RSP 4: 99-111.

REGIONAL DIFFERENCES IN THE GROWTH OF MARKET POTENTIALS, 1950-1970*

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This paper reports regional differences in the growth of market accessibility. The study was motivated by a desire to consider the possibility that the gradual completion of the Interstate highway system may have had a differential regional impact upon the growth of market accessibility. Truck operating times between pairs of metropolitan centers were used to define market potentials for 171 cities for 1950, 1960, and 1970. Population and income potentials and their growth rates were computed for each city. This paper summarizes regional differences in these growth rates by Census division and region.

The Market Potential Model

Since the gravity and potential concepts of human interaction are commonly used by regional scientists, the evolution of these concepts will not be reviewed here.[1] The specific forms of the potential model used in this study were

$$\text{Population Potential}_{it} = \sum_{j=1}^{171} \frac{P_{jt}}{D_{ijt}^{\lambda}}$$

$$\text{Income Potential}_{it} = \sum_{j=1}^{171} \frac{P_{jt} Y_{jt}}{D_{ijt}^{\lambda}}$$

where

P_{jt} = population of OBE area j at time t; OBE economic areas, defined by the Office of Business Economics (now the Bureau of Economic Analysis) in 1969, are mutually exclusive functional economic areas that include the total land area and population of the United States;

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*Research sponsored by the National Science Foundation RANN Program under Union Carbide Corporation's contract with the U. S. Atomic Energy Commission.

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[1]The interested reader may consult [2] and [6].

Y_{jt} = per capita personal income of OBE area j at time t;

D_{ijt} = shortest computed time of truck transport in hours between the metropolitan centers of each pair of OBE areas at time t; where alternative routes were possible between the metropolitan centers of nonadjacent OBE areas, the route involving the minimum access time was selected; D_{ii} = 1/4 the access time to the nearest OBE center; and

$\lambda = 1$.

Since λ has been assigned the value one, the resulting indexes have been interpreted as "general" market potentials. More product specific potentials would result if λ were assigned a value which varied inversely with the value of the commodity being shipped.[2]

Measuring Truck Operating Times Between Metropolitan Centers

Since historical data on actual truck operating times for all regions of the country were not readily available, we devoted a major effort to the development of a measurement process which emphasized the time of truck transport while standardizing for regional differences in terrain and changing conditions of truck speed, roadways, and congestion. The process consisted of (1) superimposing terrain and congestion conditions upon a road map, (2) the measurement of each road-terrain-congestion segment, and (3) the conversion of these segments into elapsed times of truck transport between metropolitan centers. The four principal ingredients to the process were:

a. Truck operating speeds - The Highway Capacity Manual, 1965, a design manual intended for highway engineers, reports highway design rules that have evolved from controlled experiments where each of the numerous roadway and traffic factors that affect highway capacity and speed has been allowed to vary independently of all others. Using these highway design rules plus many compromises and assumptions we developed truck "operating speeds" for three points in time (1950, 1960, and 1970), three classes of terrain (level, rolling, and mountainous), three classes of highway (limited access, 4-lane unlimited access, and 2-lane unlimited access), and two traffic conditions (relatively free flow and relatively congested). "Operating speed" is defined as "the maximum safe speed for given traffic conditions that an individual vehicle can travel if the driver so desires, without exceeding the design speed at any point." [4, p. 246].

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[2]Although the literature on the gravity model does include reference to how λ varies inversely with the value of the good being shipped [5], the "value of product" and alternative hypotheses are only recently being subjected to systematic testing [1].

b. Road conditions - Interstate route maps prepared for a major oil company provided reasonably consistent information about changing road conditions over the 1950-1970 time span. These maps distinguished between limited access highways (including Interstates and toll roads), multilane highways, and two lane roads. In addition, they provided approximate mileages between most town centers and road junctions.[3]

c. Terrain - The National Atlas of the United States of America [10] contains a map entitled "Classes of Land-Surface Form" which distinguishes among thirty-one classes of land-surface form defined from combined information on slope, local relief, and profile type. Since the maximum possible terrain detail permitted by our estimated truck operating speeds was level, rolling, and mountainous, the much greater variety of terrain conditions mapped in the atlas was consolidated into these three gross categories.[4]

d. Traffic conditions - With the belief that congestion is principally an urban phenomenon, we assumed that Standard Metropolitan Statistical Areas (SMSAs) were relatively congested and non-SMSAs were not. Thus, as SMSA definitions changed over time, the extent of assumed congestion was changed.

Given these ingredients, an overlay of terrain-congestion conditions was superimposed upon each road map and a map measurer was used to record the extent of various road conditions between the metropolitan centers of adjacent or nearby pairs of OBE economic areas. The length of each road segment was recorded at every change of road, terrain, or congestion condition. These segments were converted to distances in miles and then into elapsed times using the appropriate truck operating speeds. To minimize measurement errors the resulting elapsed times between cities were normalized by the ratio of approximate to computed mileages between cities. These computed truck operating times between over seven hundred city pairs for each of the three years, 1950, 1960, and 1970, served as the basis for the market potentials for each city.

The Computation of Market Potentials for a City

An application of the market potential model may be illustrated for a representative city: Knoxville, Tennessee (OBE #50). As a first step, a network analysis computer program was used to compute a minimum access time between Knoxville and the metropolitan center of every other OBE area.[5] Given population

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[3]Maps were prepared for the Humble Oil Company by the General Drafting Co., Inc. of Convent Station, New Jersey.

[4]As with all classification processes, questions arise at the class boundaries. In our case, a road running with the grain of mountainous terrain might have been more correctly classified as rolling rather than mountainous.

[5]The program in [3] was modified for our purposes by T. C. Tucker, Mathematics Division, ORNL.

and per capita personal income estimates [9] for each OBE area for 1950, 1960, and 1970, the income and population potentials for Knoxville have been computed. In addition to the 1950, 1960, and 1970 population and income potentials, the 1960 and 1970 potentials using 1950 access times and the 1970 potentials using 1960 access times have been computed. These results are found in Table 1.

Table 2 summarizes the information of Table 1 in terms of a number of rates of growth of market potential. The overall growth rate has been partitioned into (1) the rate of growth given the base year's accessibility (income/population growth) and (2) the rate of growth due to improved access time as a consequence of improved roads and increased truck operating speeds (accessibility growth). Symbolically, (a) for Population Potentials,

$$\text{Overall Growth Rate}_i = \left(\frac{\text{Population Potential}_{it_1}}{\text{Population Potential}_{it_0}} - 1 \right) \times 100$$

$$\text{Population Growth Rate}_i = \left[\left(\sum_{j=1}^{171} \frac{P_{jt_1}}{D_{ijt_0}^{\lambda}} \Big/ \sum_{j=1}^{171} \frac{P_{jt_0}}{D_{ijt_0}^{\lambda}} \right) - 1 \right] \times 100$$

Accessibility Growth Rate$_i$ = Overall Growth Rate$_i$ - Population Growth Rate$_i$ and (b) for Income Potentials,

$$\text{Overall Growth Rate}_i = \left(\frac{\text{Income Potential}_{it_1}}{\text{Income Potential}_{it_0}} - 1 \right) \times 100$$

$$\text{Income/Population Growth Rate}_i = \left[\left(\sum_{j=1}^{171} \frac{P_{jt_1} Y_{jt_1}}{D_{ijt_0}^{\lambda}} \Big/ \sum_{j=1}^{171} \frac{P_{jt_0} Y_{jt_0}}{D_{ijt_0}^{\lambda}} \right) - 1 \right] \times 100$$

Accessibility Growth Rate$_i$ = Overall Growth Rate$_i$ - Income/Population Growth Rate$_i$.

One may note from Table 2 that the Knoxville market potential grew 163 percent in terms of income and 96 percent in terms of population during the 1950-1970 period. This growth was most rapid during the decade of the sixties. The income/population growth rates indicate a much less dramatic change would have occurred in the absence of road and truck speed improvements. The accessibility growth rates imply that a large portion of the overall growth of Knoxville's market potential has been the result of improved roads and truck speeds. The contribution of improved roads was especially noticeable during the decade of the sixties.

TABLE 1: Market Potentials Knoxville, Tennessee, 1950, 1960, and 1970

	Income Potential (Millions of 1967 $)			Population Potential (000's)		
	1950	1960	1970	1950	1960	1970
1950 Access Times	$16,657.	$19,846.	$28,109.	9,337	10,493	11,598
1960 Access Times		24,112.	34,128.		12,806	14,151
1970 Access Times			43,749.			18,319

TABLE 2: Rates of Growth of Market Potentials, Knoxville, Tennessee, 1950-60, 1960-70, 1950-70

	Income Potential			Population Potential		
	1950-60	1960-70	1950-70	1950-60	1960-70	1950-70
Overall Growth	44.8	81.4	162.6	37.2	43.1	96.2
Income/Population Growth	19.1	41.5	68.8	12.4	10.5	24.2
Accessibility Growth	25.6	39.9	93.9	24.8	32.5	72.0

The Growth of Market Potentials by Region

Computations and observations similar to those just made for Knoxville have been prepared for each of the 171 OBE areas but are too numerous to include in this paper.[6] Instead, we will attempt to summarize our results by Census division and region. Tables 3-6 contain information about the "average" or "representative" market potential of the cities within each region.[7] While Table 3 may suggest that very little has occurred over time, the Northeast region and the Middle Atlantic division continue to have the largest market potentials in terms of population while the North Central and East North Central continue to lead in income terms, substantial regional differences in overall market potential growth rates appear in Table 4.

In income terms, markets in the West North Central division experienced below average rates of overall growth while those in the New England, Middle Atlantic, South Atlantic, and Pacific divisions grew at rates substantially above the national average during the 1950-1970 period. The decade of the fifties witnessed very substantial growth of market potentials in the Northeast region. During the decade of the sixties, however, markets in the Western and Southern regions and the Pacific and South Atlantic divisions in particular experienced above average growth while those of the Northeast grew most slowly. In sum, there does appear to be evidence of regional differences in overall growth of market potentials. Furthermore, these regional differences were not consistent as between the decade of the 1950's and that of the 1960's.

Table 5 presents a picture of what the growth of market potentials would have been had roads and truck speeds not changed. Above average population potential growth may be due to (1) above average birth rates (perhaps due to a younger than average population) and/or (2) net inmigration to an area. Below average internal growth may be due to low birth rates and net outmigration. Thus, it comes as no surprise that the population potentials of the West experienced the highest while those of the West North Central and the East South Central divisions experienced the lowest rates of income/population growth. In terms of income, the income/population growth of market potentials in the South was generally highest. One may reasonably attribute these regional differences to rapid population growth in the West and rapid per capita income growth in the South.

Table 6 completes our analysis of regional differences in the growth of market potentials by isolating the residual growth rate due to improved roads and truck speeds. In terms of both population and income, the contribution to market potential growth of improved roads was especially high in the Northeast and West over the 1950-1970 period, highest in the Northeast during the 1950's, but highest in the West during the 1960's. Improved roads also made a substantial contribution to the growth of market potentials in the West North Central and East South Central divisions during the 1960's.

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[6] This information is available upon request from the authors.

[7] As averages, they may conceal some variations among cities within a region.

TABLE 3: Market Potentials of Representative Cities by Region, 1950, 1960, and 1970

	Income Potential (Millions of 1967 $)			Population Potential (000's)		
	1950	1960	1970	1950	1960	1970
U. S. Average	$18,884.	$28,294.	$48,657.	9,221	13,745	18,788
Northeast	22,255.	36,823.	60,814.	13,651	21,766	28,519
N. England	17,018	27,758.	44,835.	11,042	17,445	22,499
M. Atlantic	24,436.	40,600.	67,471.	14,737	23,567	31,028
North Central	23,877.	35,166.	59,886.	10,828	16,159	21,729
E. N. Central	26,737.	40,525.	68,658.	12,723	19,429	26,054
W. N. Central	19,525.	27,010	46,537.	7,945	11,183	15,149
South	17,237.	25,386.	44,452.	8,818	12,600	17,405
S. Atlantic	17,263.	26,051.	46,132.	9,513	13,988	19,356
E. S. Central	18,062.	26,154.	45,542.	9,732	13,280	18,115
W. S. Central	16,725.	24,135.	41,787.	7,445	10,528	14,634
West	10,727	16,266.	28,789.	4,341	6,858	10,396
Mountain	10,024.	14,470.	24,879.	3,940	5,942	8,699
Pacific	11,592.	18,476.	33,600.	4,836	7,985	12,485

TABLE 4: Overall Growth Rates of Representative Market Potentials by Region, 1950-60, 1960-70, 1950-70

	Income Potential			Population Potential		
	1950-60	1960-70	1950-70	1950-60	1960-70	1950-70
U. S. Average	49.8	72.0	157.7	49.1	36.7	103.8
Northeast	*65.5*	*65.2*	*173.3*	*59.5*	*31.0*	*108.9*
N. England	63.1	61.5	163.5	58.0	29.0	103.8
M. Atlantic	66.1	66.2	176.1	59.9	31.7	110.5
North Central	*47.3*	*70.3*	*150.8*	*49.2*	*34.5*	*100.7*
E. N. Central	51.6	69.4	156.8	52.7	34.1	104.8
W. N. Central	38.3	72.3	138.3	40.7	35.5	90.7
South	*47.3*	*75.1*	*157.9*	*42.9*	*38.1*	*97.4*
S. Atlantic	50.9	77.1	167.2	47.0	38.4	103.5
E. S. Central	44.8	74.1	152.1	36.5	36.4	86.1
W. S. Central	44.3	73.1	149.8	41.4	39.0	96.6
West	*51.6*	*77.0*	*168.4*	*58.0*	*51.6*	*139.5*
Mountain	44.4	71.9	148.2	50.8	46.4	120.8
Pacific	59.4	81.9	189.8	65.1	56.4	158.2

TABLE 5: Income/Population Growth Rates of Representative Market Potentials by Region, 1950-60, 1960-70, 1950-70

	Income Potential			Population Potential		
	1950-60	1960-70	1950-70	1950-60	1960-70	1950-70
U. S. Average	19.6	40.9	68.6	16.9	12.2	31.2
Northeast	*22.0*	*39.6*	*70.5*	*14.9*	*10.9*	*27.4*
N. England	22.2	41.1	72.5	14.3	11.9	27.9
M. Atlantic	22.0	39.2	70.0	15.1	10.6	27.2
North Central	*17.2*	*39.9*	*63.9*	*16.2*	*10.8*	*28.9*
E. N. Central	18.4	40.0	65.7	16.9	11.2	30.0
W. N. Central	14.6	39.6	60.2	14.4	9.9	26.2
South	*21.0*	*43.5*	*73.6*	*16.3*	*12.9*	*31.2*
S. Atlantic	21.8	45.9	77.7	17.5	13.7	33.6
E. S. Central	20.7	42.0	71.5	13.0	10.5	24.9
W. S. Central	20.1	41.3	69.7	16.8	13.2	32.2
West	*22.2*	*38.0*	*68.8*	*26.6*	*18.1*	*49.4*
Mountain	17.6	35.6	59.6	22.0	15.3	40.5
Pacific	27.0	40.3	78.5	31.2	20.7	58.3

TABLE 6: Accessibility Growth Rates of Representative Market Potentials by Region, 1950-60, 1960-70, 1950-70

	Income Potential			Population Potential		
	1950-60	1960-70	1950-70	1950-60	1960-70	1950-70
U. S. Average	30.2	31.1	89.1	32.2	24.5	72.6
Northeast	*43.5*	*25.5*	*102.7*	*44.6*	*20.1*	*81.5*
N. England	41.0	20.4	91.0	43.7	17.0	75.8
M. Atlantic	44.2	26.9	106.1	44.8	21.1	83.3
North Central	*30.1*	*30.4*	*86.9*	*33.1*	*23.7*	*71.8*
E. N. Central	33.2	29.4	91.1	35.8	22.9	74.8
W. N. Central	23.7	32.7	78.1	26.3	25.6	64.4
South	*26.3*	*31.6*	*84.3*	*26.6*	*25.3*	*66.2*
S. Atlantic	29.1	31.2	89.5	29.5	24.7	69.9
E. S. Central	24.1	32.2	80.6	23.5	25.9	61.3
W. S. Central	24.2	31.9	80.2	24.6	25.8	64.4
West	*29.5*	*39.0*	*99.6*	*31.4*	*33.5*	*90.0*
Mountain	26.8	36.3	88.6	28.8	31.1	80.3
Pacific	32.4	41.5	111.3	33.9	35.7	99.8

Summary and Conclusion

In summary, there were regional differences in the growth of market potentials over the 1950-1970 period. The market potentials of cities in the Northeast grew most rapidly during the 1950's while those of the South (income) and West (population) grew fastest during the 1960's. In the absence of improved roads and truck speeds, the market areas of the West would have experienced rapid growth due to substantially above average population growth while those of the South would have had rapid growth (especially during the 1960's) due largely to above average per capita income growth. Improved roads contributed substantially to the growth of the market potentials of cities in the Northeast during the 1950's and in the West, South and West North Central during the 1960's.

Interesting as these results may be, they should not be surprising since the traditional role assigned to transportation improvements has been one of overcoming "the frictions of space and the obstacles which geography poses to the optimal utilization of resources" [7, p. 4]. If we have been able to quantify the dynamics of market accessibility in a useful way,[8] these measures may be able to contribute to the determination of how much market accessibility contributes to regional economic development.

[8] An alternative approach is given in [8].

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