Suburbanization of Employment and Population 1948-1975

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Analysis of data from the Censuses of Population, Manufactures, and Business indicates that during the period after World War II very little population and employment growth took place in the largest cities.

This paper presents an analysis of and empirical findings about changes in land-use patterns occurring within the 39 largest metropolitan areas during the post-war period, pertinent to the debate about alternative solutions to the urban transportation problem. Descriptive statistics on land-use trends in these areas during the periods 1948-1954 and 1954-1958 are discussed. An 11 equation econometric model is presented to explain population and employment changes within central cities and metropolitan rings for the 1954-1958 period. The model is then used to predict the land-use pattern in a typical metropolitan area during the years 1965 and 1975. The implications of the analysis and the empirical findings for the various proposed solutions to the urban transportation problem are also discussed.

• DURING the post-war period, urban transportation has become recognized as an increasingly important and difficult problem. Secular growth and migration trends are causing population to concentrate mainly in urban areas. For several decades the United States has been rapidly changing from a land of small towns and farms to one of gigantic metropolitan areas. Within these, suburban growth has been much faster than central city growth. In the post-war period this rapid growth has been accompanied by significant declines in the numbers of urban residents using public transportation facilities. For example, between 1950 and 1958 transit ridership in American cities decreased by 43 percent, from 17.2 to 9.7 billion trips per year (1). On the other hand, the number and use of private automobiles increased enormously.

The response to these transformations has been impressive. President Kennedy, for example, in a message to Congress, April 6, 1962, stated that:

> The national welfare, therefore, requires provision for good urban transportation with the proper use of private vehicles and modern mass transport to help shape as well as to preserve urban growth.

And, he requested Congressional authorization of grants for urban transportation totaling $500 million over a 3-yr period. There are also pending several ambitious rail rapid-transit plans including one in Washington, D. C. In the San Francisco-Oakland metropolitan area, voters have approved a bond issue for the financing of a 75-mi rapid-transit system having an estimated capital cost of nearly one billion dollars. The Los Angeles Metropolitan Transit Authority is ready to begin final design studies, contingent only upon obtaining adequate and low-cost financing, of a less ambitious project nicknamed "The Backbone Plan." The Los Angeles project has an estimated

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capital cost of $300,000,000 and consists of a 22.7-mi rail transit line, including 12 miles of subway. Although San Francisco and Los Angeles are the only cities having mass transit plans in such a state of readiness, proposals for new rail systems are being seriously debated in Pittsburgh and Atlanta. The National Capital Transportation agency has submitted to the President its report recommending construction of a rail transit system in Washington, D.C., at a cost of approximately $800,000,000 and a curtailment of the region's highway program (2). Moreover, Philadelphia, Boston, Chicago and New York are seeking Federal subsidies for expansion of existing rail facilities. One estimate of the next decade's capital requirements for mass transportation places them at nearly $10 billion (3). At the same time, the huge cost of urban highways is indicated by the $18 billion cost of the urban portion of the 41,000-mi Interstate System, which represents only a portion (although a large portion) of the decade's total urban highway expenditures.

As the report by the National Capital Transportation Agency proposing curtailment of Washington's highway program and substantial expansion of its public transit system indicates, highways and public mass transit are both competing and complementary Proponents of the rail solution would reverse or halt mass transit declines by making substantial improvements in transit facilities and perhaps by cutting back on construction of highway facilities. The $10 billion estimate of the next decade's public transportation capital requirements and the cost of the San Francisco and Los Angeles plans indicate the opportunity costs of the rail transit solution. If spent on further expansion of urban highways the $10 billion estimated capital costs would finance a sizable increase in the present urban interstate system. The $1 billion costs of the San Francisco-Oakland Bay plan might be used to finance many miles of urban expressway for the Bay Area. (Assuming lane-mile-costs from $0.5 to $1.0 million, between 1,000 and 2,000 lane miles could be constructed with the $1 billion, making no allowance for bridges, tunnels, and either public or private vehicles.)

Thus it is important to choose the right "mix" of these capital intensive facilities. The best mix depends to a large extent on the task confronting the local urban transportation planners. Some form of rail mass public transportation is probably best, in the sense of being most efficient or cheapest, if large volumes must be transported between high-density origins and destinations. Urban highways, with perhaps some exclusive rights-of-way for buses, may be more efficient than rail mass transit systems if low volumes and low-density origins and destinations must be served. The appropriate urban transportation investment policy is determined substantially by the spatial configuration of urban transportation demands which depends largely on the density of current and expected urban development.

If the projected increases in metropolitan populations result in increased densities and interchange volumes, considerable emphasis should be placed on rail mass-transit systems. If present urban densities are at their height and if most urban growth is to occur at low densities, emphasis should be placed on building up the highway system. If considerable uncertainty exists, a city should make an effort to emphasize flexibility so that the system can adapt to changes as they occur. In such a case, research to obtain information about future urban growth is necessary.

The debate about preferred solutions has been long and inconclusive. Assertions on both sides have been largely unsubstantiated and the evidence presented has often been contradictory. In large part this is because empirical information and evidence on urban location and development trends have been lacking.

The primary purpose of this paper is not to reach any final conclusions about alternative transportation policies or about an optimal mix of public and private transportation facilities, but to provide systematic empirical information on urban locational and development trends bearing on the appropriate mix. This will encourage and help make possible more factual and intelligent discussion of alternative transportation policies. This paper describes and evaluates locational trends common to most large metropolitan areas, not any particular metropolitan area. In this way, it is believed possible to identify the basic economic and technological forces prevailing in today's society and the commonalities of urban growth processes.

POSTWAR TRENDS IN URBAN POPULATION AND EMPLOYMENT

This section presents some descriptive statistics measuring postwar changes in the locational distribution of employment and population within the 39 largest Standard Metropolitan Statistical Areas (SMSA's). These areas are Akron, Atlanta, Baltimore, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Columbus, Dallas, Dayton, Denver, Detroit, Ft. Worth, Houston, Indianapolis, Jersey City, Kansas City, Los Angeles-Long Beach, Louisville, Memphis, Miami, Milwaukee, Minneapolis-St. Paul, Newark, New Orleans, Oklahoma City, Philadelphia, Phoenix, Pittsburgh, Portland, Rochester, St. Louis, San Antonio, San Diego, San Francisco-Oakland, Seattle, Tampa-St. Petersburg, and Washington, D. C. New York City has been excluded from the sample because of its enormous size and other unique features. For wholesaling, only 38 cities were used.

Each metropolitan area is divided into two subareas, the central city and the metropolitan ring (the SMSA minus the central city). This is a rather crude geographical breakdown. Nevertheless, a comparison of the central cities and the metropolitan rings gives a rough picture of the contrasts between developments taking place in the older higher-density and the newer lower-density parts of metropolitan areas.

Table 1 gives the mean annual percentage changes in retailing, manufacturing, wholesaling and selected services employment and in population for the central cities and metropolitan rings for the 39 SMSA's. The statistics have been calculated for the intercensal time periods: 1948-1954, 1954-1958, and 1948-1958. The raw employment data used are actual counts reported by the Census of Business and Census of Manufactures. The population data are estimates made by interpolation of population counts obtained from the 1950 and 1960 Censuses of Population. The manufacturing data are for 1947 instead of 1948.

Table 1 indicates that the metropolitan rings are growing at considerably higher rates than the central cities on the average. Although it contains no particularly surprising information, Table 1 systematically overstates central city and understates ring growth because annexations have significantly increased the size of many central cities. Corrections of both population and employment data can be made to give a rough idea of the effect of annexations and of what the growth within constant areas has been. The 1960 Census of Population provides figures for the 1960 population residing within 1950 boundaries of the central cities. Data on population annexations by the 39 central cities were obtained (4). By assuming that population changed at constant percentage rates during the period 1950-1960 within each of these cities, estimates were made of the population within 1950 boundaries in 1948, 1954 and 1958. Employment data were corrected for annexations by assuming that the percentage of employment annexed in each category was the same as the percentage of annexed population.

TABLE 1

MEAN ANNUAL PERCENTAGE CHANGES IN POPULATION AND EMPLOYMENT

Item	Central City			Metropolitan Ring		
	1948-54	1954-58	1948-58	1948-54	1954-58	1948-58
Manufacturing	3.46	0.03	2.74	9.64	4.88	9.63
Wholesaling	1.76	1.74	1.92	10.42	12.43	13.76
Retailing	0.36	1.71	1.00	4.54	9.11	7.39
Services	2.75	5.68	4.42	9.28	10.86	12.32
Population	1.80	1.50	1.80	6.44	4.60	6.60

Formally, the annexation correction for the central city is of the form:

$$E_{50i}^{cck} = E_{Li}^{cck} - \frac{\left(P_{Li}^{cc} - P_{50i}^{cc}\right)}{P_{Li}^{cc}} \left(E_{Li}^{cck}\right) \qquad (1)$$

in which E_{50i}^{cck} is the estimated employment within 1950 central city boundaries in the i-th year (i = 1948, 1954 or 1958) and for the k-th industry subgroup (k = retailing, wholesaling, selected services or manufacturing); E_{Li}^{cck} is the census employment of the k-th industry within existing legal boundaries of the central city in the i-th year; $(P_{Li}^{cc} - P_{50i}^{cc}) / P_{Li}^{cc}$ is the ratio of the difference between population in the legal and 1950 boundaries of the central city in the i-th year to the population within central city legal boundaries in the i-th year. The ring correction for annexations is identical:

$$E_{50i}^{r} = E_{Li}^{r} + \frac{\left(P_{Li}^{cc} - P_{50i}^{cc}\right)}{P_{Li}^{cc}} \left(E_{Li}^{cc}\right) \qquad (2)$$

except the annexation correction is added instead of subtracted from the census employment statistic. As a side condition annexation corrections from the ring to the

TABLE 2

MEAN ANNUAL PERCENTAGE CHANGES IN POPULATION AND EMPLOYMENT, CORRECTED FOR ANNEXATIONS

Item	Central City			Metropolitan Ring		
	1948-54	1954-58	1948-58	1948-54	1954-58	1948-58
Manufacturing	1.9	-1.7	-0.6	13.2	7.0	15.0
Wholesaling	0.9	-0.2	0.7	25.4	16.8	29.4
Retailing	-0.6	0.1	-0.4	11.5	13.6	16.0
Services	1.6	3.9	2.7	18.2	16.8	24.4
Population	0.2	0.1	0.2	8.8	6.4	9.4

TABLE 3

MEAN ANNUAL CHANGES IN POPULATION AND EMPLOYMENT

Item	Central City			Metropolitan Ring		
	1948-54	1954-58	1948-58	1948-54	1954-58	1948-58
Manufacturing	477	-1,851	-454	2,237	564	1,568
Wholesaling	191	224	204	307	501	382
Retailing	-263	454	24	756	1,662	1,118
Services	452	1,002	672	399	611	483
Population (legal)	4,470	5,840	5,018	25,632	28,929	26,951

central city are not permitted to exceed one-half of the employment within the ring for a given employment activity.

The corrected data in Table 2 indicate that percentage changes calculated on the basis of the raw data seriously overstate the central city growth and seriously understate ring growth. Indeed, the corrected data actually show a percentage decline in manufacturing employment during the 1954-1958 period in the 39 central cities. Service employment is the only category with substantial central city gains. Moreover since the raw data indicate that the smaller central cities are experiencing more rapid growth than the larger ones, it is quite possible for the mean percentage change to be positive even though the 39 central cities might actually, on the average, experience declines in their levels of population and employment.

To investigate this possibility, Table 3 gives changes in population and employment during the three time periods in question. Increases in employment and population were greater in rings than in central cities in all categories except services. The differences between central city and ring growth are particularly significant for population and for manufacturing employment. Huge population increases are occurring in the rings, while the increases in the central city population are modest. Ring manufacturing employment increased in both periods, while the central cities have suffered large losses in manufacturing employment since 1954. Even so, the central city increases are overstated and ring increases understated, because of annexations.

Table 4 presents corrected changes in population and employment. As in the case of the percentage changes when corrected for annexations, the findings for the changes in Table 3 are magnified; only services exhibit significant central city growth—approximately 800 workers per year during the 1954-1958 period (Table 4). During the 1954-1958 period, large losses occurred in central city manufacturing employment, but employment in both wholesaling and retailing remained nearly constant. Central city population increases in both periods were very small, only about 300 persons per year. If Los Angeles and San Diego are deleted from the sample, the average change in central city population is actually negative. These two rapidly growing cities bias the mean upward; here rapid central city growth is attributable to the vast amounts of vacant land within central city boundaries, which absorbed a large proportion of the tremendous population increases occurring during the postwar period.

Further understanding of central city employment and population changes can be gained by examining the numbers of central cities which experienced declines in population and various categories of employment during each period. The pervasiveness of these central city declines is indicated in Table 5, which shows the number of declining central cities and rings in each employment and population classification. The frequency and widespread character of central city declines are indicated by the fact that during the first (1948-1954) period, retailing employment declined in 26 or two-

TABLE 4

MEAN ANNUAL CHANGES IN POPULATION AND EMPLOYMENT CORRECTED FOR ANNEXATIONS

Item	Central City			Metropolitan Ring		
	1948-54	1954-58	1948-58	1948-54	1954-58	1948-58
Manufacturing	159	-2,502	-809	2,168	1,214	1,821
Wholesaling	86	-2	51	415	739	544
Retailing	-479	6	-285	972	2,110	1,427
Services	373	786	538	479	827	618
Population	290	308	297	29,812	34,462	31,672
Population annexations	4,180	5,532	4,721	-4,180	-5,532	-4,721

TABLE 5

NUMBER OF METROPOLITAN AREAS HAVING EMPLOYMENT DECLINES IN CENTRAL CITY AND RING BY INDUSTRY GROUP CORRECTED FOR ANNEXATIONS

Item	Central City			Metropolitan Ring		
	1954-48	1958-54	1958-48	1954-48	1958-54	1958-48
Manufacturing	15	29	24	6	9	4
Wholesaling	15	18	13	3	0	1
Retailing	26	17	30	4	0	0
Services	7	4	3	1	1	0
Population (legal)	17	15	16	1	2	2
Population (1950)	21	21	21	1	1	1

thirds of the 39 central cities; manufacturing employment declined in 15 during the first period and in all but 10 during the second period; and wholesaling employment declined in 15 of 38 central cities during the first period; and in 3 more during the second. Some of the declines occurring in the second period may have been caused by the business cycle. This is particularly true for manufacturing. Only selected services, buoyed up by secular increases, avoided persistent central city declines. Selected services employment declined in 7 central cities in the first period and in only 4 during the second.

The number of population declines is also large; for the entire 1948 to 1958 period, 21 central cities decreased in population using 1950 boundaries and only 5 fewer had declines using legal boundaries.

The metropolitan ring did not escape declines entirely. The lessening importance of manufacturing employment in the economy, combined with especially large declines in a number of metropolitan areas, resulted in 6 ring manufacturing employment declines during the first period and 9 during the second.

AN ECONOMETRIC MODEL

The data indicate that central city manufacturing employment decreased on the average for the 39 metropolitan areas between 1954 and 1958, and that other types of central city employment, services excepted, also decreased in a large number of these cities. Central city population appears to have grown very little, and has actually declined in a majority of urban areas, i.e., 21 out of 39. One cannot help but wonder at the causal structure bringing about these changes. Econometric models provide a systematic and reasonably efficient way to study urban structure. An 11 equation recursive model has been formulated to assist in understanding the changes in population and employment currently taking place in American urban areas. This model includes 9 behavioral and 2 definitional equations. The parameters of the equation system are estimated from data for the period 1954-1958, using least squares regression techniques (5). The model (Fig. 1) includes 11 endogenous variables determined within the equation system, and 5 exogenous ones determined outside the system. The variables are as follows:

M_g^c = yearly changes in manufacturing employment in central cities of growing areas, i.e., defined as SMSA's having increases in manufacturing employment during 1954-1958.

M_d^c = yearly changes in central city manufacturing employment of declining areas, i.e., SMSA's with declines in manufacturing employment.

M^r = yearly changes in ring manufacturing employment in all areas.

P^c = yearly changes in central city population within constant 1954 boundaries.

P^r = yearly changes in ring population within constant 1954 boundaries.

W^c = yearly changes in central city wholesaling employment.

W^r = yearly changes in ring wholesaling employment.

R^c = yearly changes in central city retailing employment.

R^r = yearly changes in ring retailing employment.

S^c = yearly changes in central city services employment.

S^r = yearly changes in ring services employment.

M_g^s = yearly changes in manufacturing employment in growing SMSA's.

M_d^s = yearly changes in manufacturing employment in declining SMSA's.
P^s = yearly changes in population, all SMSA's.
V = the ratios of central city vacant land area to total central city land area.
A = annual annexations of population from the ring to the central city.

An assumption crucial to the structure of the model (Fig. 1) is that metropolitan area changes in population and manufacturing employment, the latter representing the most important form of base employment in most urban areas, are simultaneously determined.

Base employment refers to terminology used in economic base studies. Base employment may be thought of as the exogenous variable in an economic base model. It differs from nonbasic employment in that its output is exported and thus provides the area with income. Nonbasic employment or service employment is defined as that employment which provides goods and services for consumption within the area. For some time an effort has been made to estimate and evaluate the simultaneity problem between population and base employment. The treatment here is evidence that the results of this research have not yet been satisfactory and changes in both are treated as exogenous to the model.

Given changes in SMSA manufacturing employment and population, and the ratio of central city vacant land area to total land area, the yearly changes in central city population and manufacturing, wholesaling, retailing and services employment can be obtained using the model. The model can logically be separated into three parts or stages, and thus requires three discrete steps for solution and use as a predictive mechanism.[1]

Stage 1

Changes in SMSA manufacturing employment in declining areas are used to determine changes in central city manufacturing employment for SMSA's of declining manufacturing employment. Changes in SMSA manufacturing employment in growing areas and the vacant land ratios for growing areas are used to determine central city changes in manufacturing for SMSA's of increasing manufacturing employment. The central city changes in manufacturing employment for growing areas and those for declining areas are combined to obtain a weighted average of the central city manufacturing employment changes in both declining and growing areas. The weights used are the numbers of the areas in each class, divided by the total number of areas in the sample. The weighted average changes in central city manufacturing employment are then subtracted from the changes in SMSA manufacturing to obtain the change in ring manufacturing employment. The procedure of dividing SMSA's into growing and declining areas for the central city manufacturing equation requires some elaboration. This procedure is used because of an asymmetry for the manufacturing equation and the theory on which it is based. The vacant land variable is a constraint variable limiting the size and rate of central city manufacturing increases. The hypothesis assumed is that if significant tracts of vacant land within central cities exist, a sizable proportion

[1] The model's 9 stochastic and 2 definitional equations together with the percentage of the dependent variables' total variances explained are as follows (all variables are statistically significant at the 5 percent level): $M_g^c = 1.510VM_g^s + 0.061A - 470$, ($R^2 = 0.70$); $M_d^c = 0.623M_d^s + 0.105A - 992$, ($R^2 = 0.90$); $M^r = M^s - M^c$; $P^c = 0.453VP^s + 0.650M^c - 2776$, ($R^2 = 0.50$); $P^r = P^s - P^c$; $W^c = 0.032P^c + 0.022A + 91$, ($R^2 = 0.62$); $R^c = 0.077P^c + 0.027A + 283$, ($R^2 = .65$); $S^c = 0.031P^c + 0.023P^r + 0.022A + 201$, ($R^2 = 0.77$); $W^r = 0.017P^r - 0.018A - 31$, ($R^2 = 0.56$); $R^r = 0.053P^r - 0.049A - 5$, ($R^2 = 0.82$); $S^r = 0.027P^r - 0.016A - 297$, ($R^2 = 0.79$).

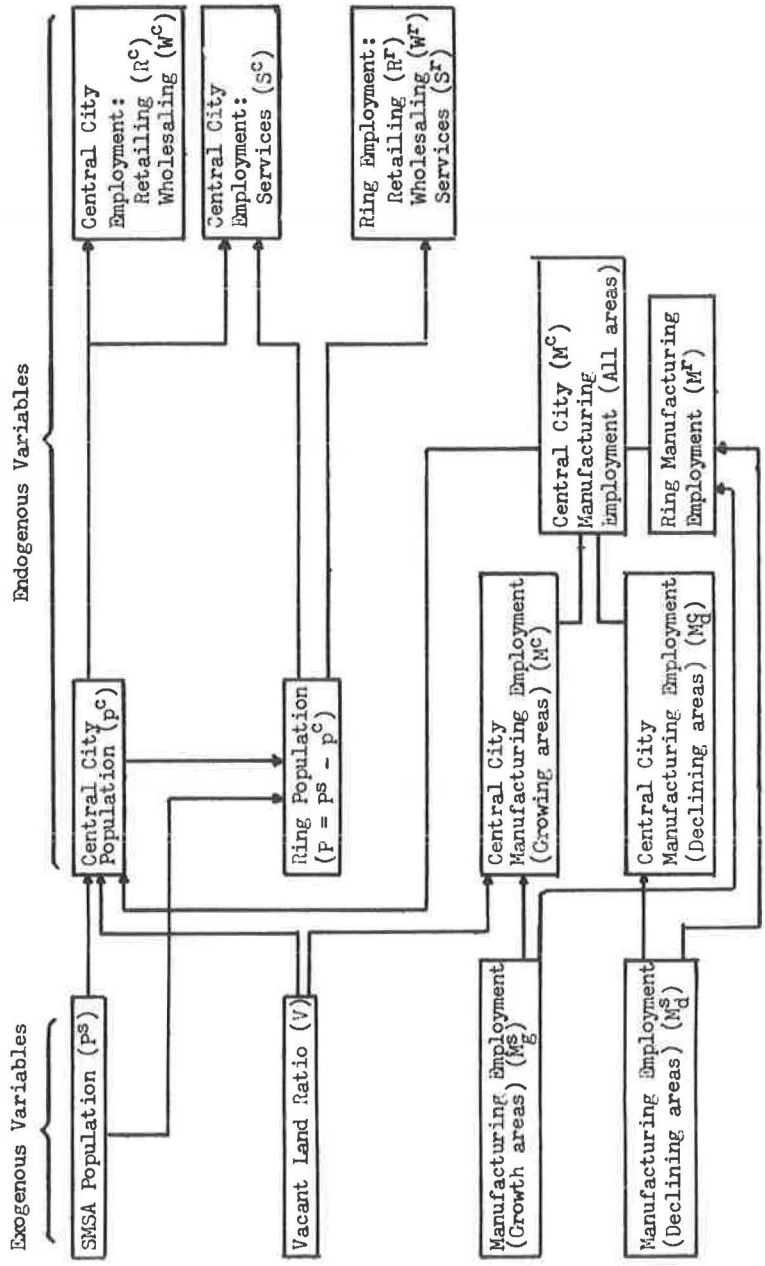

Figure 1. A model of population and employment changes.

of new manufacturing will locate there; if there is little vacant land, new manufacturing will locate on vacant land in the ring just adjacent to the central city. As this constraint is only meaningful in those areas where there are manufacturing employment increases, separate equations are estimated for increasing and decreasing areas.

Stage 2

The central city population change is obtained using the change in central city manufacturing employment (determined in Stage 1), and the predetermined values of the vacant land ratio and change in metropolitan area population variables. Ring population change is obtained by subtracting the central city population change from the metropolitan area population change. Because all except one of the metropolitan areas included in the sample increased in population in the period 1954-1958, the asymmetry characteristic of the manufacturing equation is not a problem in the population equation. Therefore, a single population change equation is used for all areas.

Stage 3

Changes in central city and ring retailing, wholesaling and services employments are obtained solely from variables determined within the model. Predictions of central city wholesaling and retailing employment changes depend on only central city population changes, while changes in service employment require as explanatory variables both central city and ring population changes. Both the central city and ring population change variables have positive and statistically significant regression coefficients in the central city selected services equation, although the coefficient of the change in ring population is somewhat smaller than that for central city population. This was expected, because people living in the ring will not purchase services located in the central city as often as those living within the city limits.

Changes in ring retailing, wholesaling and selected services employments are obtained using only ring population changes. Valid relationships between retailing and services employments and population are more probable than between wholesaling and population. It is assumed that the change in population is a fairly good proxy for changes in the distribution of the wholesalers' markets and thus a good wholesaling demand proxy. But the cause of wholesaling employment's rapid growth in the ring may be the lessening importance of centrally-located freight facilities resulting from more widespread use of trucks for moving freight. Consequently, no one should be surprised that the equations for wholesaling explain a smaller proportion of the total variation in the dependent variables than either the retailing or selected service trades equations.

PROJECTION AND PREDICTION

Having clarified to some extent the nature and causal structure of the model, it might be illuminating to use the model to predict what the typical metropolitan area would look like in 1965 and 1975 using various time paths of the exogenous variables. This procedure is carried out in two steps. Projections of the behavior of the exogenous variables over time are made. Then the changes taking place in the dependent variables during the time periods 1954-1965 and 1954-1975 are obtained by intergrating the model's equations with respect to time and evaluating the integrals.

To provide a basis for comparison, characteristics of an average or representative urban area in 1954 have been calculated. Table 6, giving the mean employment and population levels in both central cities and metropolitan rings, provides a description of a represntative urban area in 1954.

Manufacturing employment, which numerically outranks wholesaling, retailing and services employments combined, is clearly, in these terms, the most important type of employment in both central cities and metropolitan rings. Also, the growing areas seem to have fewer manufacturing employees than do declining ones. This is in part because the growing areas are, on the average, smaller. In addition, those metropolitan areas with very large proportions of manufacturing employment are strongly

TABLE 6

MEAN LEVELS OF EMPLOYMENT AND POPULATION, 1954

Item	Central City	Metropolitan Ring
Manufacturing (total)	98,718	70,918
Manufacturing (growing areas)	59,373	52,192
Manufacturing (declining areas)	132,442	86,969
Wholesaling	25,909	5,148
Retailing	48,753	23,626
Services	20,288	6,726
Total employment[a]	193,668	106,418
Population	724,315	656,052

[a]Does not take into account types of employment not included in the Censuses of Business and Manufactures such as construction, transportation and finance.

TABLE 7

PROJECTED ANNUAL CHANGES IN THE INDEPENDENT VARIABLES

Variable	Low Projection	High Projection (%)
Manufacturing employment:		
Growing areas	+3,083	+5.0
Declining areas	-1.1%	-0.5
Population	++2.6%	+3.5
Vacant land ratio	-5.9%	-5.9

oriented toward heavy manufacturing, which has declined secularly in the postwar period.

Table 7 gives the high and low sets of independent variable projections used for this paper. The low projections correspond with what actually happened, on the average, during the years 1954-1958. Since 1958 was a year of moderately severe recession, a higher set of projections incorporating more favorable developments in SMSA population and manufacturing employment is also included.

The projections of the vacant land variables are the same for both sets. The 5.9 percent annual rate of vacant land absorption is the mean obtained from a sample of 18 central cities during the postwar period.

Initial values of the vacant land variable are 0.271 in the manufacturing equation and 0.219 in the population equation. (These figures were obtained from land-use data collected by the authors from the 39 central cities included in the study.) A zero annexation level has been assumed when making the predictions, so the latter will refer to constant 1954 areas. Table 8 gives the predictions of cumulative changes over the periods 1954-1965 and 1954-1975.

Significant central city declines in manufacturing employment and population occur using the low values of the exogenous independent variables. The former are offset by increases in wholesaling, retailing and especially services so that total central city employment increases slightly. If the high set of values for the exogenous variables in each year is used, total employment consequently enjoys significant increases, as gains in the three employment categories again offset the moderate declines in manufacturing employment. Growth of the metropolitan rings is rapid using either the high or low values of the exogenous variables. The lower set of projections indicates small decreases in central city population, while the higher set entails slight gains. These

TABLE 8

PREDICTIONS OF CUMULATIVE CHANGES IN THE ENDOGENOUS VARIABLES IN BOTH CENTRAL CITY AND METROPOLITAN RING

Variable	Low Projections		High Projections	
	1954-1965	1954-1975	1954-1965	1954-1975
	(a) Central City			
Manufacturing:				
Total	-12,568	-25,084	-5,238	-10,429
Growing areas	5,052	5,333	7,734	13,519
Declining areas	-26,273	-48,742	-15,327	-29,056
Wholesaling	803	1,240	1,385	2,358
Retailing	2,638	4,328	4,037	7,019
Services	12,639	27,034	17,229	38,780
Total employment	3,512	7,518	17,413	37,728
Population	-6,174	-20,974	12,002	13,971
	(b) Metropolitan Ring			
Manufacturing:				
Total	13,536	28,210	34,692	88,873
Growing areas	28,861	59,410	74,824	193,992
Declining areas	1,617	3,943	3,479	7,115
Wholesaling	7,508	16,691	10,484	24,572
Retailing	24,415	53,961	33,694	78,532
Services	9,199	21,306	13,926	33,,824
Total employment	54,658	120,168	92,796	225,801
Population	461,706	1,020,117	636,770	1,483,727

TABLE 9

PREDICTED PERCENTAGE CHANGES IN EMPLOYMENT AND POPULATION IN BOTH CENTRAL CITY AND METROPOLITAN RING

Variable	Low Projections		High Projections	
	1954-1965	1954-1975	1954-1965	1954-1975
	(a) Central City			
Manufacturing:				
Total	-12.7	-25.4	-5.3	-10.6
Growing areas	8.5	9.0	13.0	22.8
Declining areas	-19.8	-36.8	-11.6	-21.9
Wholesaling	3.1	4.8	5.3	9.1
Retailing	5.4	8.9	8.3	14.4
Services	62.3	133.2	84.9	191.1
Total Employment	1.8	3.9	9.0	19.5
Population	-0.8	-2.9	1.7	1.9
	(b) Metropolitan Ring			
Manufacturing:				
Total	19.1	39.8	48.9	125.3
Growing areas	55.3	113.8	143.3	371.7
Declining areas	1.8	4.5	4.0	8.2
Wholesaling	145.8	324.2	203.7	477.3
Retailing	103.3	228.4	142.6	332.4
Services	136.8	316.8	207.0	502.9
Total employment	51.4	112.9	87.2	212.2
Population	70.4	155.5	97.1	226.2

TABLE 10

HIGH AND LOW PREDICTIONS OF CENTRAL CITY AND RING EMPLOYMENT IN 1965 AND 1975 AND THE PERCENTAGE LOCATED IN THE RING 1954 BOUNDARIES

Area	Low			High	
	1954	1965	1975	1965	1975
		(a) Population			
Central city	724,315	718,141	703,341	736,317	738,286
Ring	656,052	1,117,758	1,676,169	1,292,822	2,139,779
SMSA	1,380,368	1,835,899	2,379,510	2,029,140	2,878,066
Percent in ring	47.5	60.8	70.4	63.7	74.3
		(b) Total Employment[a]			
Central city	193,668	197,180	201,186	211,081	231,396
Ring	106,418	157,076	226,586	199,214	332,219
SMSA	300,068	354,256	427,772	410,277	563,597
Percent in ring	35.5	44.3	53.0	48.6	58.9

[a]Manufacturing, wholesaling, retailing and selected services.

results seem to indicate that central city population may remain relatively stable in the near future. As in the case of employment, population growth in the ring is very rapid.

Table 9 permits comparison of the percentage rates of change in central cities and rings for 1954-65 and 1954-75. When both sets of the exogenous variables are used, central city total employment for the categories included in this study (representing approximately 60 percent of total non-agricultural employment) is estimated to increase considerably faster than central city population. Evidently the central city is more attractive as a place of business than as a place of residence. Again, ring growth is very rapid for population and all four categories of employment.

Table 10 gives the high and low predicted levels of total employment and population in 1965 and 1975 and the percentage of population located in the ring in each year. According to predictions, by 1965 at least 60 percent of the population of these 39 SMSA's will reside outside of the 1954 central city boundaries. In the same year, more than 44 percent of employment should be located there. By the year 1975, it is estimated that more than 70 percent of the population and more than 50 percent of total employment will reside outside of 1954 city boundaries. Thus, SMSA population and employment will become increasingly concentrated in the metropolitan ring.

TECHNOLOGICAL AND SOCIOLOGICAL TRENDS UNDERLYING THE MODEL

The model was based on the assumption that locational changes in manufacturing employment are the driving force behind shifts in land-use patterns that took place during 1948-1958. Today it is generally accepted that new production techniques based on continuous process methods and generally requiring single-story plants of large floor area are among the principal causes of manufacturing suburbanization. Single-story plants require large sites which are not often available in the central city (6). In addition, the growing need for parking space generated by the increasing percentage of workers using the automobile for journeys to work further increases industrial land requirements. There is just not enough vacant land in the central cities to even support

present levels of manufacturing activity, let alone increase them. Furthermore, land, in part because of demolition and assembly costs, is much cheaper in the suburbs (6). Because many raw materials and finished products are now transported by motor truck, the bulk of light manufacturing is no longer forced to locate near railroad lines and yards. The same can be said for wholesaling.

Two different trends in population location, both leading toward suburbanization, stand out most clearly. The majority of the middle class seem to prefer low-density suburban living to crowded city life. Vacant land zoned for single-family residences has virtually disappeared in most central cities leaving room for expansion only in the suburbs. It is significant that an increasing proportion of city dwellers is composed of minority groups who are forced to live there either because of discrimination or low incomes. (The mean ratio of non-white to total population in the 39 central cities increased from 0.135 to 0.186 between 1950 and 1960.) People also prefer to live reasonably near their places of employment. Consequently, resident population follows manufacturing and other employment from the central cities to the suburbs. Wholesaling and retailing follow population in order to remain near their customers. The sequence of movement is likely to be manufacturing employment, population, retailing, and wholesaling. The latter probably does not move into an area until retailing is well established there. Only specialized kinds of services depending on customers from the entire metropolitan area find it convenient to locate near the city center or point of maximum access.

THE MODEL AS A FORECASTING TOOL

Before discussing the significance of these predictions for urban transportation policy and planning, there are some additional words of caution and qualification about the model. The predictions for 1965 and 1975 are obtained using constant parameters estimated from empirical information for only a single 4-yr period 1954-1958. Significant parameter shifts would invalidate or at least increase the error of the predictions. The extent to which the parameters would be expected to exhibit secular stability depends in large part on the extent to which the model includes structural relationships. The simple model presented in this paper obviously falls far short of a complete structural pattern of urban development. Still the model does have some structural characteristics. For example, the central city manufacturing and population equations based on the capacity theory of urban development do represent a beginning in terms of a more complete structural model. It is desired to construct an urban development model including the largest possible amount of structure.

The greatest single impediment to incorporating more structure into the models is the lack of data pertaining to what are thought to be the ultimate structural variables. Although the quality and quantity of data for urban areas have improved substantially in recent years, many gaps still exist. Growing awareness of urban development problems has led to the preparation and publication of an ever increasing quantity of statistical data on urban areas in a form that makes possible research of the type presented here. The 1960 Census of Population, for example, is much more useful for analysis of these problems than any previous edition. For the first time, census enumerators obtained information on the location of household members' workplaces as well as each worker's usual journey-to-work mode of transportation. Analysis of the wealth of information available from this new source will substantially enhance understanding of urban development and the interrelationships between urban development and urban transportation. Although the Census Bureau should be given the credit for these very large improvements in the 1960 census, it is desirable to expand and further develop this line of exploration. In the next census they should be encouraged to reduce the level of aggregation of the workplace data even further. Although the analysis presented here is a prima facia case for the proposition that highly aggregative data can be extremely useful and informative regarding metropolitan change, it suggests underutilizing existing sources of published information. It also suggests the tremendous gain that would be possible from greater geographic disaggregation.

As pointed out previously, the greatest weakness of the data used here is its relatively high degree of geographic aggregation; most of the statistics refer to central cities or to metropolitan rings. Thus, exact changes in employment and population levels within subareas of the central city and ring of any particular SMSA cannot be specified. This is less of a disadvantage for the cross-sectional analysis of several urban areas than if these changes for a single urban area were being described and analyzed. The metropolitan areas in the sample differ substantially in their population levels and characteristics, employment levels and distributions, growth rates, ratio of ring to central city area, etc. These differences between central city and ring characteristics and size make it possible to infer much about urban growth processes in both areas. This is particularly true of the results obtained using the more sophisticated multivariate statistical techniques. For the statistical analysis, the size of the geographic areas or the fact that they are not especially delineated is less important than whether the geographic areas differ or have significant statistical variation in the dependent and independent variables used. Geographic disaggregation only provides more information if it increases the homogeniety of the subarea and/or increases the variation between subareas. This is usually, but not always, the result of greater disaggregation.

The model's parameters for the 1954-1958 period rather than 1948-1954 were estimated because the earlier period contained too many disturbances and was too greatly affected by postwar adjustments to provide meaningful parameter estimates. This conclusion is strengthened by the fact that the results obtained for the first period, in estimating these and other relationships, are much inferior to those obtained for the second, i.e., the regression coefficients have less statistical reliability and the equations explain a smaller proportion of total variance.

The time paths assumed for the exogenous variables may be unrealistic. The estimate of the change in SMSA manufacturing employment, for example, may be too low or too high for use in a long-range projection of this kind. However, the projections of the independent variables were made wide enough apart so reality should lie somewhere in between for most of the 39 SMSA's. The predictions should be considered limits on what is likely to happen rather than exact forecasts for any specific city.

Another shortcoming of the model is that it does not include all types of employment. Construction, transportation, public utilities, finance, insurance, real estate, government, and a number of service trades (altogether about 40 percent of the civilian non-agricultural labor force), are not included because the necessary data are not available. Proprietors of unincorporated enterprises (especially important in retailing and the service trades) are also excluded from the model. It is possible that inclusion of these omitted employment groups might drastically change the picture of urban development suggested by the model's predictions and by the empirical data in Tables 1 through 5. Consequently, the empirical findings of this paper should be evaluated with these shortcomings in mind.

If these omitted employment groups are considered, however, only finance, insurance, some federal and state government employment, and some business services would, on the basis of other information, seem to be groups for which much different locational trends would be expected. Local government employment is nearly as much, or more, population oriented than retailing, as is a considerable portion of federal and state government employment, i.e., the post office, the social security administration, the department of motor vehicles, etc. Construction employment would be located where new construction occurs—predominantly in the new fringe areas. Much public utility and transportation employment is also population oriented. The greater use of motor trucks, piggy-backing, the rapid suburbanization of wholesaling and manufacturing, and finally the expansion of air transportation are all trends which suggest a rapid suburbanization of employment in intercity transportation.

The model is only a crude approximation and considerable extension and refinement of it will be necessary before it provides a highly accurate and reliable picture of the future development of urban areas.

Despite its limitations, the model suggests several significant trends. It demonstrates that the absolute levels of manufacturing employment and population in the

central cities of slowly growing SMSA's are likely to decrease over time. Moreover, it exhibits the fact that very large increases in metropolitan population and employment are consistent with only moderate increases and perhaps even declines in central city population and employment.

SUMMARY

A considerable amount of empirical information bearing on the redistribution of employment and population has been presented. This information indicates that fundamental changes in the distribution of these categories have occurred during the post-war period. The empirical findings can be summarized by stating that the observed trends strongly indicate rapid growth in the levels of employment and population in the metropolitan ring and only slow growth in the central city. If the trends of recent decades persist, tomorrow's urban areas will have a considerably different appearance from those of the past. Metropolitan densities will become more uniform since growth in the ring is rapid compared to the central city.

Automation, continuous processing and other mass production techniques have tended to make outlying locations where cheap sites may be obtained superior to more central locations for the construction of the requisite one-level manufacturing plants. By the more widespread use of motor trucks, all but a few freight intensive employment activities have been freed from locations near rail lines, spurs, or deep water. Shifts in the composition of national output towards services and other non-manufactured goods have meant that less employment is freight oriented.

Increases in per capita incomes, improved credit availability, and the availability of a relatively cheap and ubiquitous mode of individual transportation have encouraged and made possible the consumption of low-density residential services by larger numbers of urban households. The evidence is substantial that many urban households with school-age children prefer the privacy and other amenities provided by single-family and other low-density forms of residential development and are willing to devote a larger portion of their budgets to their purchase.

Nevertheless, the predictions in Tables 8 and 9 indicate that in the future, employment in the central cities will increase faster than population. This implies that more journeys to work will be made between the central city and metropolitan ring. Consequently, the flow of traffic between these areas is likely to become heavier in all but the few slowest growing SMSA's.

Unfortunately, the analysis does not tell whether the increases will occur in the fringe areas or the CBD. In the former case, increased highway construction is likely to offer the best solution to the urban transportation problem. However, if there is considerable expansion of employment near and in the CBD, mass transit systems become more attractive. Clearly, more research needs to be done before the best mix of transportation facilities can be specified.

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