INTERSTATE HIGHWAYS AND THE GROWTH AND DISTRIBUTION OF POPULATION[1]

Robert A. Bohm[2] and David A. Patterson[3]

Introduction

The relationship between improved transportation facilities and regional economic growth is generally believed to be strong and positive. With the exception of some quantitative historians [5, 8], economists and geographers agree with the conventional wisdom that the canals, railroads and highways all contributed substantially to U. S. economic development. Further support for this view has been provided by a large volume of state and federal government studies that purport to show a positive relationship between new and better highways and economic growth [2, 3, 6, 7, 12, 15, 20].

In addition to the economic effects of improved transport systems, many observers also predict that population movements, and thus inter-regional differences in population growth, might also be influenced by more efficient transportation. Brian Berry argues that better roads, and then the automobile, enabled the rural population to bypass lower level market centers (small central places) and to journey to the larger centers where chain store services are available [1, pp 114-5]. The net result has been a population decline in the very small places beyond that associated with the mechanization of agriculture. "Before 1930 hamlets with populations of 100 or less were declining; thereafter, as centralization of functions in higher levels of the hierarchy progressed, the general decline embraced villages with population of less than 500" [1, p 115].

Of course, the relatively recent decentralization trend of major industries out of the central cities and into the suburbs and out of the older more mature northern states and into the previously less industrialized southern states, has also had an effect on relative rates of population growth, more or less reversing the previous out-migration from the southern region. Industrial location theorists as well as empiricists tend to place transportation costs well up on the list of important locational considerations [4, 13, 14]. Hence, improvements in highways in general, and the interstate highway system in particular, should have affected the location of economic activity and hence the distribution of population.

In spite of the weight of theory and of empirical evidence (albeit relatively unsophisticated in the case of the empirical support), there are some who have questioned the real value of transportation improvements as a stimulus to real economic growth. Fogel and Cautner [5, 8] have both presented arguments that minimize the influence of the early railroads and canal systems. With specific reference to the interstate highway system, Friedlaender argues that "since all of the centers of production ...are already connected by an extensive network of highways and rail facilities, it seems unlikely that the...system will trigger sizable investments that would not have occurred in its absence" [9, p 64]. These authors would appear to be supporting the contention that the interstate highway system merely serves to connect already growing urban centers. According to this line of reasoning, current rates of local economic and demographic change are determined in the main by past rates of change.

The impact of highway system improvements on economic development and on inter- and intra-regional population distribution is of more than academic interest. Federal Government policy makers and others are currently expressing an interest in a policy of urban decentralization. Under our political system a decentralization policy can only be accomplished indirectly through the manipulation of a relatively small number of policy variables. Thus the possible role of the interstate system in the concentration or dispersal of population and economic activity is an empirical question of policy significance, at least to the extent that highway location is a policy variable.

The interstate highway system was begun in 1957. By the end of 1968 nearly two-thirds of the systems' planned mileage was open to traffic. The effect of this new highway system on the population growth of counties and on the intra-regional distribution of population is the subject of our analysis.

In a general sense, any change that lowers the cost of producing and distributing a product can be a source of economic growth. If the cost reduction is differentially distributed geographically, then the growth effects should be likewise distributed. That is, the cost reduction will cause some geographic areas to grow more rapidly than those areas not sharing in the cost saving. We might expect this differential growth to be composed of two parts:

(1) Net new growth that would not have taken place in the absence of the significant cost saving, and

(2) Transfer effects which can be either:
  a. Replacement of already existing or planned economic activity; e.g., a shift in the locational pattern of industries as firms move from their previous locations or expand in different ones in an attempt to realize locationally determined cost savings.

  b. Use of resources otherwise employed; e.g., land shifted from agricultural to industrial use.

Thus, a portion of an area's growth can be described as "new," or growth that would not otherwise have taken place at that time, while the balance represents a "transplanted" growth, i.e., a redistribution of activity that would normally have taken place elsewhere.

The growth that results from a cost saving also may induce further growth to the extent that new concentrations of industry and population provide new supplies of material and labor as well as new markets for output. As before, a portion of this growth may be described as "net new growth," developing, in this case, out of the external economies associated with the first-round growth effects. And, a portion of the growing area's change will reflect transfers, for example, a relative decline elsewhere as population and industry shift to the places offering lowered cost or increased marketing opportunities.

An interstate highway should have the effect of lowering the cost of transportation, possibly changing the distribution of feasible locations. Whether or not the new set of locations is sufficiently attractive to encourage net new growth or to force a transfer depends on whether the cost reduction is sufficiently large to offset locational inertia. Only a small number of industries, such as textiles and some assembly operations are described as "footloose" [13]. For most industries, the perceived cost of a move is enough to yield a high degree of locational stability. The degree of competition perceived by the individual firm is also a factor conditioning its need to respond to marginal changes in locational advantage.

Another factor affecting the response of firms to lowered transportation cost must be the extent of external economies at various location alternatives. These may change over time due, for instance, to changes in the structure of the labor force, to the presence of complementary firms and to the availability of services. Thus, some firms will have a lagged response to changes in the optimal location due to changes in transport cost.

In general, we would expect regional changes in economic activity to be reflected in corresponding regional population changes. Studies have recorded instances of employees commuting to work very long distances, as far as 60 miles and more [3, pp 65-68]. However, other studies support the view that employees' transportation cost is an important variable in the choice of residence decision [16, 18]. Thus, while granting the possibility of a lagged response, we would expect regional shifts in industrial location to be accompanied by shifts in the distribution of population within and among regions.

If the interstate highway system has merely served to connect already growing places without markedly shifting the pattern of optimal industrial locations, the effects of interstate location on county population change should have been negligible over the 1960 to 1970 decade. On the other hand, if the interstates have lowered transport costs sufficiently to generate net new growth and/or transfer effects as defined above, population changes over the decade should reflect this phenomenon. That is, interstate highway location should result in changes in county population growth that are independent of past population changes.

The Model

In this analysis, the process of county population growth is assumed to be largely autoregressive in nature. In other words, county population change from 1960 to 1970 is primarily determined by population change in previous decades. Specific county characteristics, such as the existence or nonexistence of an interstate highway, will merely lead to deviations about the growth trend.

The model may be stated as follows:

$$\Delta P_t = \alpha + \beta_1 \Delta P_{t-1} + \beta_2 \Delta P_{t-2} + bX_t + \epsilon_t \quad (1)$$

where county population change during the current period, ΔP_t, is expressed as a function of population change in previous time periods, e.g., t-1, t-2, etc. A matrix of county specific parameters is shown as X_t, and ϵ_t is a random disturbance variable which is assumed to be [4] distributed independently of ΔP_{t-1}, ΔP_{t-2}, etc. [11, pp 272-4]. In order to capture the influence of interstate highway location on county population change 1960-70, four dummy variables are included in the analysis. These variables are:

IS = 1 for all counties in which an interstate highway was completed by 1968, 0 otherwise;
ISI = 1 for all counties containing an intersection of two or more interstate highways by 1968, 0 otherwise;
ISA = 1 for all counties adjacent to IS counties, 0 otherwise;
ISIA = 1 for all counties adjacent to ISI counties, 0 otherwise.

The expected sign for all four variables is positive. It is also expected that the IS and ISI variables will have a much stronger influence on population change than the two adjacent specifications. In some instances, both the IS and ISA variables and the ISI and ISIA variables are combined. Values for all of these variables were obtained by inspection of the 1969 Rand McNally Road Atlas which included the status of the interstate system at the end of 1968[5] [17]. Our assumption is that completions after that date would have little impact on the population changes shown in the 1970 Census.

Three additional variables are included in the analysis. These variables cover the degree of urbanization of a county (URBAN), the county's Standard Metropolitan Statistical Area designation (SMSA), and whether or not it is adjacent to such a county (ASMSA). The SMSA designation is used to control for metropolitan-nonmetropolitan differences among counties. Previous analysis of 1960 Census data revealed significant differences between these two groups in county population change for the period 1950-60 [25]. Except for counties composed entirely of large central cities, metropolitan county growth was considerably greater than that of nonmetropolitan counties. The SMSA dummy variable is included to pick up a possible continuation of this dichotomous growth pattern. A positive sign is expected.

Counties adjacent to SMSA counties might be expected to be affected by their proximity to these more heavily urbanized areas. Furthermore, the boundaries of SMSA areas have not been redefined since 1966. Hence the ASMSA designation is used to bring out county population change due to a spillover from SMSA areas. A positive sign is expected here also.

The degree to which a county was urbanized in 1960 was determined from 1960 Census data [23]. The percent of urban population in a county (URBAN) would be expected to affect county population growth in three ways: (1) Within metropolitan areas, the process of decentralization (i.e., urban sprawl) leads to the older, more urbanized areas having slower rates of population growth and perhaps population decline. (2) In rural areas, relatively high values for URBAN indicate the existence of local service centers, i.e., small towns. Due largely to the decline of traditional rural-farm markets, the majority of these small towns have been experiencing population decline since 1945. (3) Some threshold level or urban size is probably necessary for a place to begin to achieve self-sustaining growth [21, pp 15-60]. The first and second influences should have a negative effect, strong enough to offset the positive influence of urban places that have achieved a growth threshold. Thus we expect a negative sign for URBAN.

Regression Results

Regressions were run for each of the nine major census regions.[6] For the purpose of this analysis, ΔP_t in Eq. (1) is defined as the relative change in county population 1970/1960 (POP76), ΔP_{t-1} is defined as the relative change in county population 1960/1950 (POP65), and ΔP_{t-2} is defined as the relative change in county population 1950/1940 (POP54).[7] All other variables included in the regression equations are as defined above. Results are reported in Table 1. For each census region, only the best overall estimate is shown. In all cases the dependent variable is POP76.

With the exception of the Pacific equation, all coefficients reported in Table 1 are statistically significant at the .10 level or better. In the Pacific census region, several variables with rather large estimated coefficients have been retained even though they failed to pass the usual significance tests.

In the discussion to follow, the continuous variables included in the regression will be considered first. The significance of the various dummy variables on county population change 1960-70 will then be considered.

In all census regions except Mountain and Pacific, POP65 is a significant variable. This variable is strongest in the Middle Atlantic region where its coefficient is .595. By way of contrast, the coefficient of POP65 is .271 in the West South Central region and .167 in the West North Central region. Apparently, the influence of population change in the immediately preceding period on 1960-70 county population change is considerably less in the western portion of the country than in the East. The variable, POP54, appears in six of the nine equations. In five of these regions, the influence of POP54 is less than POP65 (East North Central, South Atlantic, East South Central, West South Central, and Mountain). In fact, in the West South Central and Mountain regions, the sign of POP54 is negative. The implication of these results is that fairly remote population changes have a negligible or negative influence on current developments in most of the country.

In New England, however, the relationship between the coefficients of POP65 and POP54 is reversed. The coefficient of POP65 is .348 while POP54 is .503. In New England, it seems clear that the influence of factors which resulted in high county population growth rates between 1940-50 are still being felt. Moreover, indications are that the influence of these 1940-50 growth factors exceeds that of more recent factors.

In Table 1, URBAN appears in five equations. It is significant in four equations. In the Pacific equation, URBAN has a "t" value of 1.44. In accord with our a priori expectation, the sign of URBAN is consistently negative, i.e., a relatively high percent of county population defined as urban in 1960 retards county population growth 1960-70. Note that this variable has a significant influence only in those regions which contain a substantial number of established large cities. It is interesting to note further that these are also the regions in which past population changes are important variables.

Table 2 has been constructed to facilitate the discussion of the dummy variables. To properly interpret the dummy variables, they must be considered in relation to the constant term. For example, in the Middle Atlantic region the constant is .456 and the coefficient of ISI is .048. In otherwords, for interstate intersection counties the regression plane shifts up .048. If recent population change (i.e., POP65, POP54) equaled zero, POP76 would equal .456 in all Middle Atlantic counties according to the estimate presented in Table 1. Under the same condition, POP76 would equal .504 in interstate intersection counties. The latter number is arrived at by adding the estimated coefficient of ISI to the constant. It is recorded in the appropriate cell in Table 2, Part A. In Part B of Table 2, the percentage effect of each dummy variable on county population growth is entered. For example, interstate intersection counties in the Middle Atlantic region grew (1960-70) 10.5% faster than all counties in the region.

The immediate impression created by Table 2 is that the interstate and SMSA dummy variables have quite different effects on county population change in different regions of the country. As Table 2, Part B shows, IS counties grew 6.4%, 5.1% and 4.4% faster than all counties in the South Atlantic, West South Central and West North Central regions respectively. In the

Mountain region, the comparable figure was 50.9%. The percentage growth differential for ISA was 4.9% in West South Central while that of IS + ISA was 34.4% in New England. The percentages were 10.5, 25.6, and -13.0 for ISI counties in the Middle Atlantic, West South Central and West North Central regions.

The variable ISIA has an effect in the largest number of regions (4). For counties adjacent to interstate intersections, POP76 would equal .656, .589, .995, and .602 as opposed to .534, .518, .824, and .522 for all counties (POP65 = 0, POP54 = 0) in the South Atlantic, East South Central, West South Central and West North Central regions respectively. The percentage figures were 22.8, 13.7, 28.8, and 15.3.

The SMSA counties had significantly different growth rates in three regions. In the South Atlantic region, they grew 7.7% faster than all counties. In the West North Central, the SMSA percentage differential was 26.1. The ASMSA counties had higher growth rates in the Middle Atlantic, West North Central and Mountain regions. The percentages were 11.0, 12.1 and 68.5.

The interpretation of the dummy variables included in the Pacific estimate is somewhat different than in the rest of the results. In the Pacific equation, the sole continuous variable is URBAN. If URBAN = 0, then county population change 1960-70 would be 1.942. The percentage effects were 121.9 and 65.9 for ISA and SMSA, respectively.

Finally, it should be noted that the level of R^2 reported in Table 1 indicates important variables have been omitted from the analysis in all regions. The highest R^2 obtained is .662 for the Middle Atlantic region. R^2 is .634 in New England, .603 in the East North Central region and .557 in the South Atlantic region. In the East South Central, West South Central and West North Central, R^2 equals .422, .191, and .394 respectively. The model exhibits especially poor performance in the Mountain and Pacific regions. The standard error of the estimate and R^2 obtained here require that the regression results for these regions be interpreted with care.[8]

Some Conclusions

The principal objective of this paper has been to investigate the impact of the interstate highway system on county population change. From the results presented in Tables 1 and 2, it is clear that this impact has been fairly substantial. Variables reflecting the influence of interstates are significant in all regions of the country except the East North Central.

The interstate variables have their strongest impact in the South Atlantic, East South Central, West South Central and West North Central regions. The influence of all dummy variables including SMSA and ASMSA, is most pervasive in South Atlantic, West South Central and West North Central. These are also the regions where POP65 and POP54 have relatively small coefficients. In New England, Middle Atlantic, and East North Central, the situation is reversed and past population change dominates. Although some large dummy coefficients are reported for the Mountain and Pacific regions, these results are considered somewhat suspect. As noted above, R^2 in these two regions is quite low.

The conclusion that the dummy variables have a greater impact in the South and Plains sections of the country is not especially surprising. These regions have been slower to industrialize than the North East and Middle West. Perhaps of greater importance, past investment in highways has lagged in the South and Plains. A past deficiency in highway development should serve to magnify the current influence of the interstate system on county population change.

Population Concentration

An additional aspect of this study is a detailed consideration of the determinants of intra-regional population concentration. To facilitate this analysis, a modified Lorenz Curve technique has been utilized. This technique permits us to calculate coefficients of population concentration. Preliminary results reveal considerably increased concentration between 1940 and 1970 in the South Atlantic, East South Central, West South Central, West North Central and Mountain regions. In New England, East North Central and the Pacific regions there was very little change. Population dispersal became apparent in the Middle Atlantic region during the 1960-70 period. Although our attempts to fully explain these phenomena have just begun, it is interesting to note that concentration is occurring in the rapidly industrializing states and stabilizing in the more mature states (where suburbanization may be having an important effect). Furthermore, many of the regions where increased concentration is evident have received more than their proportional share of interstate highway mileage in use by the end of 1968.

Footnotes

[1]Work supported by the Department of Housing and Urban Development and the U.S. Atomic Energy Commission under Interagency Agreement No. IAA-H-35-70 AEC 40-192-69, and conducted at Oak Ridge National Laboratory, Oak Ridge, Tennessee operated by Union Carbide Corporation for the U.S. Atomic Energy Commission. Opinions expressed in this report are solely those of the authors and do not necessarily represent the views of ORNL, AEC or HUD.

[2]University of Tennessee, Knoxville

[3]Tennessee Valley Authority, Knoxville

[4]Thus, the autoregressive linear regression model is applicable, since regressors and errors are contemporaneously uncorrelated. Ordinary least squares estimates of Eq. (1) will exhibit desirable asymptotic properties.

[5]The authors' judgement was used in some cases to exclude a county from a particular classification because of terrain or distance; for example, Grand, Park and Teller counties in Colorado were excluded from an ISA classification because of terrain. A list of all exceptions is available upon request.

[6]The regions are New England (NE), Middle Atlantic (MA), East North Central (ENC), South Atlantic (SA), East South Central (ESC), West South Central (WSC), West North Central (WNC), Mountain (Mt.), and Pacific (Pac.).

[7]A table showing average percentage county population change by Census Region 1940-50, 1950-60, 1960-70 is included as an Appendix.

[8]A partial explanation for the poor performance of the model in the Mountain and Pacific regions may lie in the extremely large population changes that have occurred there since 1940 (see Appendix).

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Table 1. Regression Results By Region

Variable Name	Region								
	NE	MA	ENC	SA	ESC	WSC	WNC	Mt.	Pac.
Constant	.224	.456	.390	.534	.518	.824	.522	5.668	1.942
POP65	.348[a] (.124)	.595[a] (.038)	.370[a] (.034)	.411[b] (.023)	.519[a] (.035)	.271[a] (.042)	.167[a] (.025)	-	-
POP54	.503[a] (.164)	-	.306[a] (.048)	.102[b] (.040)	-	-.096[b] (.037)	.275[a] (.038)	-5.126[c] (2.698)	-
IS	-	-	-	.034[b] (.016)	-	.042[c] (.022)	.023[c] (.014)	2.887[c] (1.690)	-
ISA	-	-	-	-	-	.040[b] (.020)	-	-	2.367[b] (1.044)
IS+ISA	.077[b] (.031)	-	-	-	-	-	-	-	-
ISI	-	.048[b] (.022)	-	-	-	.211[a] (.057)	-.068[c] (.035)	-	-
ISIA	-	-	-	.122[a] (.027)	.071[a] (.017)	.131[a] (.034)	.080[a] (.027)	-	-
SMSA	-	-	-	.041[c] (.016)	-	-	.136[a] (.028)	-	1.279 (1.129)
ASMSA	-	.045[b] (.018)	-	-	-	-	.063[a] (.016)	3.880[c] (2.080)	-
URBAN	-.081[b] (.037)	-.119[a] (.033)	-.108[a] (.018)	-.117[a] (.034)	-	-	-	-	-2.547 (1.762)
R^2	.634	.662	.603	.557	.422	.191	.397	.037	.056
F	26.8[a]	69.0[a]	218.9[a]	113.9[a]	131.8[a]	18.2[a]	57.3[a]	3.48[b]	2.57[c]
SE	.080	.096	.080	.151	.105	.178	.118	12.55	4.25
SAMPLE SIZE	67	146	436	551	364	470	618	278	133

[a] Significantly different from zero at the .01 level.
[b] Significantly different from zero at the .05 level.
[c] Significantly different from zero at the .10 level.

Table 2. Impact Of Dummy Variables By Region

Variable Name	Region								
	NE	MA	ENC	SA	ESC	WSC	WNC	Mt.	Pac.
Constant	.224	.456	.390	.534	.518	.824	.522	5.668	1.942
			A. Total Effect (coefficient + constant)						
IS	-	-	-	.568	-	.866	.545	8.555	-
ISA	-	-	-	-	-	.864	-	-	4.309
IS+ISA	.301	-	-	-	-	-	-	-	-
ISI	-	.504	-	-	-	1.035	.454	-	-
ISIA	-	-	-	.656	.589	.995	.602	-	-
SMSA	-	-	-	.575	-	-	.658	-	3.221
ASMSA	-	.501	-	-	-	-	.585	9.548	-
			B. Percent Effect (coefficient ÷ constant)						
IS	-	-	-	6.4	-	5.1	4.4	50.9	-
ISA	-	-	-	-	-	4.9	-	-	121.9
IS+ISA	34.4	-	-	-	-	-	-	-	-
ISI	-	10.5	-	-	-	25.6	-13.0	-	-
ISIA	-	-	-	22.8	13.7	28.8	15.3	-	-
SMSA	-	-	-	7.7	-	-	26.1	-	65.9
ASMSA	-	11.0	-	-	-	-	12.1	68.5	-

Source: Table 1.

APPENDIX

Average Percentage County Population Change by Census Region 1940-50, 1950-60, 1960-70

Decade	Region									
	US	NE	MA	ENC	SA	ESC	WSC	WNC	Mt.	Pac.
1960-70	13.8	12.7	10.6	8.6	9.2	2.7	3.5	-2.6	81.9	54.5
1950-60	6.4	10.4	14.8	10.9	11.3	-3.5	0.9	-0.5	13.2	24.7
1940-50	4.7	9.4	9.5	7.0	8.3	-1.4	.010	-3.1	5.6	38.4

SOURCES: United States Department of Commerce, Bureau of the Census, 1970 Census of Population, Advance Report (Washington, D.C.: United States Government Printing Office, 1970); United States Department of Commerce, Bureau of the Census, Statistical Abstract of the United States 1970, (Washington, D.C.: United States Government Printing Office, 1970), Table 13.