	-2.196 (-1.885)
HOUPRE40	-1.56 (10) ^{3*} (-2.389)	PEBUSEXP	-0.264 (-1.012)
FRMPAR80	-0.471 (-0.512)	EQZDTX80	124.174 (0.720)
AVGRADON	-51.867 (-1.290)	TOTMAN82	-0.239 ** (-4.549)
PCNECEXP	4.150 (1.872)	TOTRET82	0.593 ** (5.908)
PCTAX80	-1.109 * (-2.072)	TOTFIR82	-0.306 (-1.404)
TOTEMP80	-9.16 (10) ⁻³ (-1.138)	TOTSER82	0.127 (1.424)
(<u>I</u> + <u>W</u>) *	0.034	TOTPOP80	-1.5 (10) ⁻³ (-0.805)
EMP8880 ††	(0.586)	(<u>I</u> + <u>W</u>) *	0.081 **
POP80	-0.022 ** (-4.350)	POP8880 ††	(3.276)
INTERCEPT	292.524 (0.158)	EMP80	0.021 (0.861)
		INTERCEPT	1395.808 (0.787)
N	358	N	358
log L	-2816.002	log L	-2911.421
θ_1	0.18	θ_2	-0.03

t-statistics in parentheses

†† instrumented in spatial autocorrelation fit

* significant using .05 two-tailed test

** significant using .01 two-tailed test

Table 4: Standardized Regression Coefficients from Model with Spatially Autoregressive Error

dependent variable: <u>POP8880</u>		<u>EMP8880</u>	
NYCDSTSQ	-0.959	TOTRET82	0.612
LANDAR80	0.483	TOTMAN82	-0.501
POP80	-0.266	VIORAT80	-0.323
VIORAT80	-0.179	(<u>I+W</u>) POP8880	0.254
ANYHIWAY	0.141	LANDAR80	0.210
HOUPRE40	-0.126	NJTRANSIT	0.145
PCTAX80	-0.119	ANYHIWAY	0.137
		PRPRAT80	0.123

Note: only statistically significant variables are shown