THE IMPACT OF HIGHWAYS UPON METROPOLITAN DISPERSION: ST. LOUIS

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I. INTRODUCTION

A major question in urban location studies is whether major shifts in employment and household location occur as a result of transportation system changes. If so, is the urban dispersion process a result of biases in public policy which have generally favored capital expenditures for highways over public transit? Or do trends toward dispersion result from changes in production techniques and deep-seated preferences of urban residents for low-density living (aided by rising incomes, and favorable government mortgage policies)? In other words, is transportation only a second-order influence on metropolitan dispersion patterns?

Such questions cannot be definitely answered because transportation change and metropolitan development are virtually simultaneous and mutually reinforcing. However, in the case of St. Louis, we had reason to suspect that the construction of the interstate highway system had indeed been a major stimulus to industrial expansion and relocation from the city to the surrounding suburban area. Because accessibility* to employment is one factor influencing household location decisions, it follows that the interstate highway network in St. Louis could also

*Throughout this paper the term "accessibility" is used as a measure of the opportunities for interaction of socioeconomic activities from a given sub-area of the Standard Metropolitan Statistical Area (SMSA). Two types of accessibility are defined: (1) Central Business District (CBD) accessibility, which measures access to a single point, and (2) SMSA accessibility, which measures the interaction opportunities of a given sub-region to all other sub-regions of the SMSA. These measures are explained more fully in Sec. IV.

have indirectly caused shifts in the patterns of residential location.

In this paper, we attempt to examine the relationship between highway improvement and changes in urban form in the St. Louis Standard Metropolitan Statistical Area (SMSA). We first offer a theoretical construct and then provide empirical evidence to support the hypothesis that the interstate highway system *has* been a causal factor in the dispersion of jobs and people throughout the St. Louis SMSA. Our methodology employs descriptive statistics, as well as simple regression models designed to explain variations in land use change as measured by changes in employment and population density. Accessibility changes are represented by highway travel time changes between sub-regions of the SMSA. The data utilized describe the 1965-1970 period.

The analysis is admittedly partial in two senses: first, other potentially important influences, such as changes in land value, personal income, and amenities (e.g., recreation and education facilities, public services, etc.) are not included because of data deficiencies; second, travel time changes affect only a portion of the total trip costs -- i.e., the nonmonetary portion.* As a result, our conclusions must be regarded as only suggestive of the effect that highway changes have had and will continue to have on land usage in the development of the St. Louis SMSA.

Section II of this paper briefly reviews the theoretical literature concerning industrial location. Section III summarizes highway improvements and land use changes that occurred in the St. Louis region during the 1960s. Section IV presents regression models relating land use changes to travel time change and reports the results. The final section summarizes our tentative conclusions.

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*The total cost of an urban trip is composed of the monetary cost per mile (operating expenses) and the value of alternative time pursuits for the person making the trip. If the trip time declines while the other components of trip cost remain constant, the trip cost decreases. Other things being equal, we assume that the interstate system has reduced trip times and thus has caused a decrease in trip costs to and from areas previously beyond the urban area.

II. GENERAL THEORY AND MODEL CONSTRUCT

Much of the literature dealing with industrial and residential location is solely descriptive in nature. Kain and Meyer suggest that "little effort has been made to explain the existing pattern of industry location. Even less attention has been devoted to explaining changes in this pattern."* Literature purporting to explain patterns of location tends to be very abstract, to deal with highly aggregated concepts, and to be generally unsuitable for building relatively small area forecasting models or for policy purposes.

An example of this basic lack of understanding of the forces underlying and motivating location decisions is the use of Monte Carlo or other random selection devices to define specific area demand and supply.** Use of such methods both obscures and highlights the basic problem: very little is known about the actual processes of decision to relocate. This problem was especially relevant in the San Francisco Housing Simulation Model.***

This section briefly reviews the literature and suggests a series of testable general hypotheses regarding industrial location.

INDUSTRIAL LOCATION

Statistics show that industries tend to cluster together, usually within densely populated areas.**** Until relatively recently, the classic stereotype of American cities has manifested this clustering

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*John F. Kain and John R. Meyer, *Computer Simulations, Physio-Economic Systems, and Intra-regional Models,* Harvard Program on Regional and Urban Economics, Discussion Paper No. 25, Cambridge, Massachusetts, December 1967, p. 13.

**Arthur D. Little used Monte Carlo methods in the San Francisco Housing Simulation Model; see Arthur D. Little, Inc., *Model of the San Francisco Housing Market,* San Francisco Renewal Program, Technical Paper No. 8, January 1966.

***See Garry D. Brewer, *Politicians, Bureaucrats, and the Consultant: A Critique of Urban Problem Solving,* Basic Books, New York, 1973.

****See Charles E. Richter, "The Impact of Industrial Linkages on Geographical Association," *Journal of Regional Science,* Vol. 9, No. 1, 1969, pp. 19-27.

syndrome -- a concentration of industry and business providing employment for the population, who, in turn, supply the requisite labor. Given this agglomerative tendency of firms and any number of reasons not to relocate, why is it that we find firms and entire industries moving from their original center city location to suburban sites?

That such an industrial outmigration has occurred in the United States since World War II is scarcely debatable. Although regional and urban differences exist, the central city areas of the forty largest U.S. "metropolitan areas lost an average of over 17,000 manufacturing jobs in only five years [1958-1963]."* Census data for 1970 give no indication that this trend has been halted or even deaccelerated.

A number of economic reasons for this outmigration are immediately apparent:**

1. Space for expansion may be unavailable in the densely populated center city regions.
2. Suburban land costs may be far below comparable center city sites.
3. A firm may want to move closer to its source of supply. (However, this is a two-edged proposition: moving closer to the supply may entail moving farther away from the market.)***
4. A firm may want to move closer to a particular skilled labor market.

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*John F. Kain, "Postwar Changes in Land Use in the American City," in Daniel P. Moynihan, ed., *Toward a National Urban Policy*, Basic Books, New York, 1970, p. 75.

**This listing of possible reasons that a firm might relocate excludes a number of personal reasons, such as executive preference for a particular site or fear of crime. We do not mean to suggest that such reasons are irrelevant, but they do not enter into the scope of this research.

***For a review of this argument, see William Alonso, "Location Theory," *Regional Development and Planning*, in John Friedmann and William Alonso, eds., MIT Press, Cambridge, Massachusetts, 1969, pp. 78-106. The classic work is Edgar Hoover, *The Location of Economic Activity*, McGraw-Hill, New York, 1948.

IMPORTANCE OF TRANSPORTATION COSTS

Although the two dimensions of the move to suburban areas are direction and structure of the relocation activity,* the underlying theme among the diverse theories of spatial growth and possible firm relocation is *transportation*. This does not mean that transportation costs are the only consideration in locations; if there were zero transportation costs, a clustering effect would still exist for a number of reasons (for example, labor force and area amenities). However, there is little question that distance and travel time are extremely important variables in the location calculus.

Firms tend to agglomerate in order to minimize the total trip costs of transporting both their raw materials and products. This minimization includes a reduction of distances between firms within a given industry, between industries (especially those that contribute to a specific product), between a firm and its customers, and between firms and the primary shipping and/or receiving points (shipyard, railyard, etc.). If these costs -- represented by travel time -- can be reduced, then a firm can consider increasing its distance from other firms, industries, or customers without incurring an added expense. The ability to maintain a relatively constant travel time (or other accessibility index) permits a firm to relocate, thus abandoning the relatively high density, high rent, central business district for the lower rent urban peripheries.

High-speed highways provide just such an opportunity for a large and varied number of firms and industries to leave a congested CBD and establish new physical facilities in the suburbs without incurring additional transportation costs. Kain comments:

> These trends in industry location are the result of basic changes in production and transportation technologies. Intercity and intracity motor trucks freed most producers from

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*These dimensions are addressed in the different descriptive growth theories advanced by Johann van Thünen, Hoyt, and Firey. See Homer Hoyt, *The Structure and Growth of Residential Neighborhoods in American Cities*, Federal Housing Administration, Washington, D.C., 1939; and Walter Firey, *Land Use in Central Boston*, Harvard University Press, Cambridge, Massachusetts, 1947.

> having to crowd into the limited area near deep-water ports or railroad marshalling yards . . . For an increasing number of firms, outlying locations near major intercity highways and suburban beltways became more advantageous. . . . [In sum, the] principal effect of these changes in freight and communications technologies was to make locations throughout metropolitan areas more uniform in terms of transportation costs, reducing greatly the former locational advantages of central areas conferred by the concentration of freight and passenger terminals there.*

If changes in the location of industry are partially a function of highway improvements and a resultant reduction in travel times, then this phenomenon should be subject to empirical verification by examining the relationship between *land use changes* and *travel time decreases* from the urban periphery to the CBD and other areas of the SMSA. Specifically, we want to test the hypothesis that *declining travel times exert a positive influence on industrial employment location.*

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*Kain, op. cit., pp. 76-77.

III. HIGHWAY IMPROVEMENT AND URBAN CHANGE IN ST. LOUIS

INTERSTATE SYSTEM

The decade of the 1960s provides an excellent opportunity to examine the relationship between transportation improvements and the residential-employment dispersion that occurred in the Missouri portion of the St. Louis metropolitan area. During this period, the federal government provided financial support for the construction of five major interstate highways; this network is shown in Fig. 1. Three of the links in this system (I-70, I-44, and I-55) are radial routes extending west from the CBD; the other two links (I-270 and I-244) comprise the outer beltway which connects the northern and southern portions of St. Louis County. These routes were completed on the following dates: I-70, July 1961; I-270, June 1964; I-55, July 1967; I-244, November 1968; and I-44, December 1972.* Total capital expenditures on the interstate system exceeded one quarter billion dollars during this period, with the state providing 10 percent of the total revenues required.**

The distribution between radial and beltway highways is important because their respective impacts on employment location decisions may be decidedly different. The construction of high-speed radial routes allows for increased accessibility measured in travel time between the established CBD and regions beyond the urbanized city-county ring. This increased accessibility, combined with the relatively inexpensive land available in outlying areas, provides a strong impetus for firms and households to locate farther from the CBD on land adjacent to the

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*In addition to these five interstate highways, two other major arteries were developed during the 1960s. State Highway 40 (the Daniel Boone Expressway) was substantially improved, and St. Louis County completed a portion of the inner beltway connecting Highway 40 with I-70 (see Fig. 1).

**The expenditure data were obtained from *Highway Statistics*, Table SF-15, annual volumes 1965-1970, U.S. Department of Transportation, Federal Highway Administration, and cover Jefferson, St. Charles and St. Louis Counties and St. Louis City.

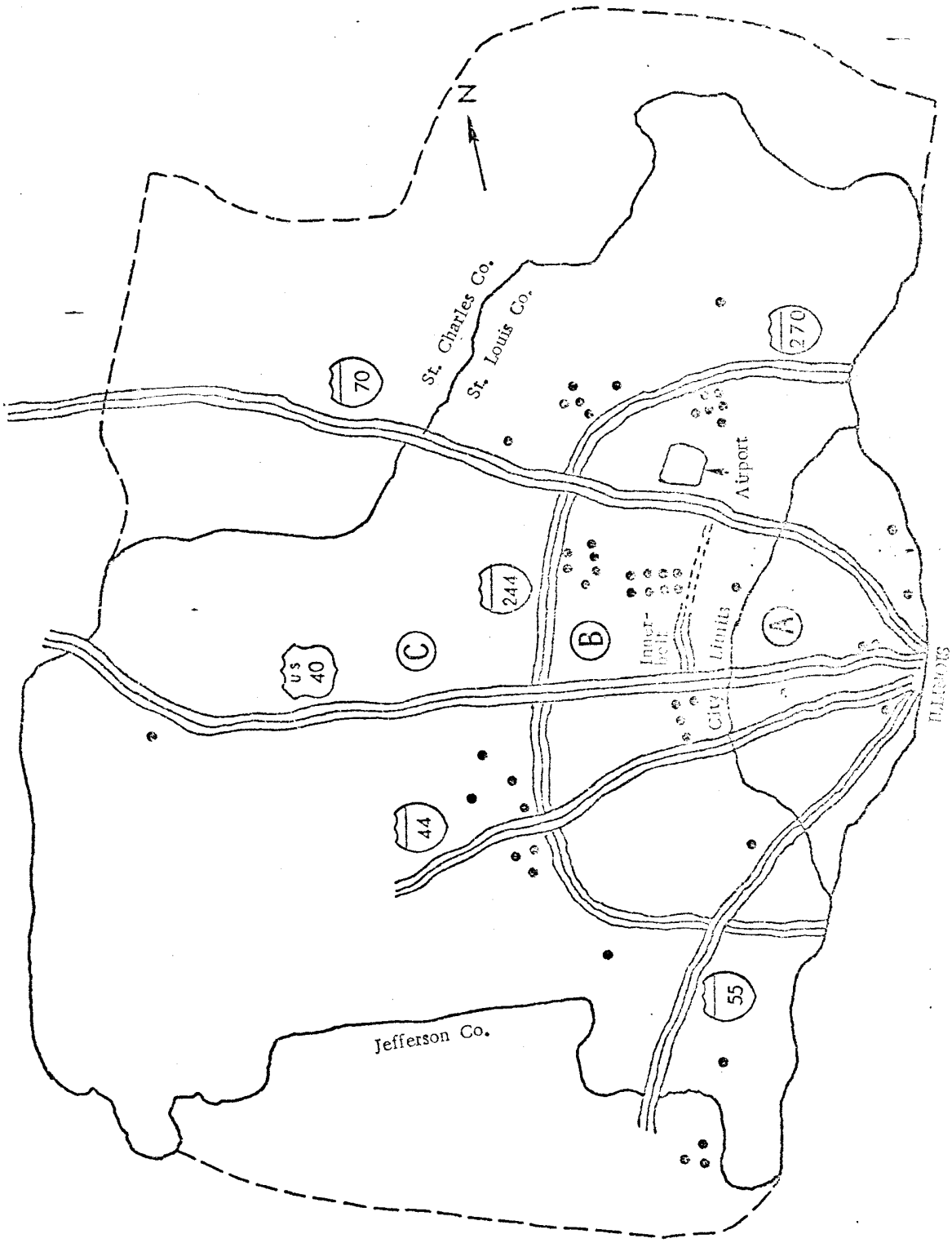

Fig. 1--Location of major highways and industrial parks in the St. Louis SMSA

SOURCE: Dempster K. Holland and George D. Wendel, *Development of Industrial Parks in St. Louis County, Missouri,* The Rand Corporation, R-1358-NSF (forthcoming).

new highway corridors. By contrast, the interstate beltway provides improved accessibility between various sub-regions of St. Louis County, thus encouraging new residential and employment location clusters to occur in concentric ring patterns emanating from the previously established urban boundary. As the dispersion process continues, the need for access to the CBD diminishes as people and employment begin to interact within the newly formed urban rings. Thus, our research concerning the impact of federal highway policy in St. Louis was organized to identify the separate effects of radial versus beltway highway routes. This dichotomy is recognized to be somewhat arbitrary because the process of metropolitan growth occurs in response to changes in the *entire* transportation network rather than simply one part of the system.* Nevertheless, the distinction is useful for an initial analysis of the complex relationship between transportation change and urban form in the St. Louis region.

INDUSTRIAL LOCATION CHANGES

Concurrent with the interstate highway construction, new patterns of industrial employment location began to be seen in the St. Louis SMSA. The emergence of industrial parks appears to have been a major factor contributing to this dispersion.** The developers of these parks offered a valuable service to firms wishing to establish new facilities, expand, or relocate. By converting underdeveloped land into desirable employment sites -- equipped with low-cost parking facilities and complete utilities -- developers provided a convenient means by which the dispersion process could occur. For purposes of

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*More specifically, radial and beltway routes quite likely influence location decisions in ways other than those described above. Radial routes have probably been a factor inducing clusters of employment and residential activity that no longer require access to the CBD to form in the county. Likewise, the beltway connects radial routes and thus provides improved accessibility to the CBD for many new areas.

**For a complete description of the industrial park development process in the St. Louis area, see Dempster K. Holland and George D. Wendel, *Development of Industrial Parks in St. Louis County, Missouri*, The Rand Corporation, R-1358-NSF (forthcoming).

this research, it is important to note that almost without exception, the industrial park is located near an interstate highway.*

Some limited information concerning the location of new industrial plants is available for the 1967-1968 period. Koepke has divided these new operations into two groups.** The first group, termed "locals," consists of long-time residents of the region who view St. Louis as the primary market for their products; 70 percent of the market for the typical "local" plant is within the area. Manufacturing is the primary activity of these new plants, and the average firm obtains one-half of its raw materials from local sources. During 1967-1968, eleven "local" plants were opened, four within St. Louis City and seven within the county.

The second group, termed "outsiders," was quantitatively more important as a source of new operations. Manufacturing and warehousing facilities each accounted for half of the fourteen new plants. To the "outsiders" -- generally branch operations of large national firms -- the adjacent market is much less important than it is to the "locals." Only 34 percent of the total market for this group is located in the St. Louis region. Sixty-one percent of the "outsiders" chose county industrial park sites, while only one firm located within the city limits.

Koepke found that the new industrial firms -- both "local" and "outsider" -- rely almost entirely on truck transportation to obtain raw materials and distribute their products. For the average "outsider" operation, approximately 85 percent of the inbound and outbound shipments move by truck; for the "locals" the average is even higher -- roughly 93 percent. The "outsider" firms tended to locate adjacent to

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*In Fig. 1, industrial park locations are represented by dots.

**R. L. Koepke, *Industry in the St. Louis Region: Phase I - the Location of New Plants 1967-68*, East-West Gateway Coordinating Council, February 1970, pp. 13-29. Industrial expansions are discussed by Koepke in a companion volume: *Industry in the St. Louis Region: Phase II - The Nature and Location of Industrial Expansions, 1966-1969*, East-West Gateway Coordinating Council, February 1971.

the interstate beltway, but the "locals" chose sites nearer the inner beltway and the radial routes entering the city.* This pattern tends to support the theory that "outsiders" view St. Louis as a collection and distribution point rather than a primary market. For these firms, the beltway provides a high-speed transportation system which allows access to, from, and within the St. Louis region without passing through the city itself.

POPULATION AND EMPLOYMENT DENSITY CHANGES

To gain a perspective of how SMSA land use patterns have shifted as the highway network has expanded, we examined the population and employment densities for three rings of the SMSA (Fig. 1): Ring A, which is bounded by the city limits on the west and includes all traffic zones within the city; Ring B, which contains all zones in the county bounded by the interstate beltway (I-270, I-244); and Ring C, which includes the remaining county zones west of the beltway, plus portions of St. Charles and Jefferson Counties. Table 1 shows the calculated densities for 1965 and 1970.

Several interesting trends can be observed in Table 1. Population density is roughly three times greater in the city (Ring A) than the inner county (Ring B); in both areas the population density declined during the 1965-1970 period. Ring C -- outer St. Louis County and portions of Jefferson and St. Charles Counties -- displays a population density increase of approximately 33 percent, although the absolute density of this ring is only one-third that of the inner county (Ring B) and only about one-tenth of the city (Ring A). Industrial employment density declined in Ring A and increased in both Rings B and C, supporting the earlier hypotheses concerning industrial expansion. By contrast, commercial employment density actually increased slightly in the city (Ring A) while falling in Ring B during the period. This reflects the relative interdependence (hence, reluctance to relocate) of commercial firms as compared to industrial concerns. Also, commercial activities are less land-intensive in this demand and therefore less likely to

*Nine of fourteen "outsider" firms locating in the St. Louis region during the 1967-1968 period chose sites adjacent to the I-244/I-270 beltway. See Koepke, *Phase II*, op. cit., p. 33.

require large amounts of land for expansion. Commercial employment density nearly doubled in Ring C, although, like population density, commercial employment density in Ring C is much less than in Rings A or B. These data alone cannot support firm conclusions regarding the impact of the interstate system on the urban form of the SMSA. However, the density changes of Table 1 do suggest that the urbanization process is continuing well beyond the previous county suburban boundary (as represented by the inner beltway).

Table 1

POPULATION AND EMPLOYMENT DENSITIES IN THE ST. LOUIS SMSA (1965 and 1970)

Ring	Year	Population Density[a]	Industrial Employment Density[b]	Commercial Employment Density[b]
A	1965	33.5	12.7	10.5
	1970	31.4	12.0	10.8
B	1965	11.7	3.1	4.7
	1970	10.5	3.4	4.2
C	1965	2.3	0.75	1.3
	1970	3.2	1.00	2.4

SOURCE: Traffic zone data obtained from Missouri State Highway Commission for 250 traffic zones.

[a]Population density figures refer to people per residential acre.

[b]Employment densities represent persons employed per industrial or commercial acre.

IV. REGRESSION ANALYSIS

The hypothesis that decreases in highway travel time--either to the CBD or to other SMSA locations--affect the location of urban activity may be tested using standard regression analysis techniques. In this section, a simple regression model is specified which attempts to explain variations in industrial employment density changes for the period 1965-1970.* The coefficients of the equation are estimated by ordinary least squares, using 1965 and 1970 traffic zone data for the Missouri portion of the St. Louis SMSA.**

DEFINITION OF VARIABLES

1. Dependent Variable

The change in industrial urban land use patterns is used as the dependent variable in the regression models:

ΔI = change in industrial employment density, defined as employment per industrial acre, between 1965 and 1970.

This variable represents the absolute difference in density between 1965 and 1970. In earlier specifications of the model, percentage changes were used; however, the statistical significance of the results (i.e., R^2 and t-statistics) was, in general, less satisfactory than those obtained with the absolute density change measure. Consequently, only the equation results using absolute changes are presented below.

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*Some preliminary regression equations were also estimated which attempted to explain population density changes, but the results were inconclusive and are not presented in this paper.

**Data were obtained from the Missouri State Highway Commission.

2. Independent Variables

a. Changes in Accessibility. Two measures of changes in accessibility are used in the regression model. The first measure is defined as the change in travel time from a given zone to the CBD. The CBD accessibility variable ΔT_{CBD} is obtained by calculating the highway travel time change (in minutes) between traffic zones for 1965 and 1970. This measure of accessibility is most appropriate for a model in which the CBD is viewed as the major employment and distribution center. Accordingly, variations in density change of the non-CBD traffic zones are hypothesized to result from differences in the travel time changes--which result from radial highway construction--to this single center of activity.

The second measure of accessibility is an index calculated as

$$A_i = \sum_{\text{all } j} \frac{M_j}{t_{ij}}, \qquad j \neq i,$$

where

A_1 = vehicle accessibility index of zone i to activity M;

M_j = quantity of industrial activity (i.e., industrial employment density) located in zone j;

t_{ij} = travel time between zone i and j (in minutes).

Changes in this index between 1965 and 1970 form the second version of the accessibility change variable ΔA; as interzone travel times decline, the value of this variable increases for all zones.* The model specification which uses this variable postulates that density changes result from changes in the accessibility of a given zone to employment or population in *all* other zones (not simply the CBD). The hypothesis is that the beltway system has rendered new areas of the country more accessible to existing population and employment activity;

*The accessibility index for all zones, both city and county, increase when the interzone travel times decrease. Because we are interested in explaining growth patterns in the county--due to the beltway--only those zones that displayed density increases between 1965 and 1970 are used to estimate the regression models employing ΔA.

therefore, density changes in these zones will be greater than in zones relatively unaffected by the beltway location. In other words, we would expect the coefficient of ΔA to be positive.

b. Initial Density Variable (I_{65}). This variable, which measures the density of activity in 1965, is included to control for differences in the initial level of activity between zones. If a given zone displays high employment density in 1965, then, all other conditions being equal, its potential for density increase during the ensuing time period is less than that of a zone with a lower level of activity in 1965. In general, we would expect the coefficient of this initial density variable to be negative.

OMITTED VARIABLES

Many other factors, of course, influence changes in the location of employment over time. The presence or lack of complementary activities (such as education or recreation facilities), average family income, residential lot size, the existing type of employment (light vs. heavy industry), and undeveloped land values all exert some influence on changes in employment density throughout any urbanized area.* Such detailed information would be necessary before the estimated model could be relied on for predictive purposes.

CHANGES IN INDUSTRIAL EMPLOYMENT DENSITY

The following regression results were obtained for the industrial employment models:

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*Explanatory variables of this type have been used with some success in statistical studies of the determinants of land and property values in the St. Louis area. See R. F. Muth and K. Wieand, "A Note on the Variation of Land Values with Distance from the CBD in St. Louis," *Journal of Regional Science*, December 1972, p. 469, and K. Wieand, "Air Pollution and Property Values: A Study of the St. Louis Area," *Journal of Regional Science*, Vol. 13, April 1973, p. 91.

a. CBD Model*

$$\Delta I = 2.5 + 0.038\ \Delta T_{CBD} - 0.238\ I_{65} \quad (1)$$

(2.1) (+0.13) (-2.4)

$R^2 = 0.20$ DW = 2.04 F(2,172) = 2.06

Equation (1) was estimated using 174 traffic zones; this sample includes all zones in which the travel time to the CBD decreased during the period 1965-1970. The sign of ΔT_{CBD} is positive,† which suggests that density increases are directly related to changes in the CBD travel time; however, it should be noted that the coefficient is not statistically significant. This result does not support our hypothesis that industrial expansion varies directly with increased accessibility to the CBD.

We later estimated the model for two subsamples, the northwest and southwest portions of the SMSA,** We did this because the major northern radial route, I-70, was completed in 1961; and our travel time data for 1965 and 1970 did not capture the full impact of highway improvement in the northern region. The regression results are:

Northwest SMSA

$$\Delta I = 1.8 + 0.03\ \Delta T_{CBD} - 0.349\ I_{65} \quad (2A)$$

(2.0) (0.80) (-5.9)

$R^2 = 0.15$ DW = 2.1 F(2,83) = 3.8

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*t-statistics are shown in parentheses. Throughout this section the level of statistical significance referred to is 0.10.

†A positive relationship denotes $\frac{\partial(\Delta D)}{\partial(\Delta T)} > 0$, where D = density, T = travel time, $\Delta D = D_{70} - D_{65}$, and $\Delta T = T_{70} - T_{65}$.

**Our dividing line between north and south was State Highway 40 (see Fig. 1).

Southwest SMSA

$$\Delta I = -4.4 \quad - \quad 0.82\ \Delta T_{CBD} \quad - \quad 0.85\ I_{65}$$

$$(-3.4) \qquad (-2.4) \qquad\qquad (-6.2) \qquad\qquad (2B)$$

$$R^2 = 0.65 \qquad DW = 1.75 \qquad F(2,89) = 45.2$$

Equation (2A) displays the same relationship between ΔI and ΔT_{CBD} as Eq. (1). However, a negative (and statistically significant) coefficient was obtained for ΔT_{CBD} in Eq. (2B), which implies that changes in industrial employment density had been strongly influenced by decreasing CBD travel times in the south SMSA. The coefficient of -0.82 is statistically significant, and the equation fit ($R^2 = 0.65$) is relatively good.

The negative relationship obtained for the north SMSA implies an important feature of the urban growth process in St. Louis: although some industrial employment changes occur simultaneously with highway improvement (specifically, the case of the south SMSA for 1965-1970), there is a significant time lag before the adjustments are completed. In other words, during the second half of the decade, important increases in employment density continued to occur in the north SMSA in response to travel time changes which accrued from highway construction in the early 1960s.*

The sign and magnitude of I_{65} verifies our expectations; that is, we would predict that traffic zones with high industrial density in 1965 would demonstrate a lower growth rate than those with initially lower densities.

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*This conclusion is partially supported for the case of industrial employment by an inspection of the pattern of industrial park development during the 1960-1970 period. Of the 25 parks developed during the decade in North St. Louis County, 13 were opened after 1965. Data on opening dates of industrial parks were obtained from Holland and Wendel, *op. cit.*

b. SMSA Model

$$\Delta I = -0.83 + 0.006\Delta A(Pop) - 0.263I_{65} \quad (3)$$

$$(-0.28) \quad (1.6) \quad (-4.9)$$

$$R^2 = 0.15 \qquad DW = 1.48 \qquad F(2,161) = 2.01$$

Equation 3 was estimated using the traffic zone data for the western portion of the SMSA; $\Delta A(Pop)$ represents the change in the population accessibility index. The model thus states that changes in industrial employment density are determined by changes in accessibility to the labor force (population). As noted earlier, this specification is designed to test for the impact of changing travel times within the county as a result of the beltway construction.

Although the model fit ($R^2 = 0.15$) is poor, the signs of the independent variables are in accordance with our expectations and are statistically significant. $\Delta A(Pop)$ is a positive influence on ΔI, reflecting the importance of improved accessibility (in terms of the labor force) in the location decisions of new industry. The negative sign for I_{65} also verifies our prior expectations concerning the influence of initial employment density.

V. CONCLUSIONS

First, our analysis of land use density data for the 1965-1970 period confirmed the general trend of population and job dispersion from the city to the county reported in other studies.* The one exception to this general trend was the case of commercial employment density, which increased in the city during this period. The outer county--defined as that region west of the interstate beltway--displayed the largest relative gains in industrial and commercial employment and population density, a fact that may suggest a pattern of growth induced by construction of the interstate highway network. However, we must stress that transportation is only *one* of the many factors influencing location decisions. Thus any explanation that points to federal government highway policies as being solely or even primarily responsible for these changes is an oversimplification. Further work with improved and expanded data sources should isolate this effect more precisely.

Second, using regression analysis techniques, we tested the hypothesis that radial highway improvements which result in decreased travel times to the CBD from suburban areas are a positive influence on increases in land use density. For the case of industrial employment in the southwestern portion of the St. Louis SMSA, the hypothesis was supported by the statistical results. Our tentative conclusion is that radial routes have allowed firms to either expand or locate in regions previously beyond the urban boundary without incurring additional transportation costs to firms and markets in the city.

Third, we tested the hypothesis that construction of the beltway (resulting in increased accessibility between regions of the county) is a positive influence on increases in land density. The results for industrial employment supported the hypothesis; i.e., increases in employment density were directly related to changes in the accessibility of a region to the labor force (in this case, represented by population density).

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*See Holland and Wendel, *op. cit.*; Koepke, *op. cit.*

In sum, our analysis suggests that highway improvements have been an influence on the dispersion and location of jobs and population throughout the St. Louis region. The analysis also supports the impression that the westwardly growth of the metropolitan area is likely to continue, with the outer counties growing most rapidly. The interstate beltway system has already sparked industrial development in areas far beyond the previous suburban ring (as represented by the inner beltway). In the absence of any radical changes in the socio-economic trends of the past decade (i.e., rising incomes and the desire for increased living space), we would expect the increasing dispersion and suburbanization of population and jobs within and around St. Louis to continue.