Role of Transportation in Manufacturers' Satisfaction with Locations

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A study is currently under way in North Carolina to examine the complex relationship between transportation investments and satisfaction of manufacturing firms with location. The study is part of a continuing analysis by the University of North Carolina at Charlotte to develop the linkage between transportation and economic development. The 100 counties of North Carolina were classified according to transportation access, economic structure, manufacturing composition, and socioeconomic characteristics. A data set consisting of more than 400 variables was analyzed using factor analysis and cluster analysis to develop the classifications. The counties were then grouped into six clusters. Using this cluster structure, a survey of about 1,000 manufacturing firms in North Carolina is being conducted using an extensive mail questionnaire. Manufacturers have been asked to describe their perceptions of the importance of transportation systems and other factors in bringing in materials, shipping out products, and providing access to labor markets. These data will be correlated with information on highway investments, location of the firm with respect to the highway system, and other transportation access measures. Models such as factor analysis, discriminant analysis, and canonical modeling will be used to determine the relative importance of transportation against other socioeconomic and fiscal variables in determining manufacturer satisfaction. Then, policy analysis of various transportation funding strategies will be used to determine the effects of investment. Findings will be used to help rank transportation system investments intended to strengthen the state's industrial base.

The approaching completion of the Interstate system marks the end of an era in U.S. economic development and transportation investment. After approximately 35 years and more than $100 billion, the 44,000-mi system is largely complete. During its development, the system has contributed to a transformation of the U.S. economy from one based largely on separate regions with significant intraregional economies to one based on highly interdependent regions connected by a vast network of transportation services. At this megascale, the Interstate system has not only facilitated the transformation of the U.S. economy but has propelled it forward in many positive ways. The Interstate system has returned its investment manyfold through economic growth, greater national interconnectedness, and higher quality of life. Perhaps no other governmental investment in U.S. history has had so great a relative effect on the nation's economy.

What else can be done? How should future transportation dollars be spent? These are simple questions with complex answers. In spite of a general understanding of the impact of the Interstate system, knowledge of the relative effects of specific transportation investments on economic development is surprisingly limited. Current transportation economic analysis focuses almost entirely on the quantification of user benefits, that is, benefits derived from savings in travel time, reductions in operating costs and accidents, and other quantifiable effects on users of transportation systems. Modern transportation economics is based on the evaluation of such benefits. Nonuser benefits (including second-order positive and negative effects on adjacent land owners, increases in land values, additional increases in economic activity that result in greater tax dollar flows, improvements in competitive position, and improvements in the quality of life) are not only generally not quantified but are often ignored as inconsequential or dismissed as irrelevant to transportation decisions. Methodology for determining such effects is not extensively developed.

More recently, broader views of transportation evaluation have included assessments of the effects on economic development, but in an essentially nonquantifiable or quasiquantifiable way. That is, estimates of the number of units affected or the resulting change in accessibility (for example, the number of jobs within 30 min of a downtown area) have often been added to the users' dimension. Because of the difficulties of incorporating such elements in a dollar-based fashion, they have usually been treated separate from more easily quantifiable measures such as travel time, operating costs, and accidents.

Economic development reacts to transportation investments, but the reaction varies by industry type, preexisting local conditions, geography, site characteristics, demographics, and previous investments in transportation and other elements of the infrastructure. This study was intended to provide an understanding of these complex relationships, including issues such as the following:

1. For a given transportation proposal, what are its first- and second-order economic benefits or effects?
2. How important is transportation, relative to other factors, in determining the price of goods, in making siting decisions, in acceleration or deceleration of urban growth, in providing labor accessibility, and in moving materials or products?
3. If a given amount of money is spent on a statewide or regional transportation program, what will be the economic effect?
4. How can current companies be retained, and new ones attracted, through additional transportation investments?

Transportation analysts have found it difficult to answer such questions in satisfactory terms. Often, specific first-order

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effects on construction jobs cannot be estimated, and second- and third-order effects become impossible to assess without using high-level assumptions such as regional economic multipliers. The result is a less-than-satisfactory state-of-the-art in an area that is continuing to generate considerable interest.

LITERATURE REVIEW

Economic development has long been recognized as an important rationale for transportation investment, but the nature of the relationship remains unclear. At the national level, TRB (*1*) identified the following as critical research needs: (a) transportation and the U.S. competitive position worldwide and (b) transportation and economic development. NCHRP recently issued a request for proposal to determine the nature of this linkage. The Eno Foundation (*2*) assessed the relative importance of transportation to a healthy economy. The recent call for a system of Highways of National Significance (*3*) is one effort to propose a national corridor-level system of about 150,000 mi.

At the regional level, Toft and Stough (*4*) developed a shift-share model of the U.S. economy that showed economic shifts in transportation sector employment from the Old North to the Old South and West. Sullivan (*5*) analyzed the effects of transportation investments in the Pacific Northwest Coastal region. The Appalachian Regional Commission (*6*) justified the Appalachian Development Highway System on improvements in access leading to better delivery of services and attractiveness to industry.

At the state and local level, recent strategic plans for transportation (*7–10*) have recognized the importance of transportation access to economic growth. Many states have developed and are implementing corridor plans for upgrading selected highways to four-lane or Interstate standards. Wilson et al. (*11*) surveyed industrial firms in the maritime region of Canada to examine the relationship between transportation public expenditures and economic development stimulation. They used a local factor preference index model to analyze the importance of transportation and other factors in attracting industry to siting locations. Larson (*12*) found that the Interstate system is critical to Pennsylvania's economic growth. Lebo and Adams (*13*) developed an industrial- and commercial-access transportation network to accelerate Pennsylvania's economic development. Moon (*14*) found that the effect of 65 nonmetropolitan interchanges in Kentucky on local economics was large, even creating interchange villages on isolated land. Sinha et al. (*15*) reviewed the role of transportation on the northwest Indiana economy. Poole and Cribbins (*16*) developed a benefits matrix model for evaluating transportation proposals in North Carolina. Also in North Carolina, Clay et al. (*17*) developed a straightforward linear relationship between job growth and highway investment, by county type. Although the study found that each $5,796 in investments was correlated with one job increase, the authors recognized the inherent complexity of the relationship being studied. In nearby Georgia, Floyd and Melvin (unpublished data) found that the most important factor in giving a region a competitive edge in economic development is a superior transportation system. They projected that over half of all the growth in Georgia up to the year 2000 will occur in and close to Atlanta, because the state's current non-Interstate multilane system is inadequate compared with those of other southeastern states and considering desired growth rates. Also in Georgia, Maggied (unpublished data) investigated the relationship between mobility and poverty and concluded that Georgia counties could be clustered by different levels of mobility and economic deprivation.

Not all the studies show positive results. In a review of Interstate system effects on minority communities, Steptoe and Thornton (*18*) found that the presence of an Interstate system did not attract new businesses in minority communities. Eagle and Stephanedes (*19*) concluded that the effects of highway investment on the economy do not lead to long-term jobs, except in counties that are already economic centers. Even more pessimistically, Briggs (*20*) concluded that the presence of an Interstate system alone did not ensure development, particularly for manufacturing and wholesaling industries. He concluded that the Interstate's role seems to have been to increase accessibility levels throughout the country.

The importance of transportation to advanced-technology firms was reviewed by Hummon et al. (*21*). They found that Standard Industrial Classification (SIC) code variables representing industry type did not predict transportation preference, which was better predicted by type of firm, age of technology, and firm size. The study focused on advanced technology firms in Pennsylvania. It was concluded that transportation access is a necessary, but not sufficient, condition for locating and generating successful business at a given site. Paaswell (*22*) surveyed Illinois companies to identify the strengths and weaknesses for growth industries. In various input-output models, e.g., Liew and Liew (*23*), transportation investments affect the economy but in different ways for different sectors. Toft and Mahmassani (*24*) concluded that high-technology industries possess spatial and production attributes that require different transportation services.

The methodology of these studies varies widely. Constantin (*25*) suggested a functional logistics-based method, noting that the functional approach gives a better overall perspective on the role of transportation in small towns and rural areas. Varaprasad and Cordey-Hayes (*26*) developed an integrated set of 10 differential equations to describe London's population dispersal into two concentric rings. Twark et al. (*27*) used a system of simultaneous equations calibrated by two-stage least squares to predict economic development at 93 Pennsylvania Interstate interchanges. The model system used 15 exogenous and 25 endogenous variables. Maggied used factor analysis of county-level variables. Clay et al. (*17*), on the other hand, used straightforward trend statistics and simple correlation ratios.

MODEL STRUCTURE

To facilitate this study, the University of North Carolina at Charlotte (UNCC) team is working under the general guidance of several conceptual models of firm location and investment. These include a county-level economic model, a firm performance model, and a location life-cycle model.

Figure 1 shows how county-level economic structure influences firm activities. Firms are viewed as the decision-making

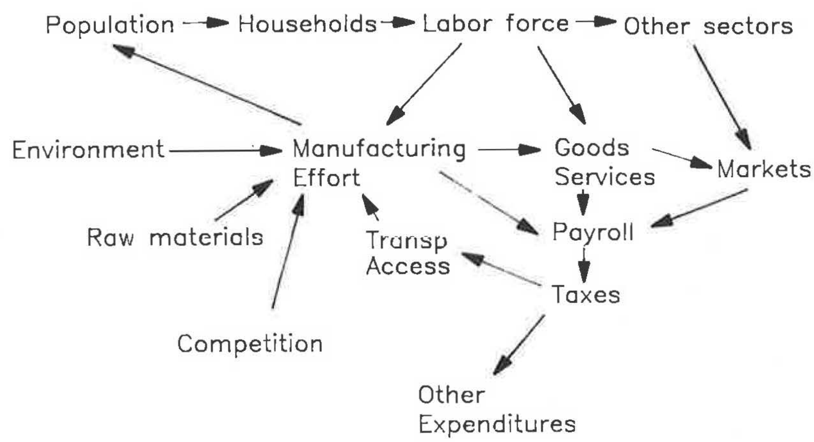

FIGURE 1 County-level manufacturing model.

unit embedded in a physical and socioeconomic county environment. Using labor, land, money, and other resources and raw materials shipped in from outside, firms generate wages and payrolls through the production of useful products and services. The transportation system provides the accessibility by which firms attract and hold employees and move the factors of production from the site to the marketplace through the manufacturer. This high-level view follows traditional economic thinking and relates the key elements of the firm's environment to its output products.

Firm performance (Figure 2) is viewed as the product of interactions among the firm's internal activities, wages, taxes, labor, the transportation system, characteristics of the firm's specific location, and actions of its competition. In this model, transportation access operates as a lens that mollifies or accentuates the effectiveness of the firm's ability to interact with its labor force, its markets, and its production system.

The firm's siting-decision process is viewed as a temporal series approximating a long-term life cycle (Figure 3). The firm's satisfaction with its current location and situation is

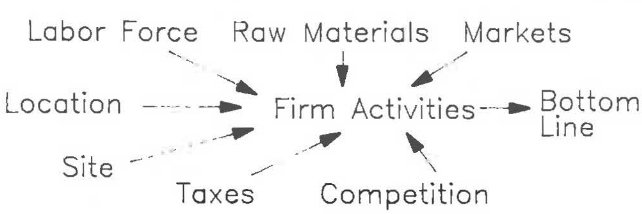

FIGURE 2 Firm performance.

hypothesized to be highest immediately after a move. After an interim honeymoon period, factors such as competition, aging facilities, price changes, labor, and supply problems generate a number of difficulties associated with the location, which deteriorates the satisfaction level. Eventually, these problems initiate a reevaluation process in which the firm consciously decides to assess its location in some formal way. A review of alternatives then generates a decision to stay put, move, or otherwise change its locational situation. In North Carolina, many firms have been operating at the same locations for up to 100 years; nevertheless, changes in labor, raw materials, markets, and competition can render the location less competitive now than when the siting decision was made. It might be expected therefore that companies expressing various levels of satisfaction with their current locations could be expected to be in various stages of their siting-decision life cycle. The issue is how firms currently view their location in light of changed circumstances.

The location of a factory is a major capital allocation decision. Once made, the factory is immobile until the investment can be amortized (in 20 to 30 years), unless it is sold. Thus location decisions take on geographic inertia—a resistance to relocation. A company may be unhappy with a location but financially unable to relocate for some time. The study survey will reveal this latent relocation potential, along with reasons for dissatisfaction that might be addressed by state policy changes. This emphasis on location satisfaction of existing manufacturers—as opposed to original location decision making—makes this study unique.

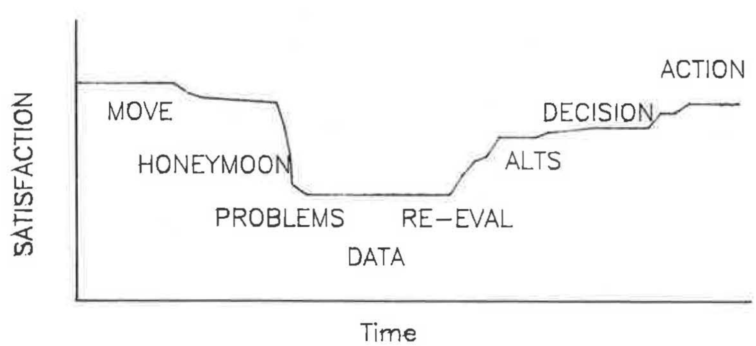

FIGURE 3 Location decision life-cycle.

STUDY STRUCTURE

A particularly interesting aspect of the relationship between economic development and transportation is the relationship between transportation access and the location satisfaction of manufacturers. Several aspects related to this process are addressed:

- What perceptions do manufacturers have of transportation access, and how are these current perceptions related to their previous siting decisions?
- What policies could be suggested to improve satisfaction with transportation systems, and how would such policies attract new firms or hold current ones?
- What other factors influence manufacturing firm satisfaction with location, and how are these factors different in rural and urban areas and rapidly growing versus slowly growing communities?

Earlier assessments found that North Carolina's crucial manufacturing base was undergoing change that threatened the viability of rural economies in particular. With about 30 percent of its workforce still in factories, the state is heavily industrialized. More uniquely, this industry is concentrated not just in cities; a large part is dispersed throughout small towns and rural areas. The more dispersed factories are largely in labor-intensive industries, especially textiles and apparel, which are vulnerable to offshore competition. Urban areas have experienced dramatic growth in nonmanufacturing, but the more specialized rural economies have not shared proportionately in these gains. Thus, North Carolina is seeking ways to retain and strengthen its manufacturing base, particularly in rural counties. Because manufacturing is viewed as the key to economic stability in these areas, the manufacturing sector of the economy is emphasized.

The study is divided into the following analytical tasks.

Classification of Counties

An economic and transportation-access classification of counties, necessary for survey sampling and analytical work, was developed. Previous works have shown that groupings such as rural or urban and metropolitan or nonmetropolitan are too simplistic for analytical purposes. Further, some terms, such as "rural," engender emotional responses that interfere with objective analysis. The 100 counties in North Carolina are being classified along socioeconomic, employment mix, manufacturing structure, and transportation dimensions. A large data set consisting of over 414 variables has been developed describing characteristics of the labor force, transportation access by various modes, and socioeconomic indicators. Sources of this information include census publications, materials from state and federal agencies, and private organizations. For many data items, information is available for several points in time, which will enable trend statistics to be developed. Table 1 presents the variables used in the classification. At the completion of this step, the four separate classifications will be merged into one that reflects the characteristics of each scheme.

Survey of Manufacturers

A representative sample of about 2,000 North Carolina manufacturing establishments will be drawn from the total of about 6,800 manufacturers in the state, in anticipation of receiving about 1,000 returns. The survey sample will be a stratified random sample using county classification structure and manufacturing industry type. Manufacturers will receive a six-page questionnaire focusing on their perceptions of transportation and other factors relating to their satisfaction with their current location.

TABLE 1 OVERVIEW OF COUNTY-LEVEL DATA

Group	Number of Variables	Description
Classification	19	State, regional, FIPS groups
Labor force	14	Labor/force 1980-1987
Unemployment	8	Unemployment rates 1980-1987
Employment	99	Employment by sector/year
Manufacturing Employment	92	Wages, Employment & Establishments in SIC codes 20-39
Education	18	Population at educational levels and institutions
Crime	4	Crime and prisons
Health	8	Doctors, nurses, beds, rates
Income	13	Per-capita income
Population	50	Population by age group 1970-2000
Population density	6	Density 1980-2000
County size	4	Area measure
Poverty	10	AFDC etc. statistics
Misc.	11	Tourism, sales, companies
Transportation-mileage	43	Miles by system, yr., width
-financing	17	Expenditures by system 1973-1985
-intercity	27	Access to train, bus, air, port, interstate

Analysis

Analytical work will involve a number of straightforward methodologies. Descriptive statistics will be prepared both for manufacturers and counties, describing their current economic structure and overall linkages with respect to transportation. Clustering methods are being used to classify counties and develop profiles matching county characteristics with industry characteristics. Correlations will be developed between transportation investment and perceptions of the quality of transportation service. Classification procedures such as Automatic Interaction Detector (AID), CLUSTER, and discriminant analysis are being used to identify the characteristics of firms that express very high and very low satisfaction levels with transportation facilities and network investment.

Policy Model

The study team will develop a policy model relating transportation investments to firm employment and siting-decision satisfaction. It is expected that the model will contain a number of simultaneous equations that will be embedded in a spreadsheet for forecasting purposes. Numerous policies, such as those being considered by the North Carolina legislature involving transportation investments for a proposed $8.6 billion highway program, could be evaluated for their effect on employment and economic development.

PRELIMINARY RESULTS

As of July 1989, study results were available only for county classification. The following results relate primarily to the classification structure.

County Classifications

The county classifications effort has focused on three major activities:

1. Descriptive statistics,
2. Factor analysis to identify key variables describing the differences in county structure, and
3. Cluster analysis of counties on the basis of these key variables.

Preliminary results of the assessment are as follows.

Trends and Statistics

North Carolina's economic development patterns are not uniform. Rather, overall economic growth has been concentrated primarily in major metropolitan counties, with additional strong growth concentrated in surrounding fringe counties. Overall employment trends in North Carolina (Figure 4) show essentially flat employment in manufacturing and a decline in agriculture, with a significant increase in nonmanufacturing employment. Changes in population have been most rapid in urban core counties and their surrounding environment, as well as in recreation and retirement counties (Figure 5).

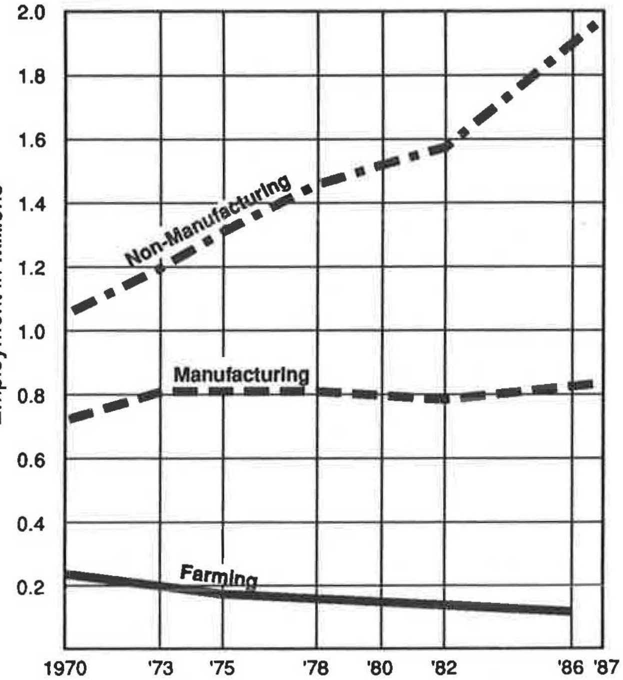

FIGURE 4 Employment trends in North Carolina.

Employment

Initial review of the employment portion of the data set suggested that employment in North Carolina can be represented by 11 variables, which were collected from data supplied by the Bureau of Economic Analysis (BEA) for 1986. After factor analysis was performed on this set of variables, seven were chosen as explaining the most variation between the counties. The 11 variables initially chosen are listed below.

- CVILEMP (STALOC + FEDCIV): state, local, and federal employees, excluding military.
- FIRE: finance, insurance, and real estate employees.
- BMFG: manufacturing employees.
- AGSMIN: agriculture and mining employees.
- CONST: construction employees.
- FARM: farming employees.
- HSLETRD: employees in wholesale trade.
- MILITARY: military employment.
- SERV86: services employment.
- TRAVEX86: travel expenditures, in thousands of dollars.
- BTOTEM86: total employment.

After the clusters were formed, a classification scheme of six groups of counties was chosen. The results of this classification are shown in Figure 6. The six groups include manufacturing, services, mixed manufacturing, farm, government, and military. Although the model developed for the employment section was fairly decisive, it did not explain much of the variation among the 100 counties in North Carolina. Of the total variation in these seven variables, 25 percent was explained by the six-cluster model. Forty-three percent of the counties had enough of a manufacturing emphasis to be clustered around the manufacturing dimension. Only the large urban counties and those with a large military pop-

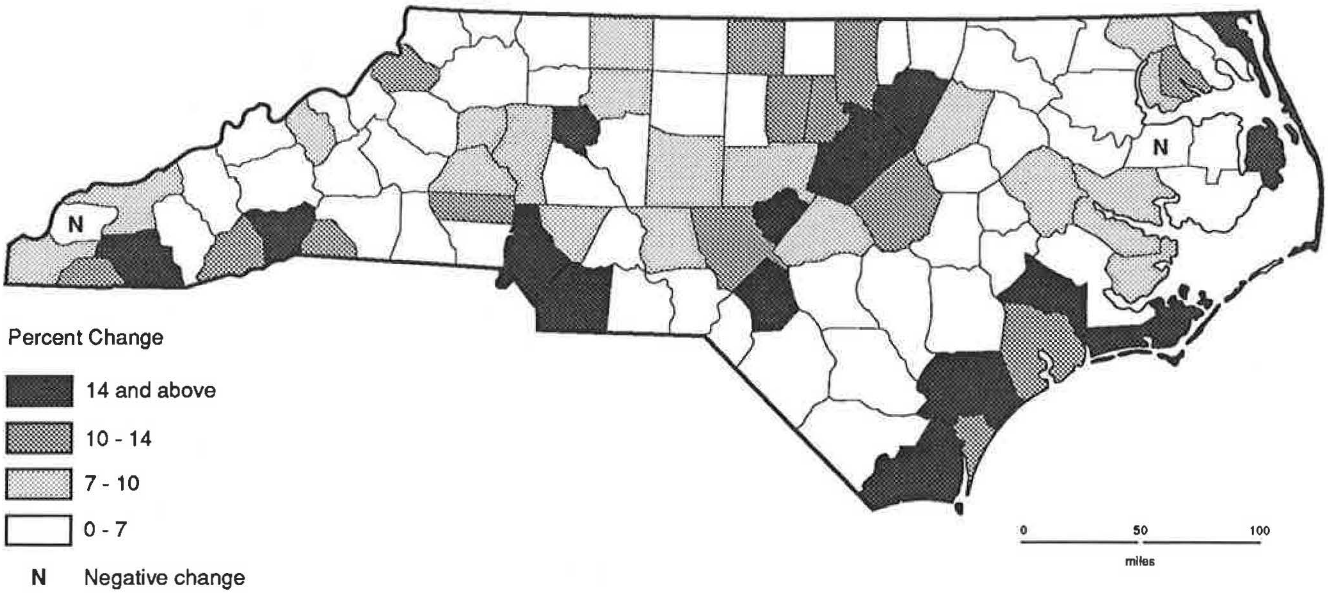

FIGURE 5 Percent change in population by county, 1980–1987.

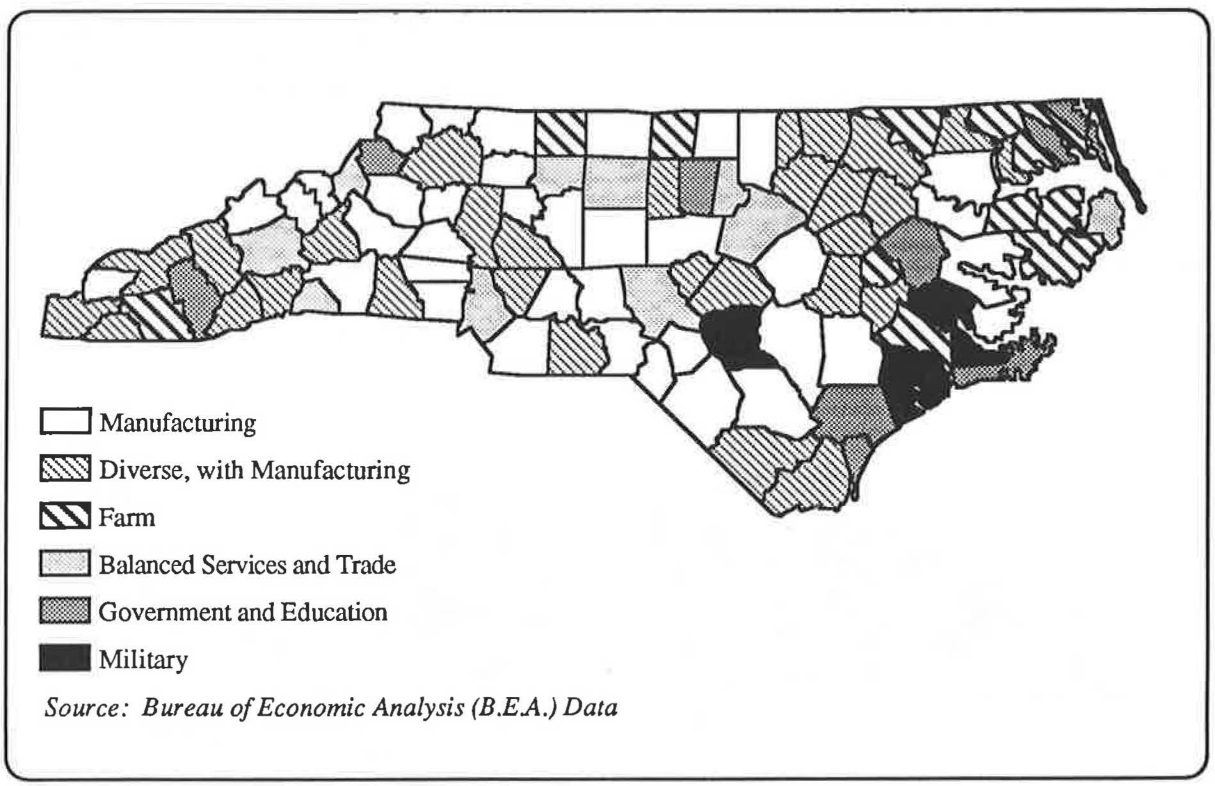

FIGURE 6 Employment focus by county, 1986.

ulation were well-defined groups, the remainder having a variety of employment types.

Several variables had little impact on defining the clusters. Among these are agriculture and mining, construction, transportation and utility, and wholesale trade employment. The factor loadings were rather weak: any variable that had a coefficient above 0.50 was considered acceptable for inclusion in the cluster analysis. Therefore, it would be incorrect to say that wholesale trade does not have an impact on the employment structure of the state; rather, these activities are spread thinly throughout the state.

Manufacturing

The manufacturing portion of the data consisted of 25 variables, each representing a part of the manufacturing employment in North Carolina. These data were compiled by the Employment Security Commission. Each variable represents one, or a portion of one, complete two-digit SIC category. In some instances, the SIC category was subdivided to sharpen differences within the category. For example, SIC 21 was broken into two categories, with cigarettes and tobacco in one and tobacco stemming in the other. Several sites were made at the three-digit level.

In the case of manufacturing, simply choosing variables that ranked high and running them through a cluster analysis was not feasible because this method was not able to break apart a large, diversified cluster of counties. Instead, a cluster model was performed on the basis of six factors, with each factor having special characteristics. For example, one factor was labeled "Office, Computing, and Accounting Machines," and another was called "Agricultural Chemicals/Apparel." When these six factors were used as a basis for a clustering algorithm, the pattern of clusters shown in Figure 7 resulted.

Fifty-five counties were left as a diversified cluster; that is, they did not cluster strongly around any single variable. Some tendencies toward the Tobacco Stemming/Miscellaneous Plastics group are evident, but the associations are weak. A plot of the factors showed that the clustering was weakly organized, with the diversified cluster (Cluster 1) mixed in with the remaining clusters (Clusters 2 through 5). This plot indicates the lack of strength of the model for forming clusters, especially for this group. The counties in the Diversified Products category are spread throughout the state, with the majority lying in the middle of North Carolina and two arcs extending through the coastal plains region all the way to the coast.

The cluster model developed for manufacturing is weak. The total amount of variance explained by the model is only 12 percent. Any plot of these clusters shows a high degree of intermixing. The categories should be interpreted as a general classification, or a focus, of the manufacturing employment structure of the counties in North Carolina.

Socioeconomic

From the data base, 24 variables were chosen to represent the socioeconomic characteristics of the counties. These variables include county population, population characteristics, and health aspects. Many of them were calculated from the more general variables found in the data base.

These variables were used in a factor analysis to determine which were the most important in determining the overall socioeconomic status of the counties. The factor analyses were performed with four, five, and six factors. The analysis that used four factors was found to be inconclusive; however, the analyses using five and six factors found 12 and 14 variables, respectively, to be pertinent for further analysis. These variables were then used in a cluster analysis to group the similar counties. Four major clusters of counties were identified as follows:

- *Cluster 1 (Distressed Rural) (very low)*—These 34 counties have generally low-level health variables, percentage of persons age 16 to 64, and size variables (population, density, and employment), as well as low employment figures and low personal incomes. They also tend to have a high percentage of nonwhites, a high percentage of families receiving aid for dependent children (AFDC), and a high unemployment rate. They are located primarily in the eastern part of the state (see Figure 8).
- *Cluster 2 (Mountain and Coastal Fringes) (low)*—These 39 counties have the lowest percentage of nonwhites and the lowest percentage of families receiving AFDC. They also have

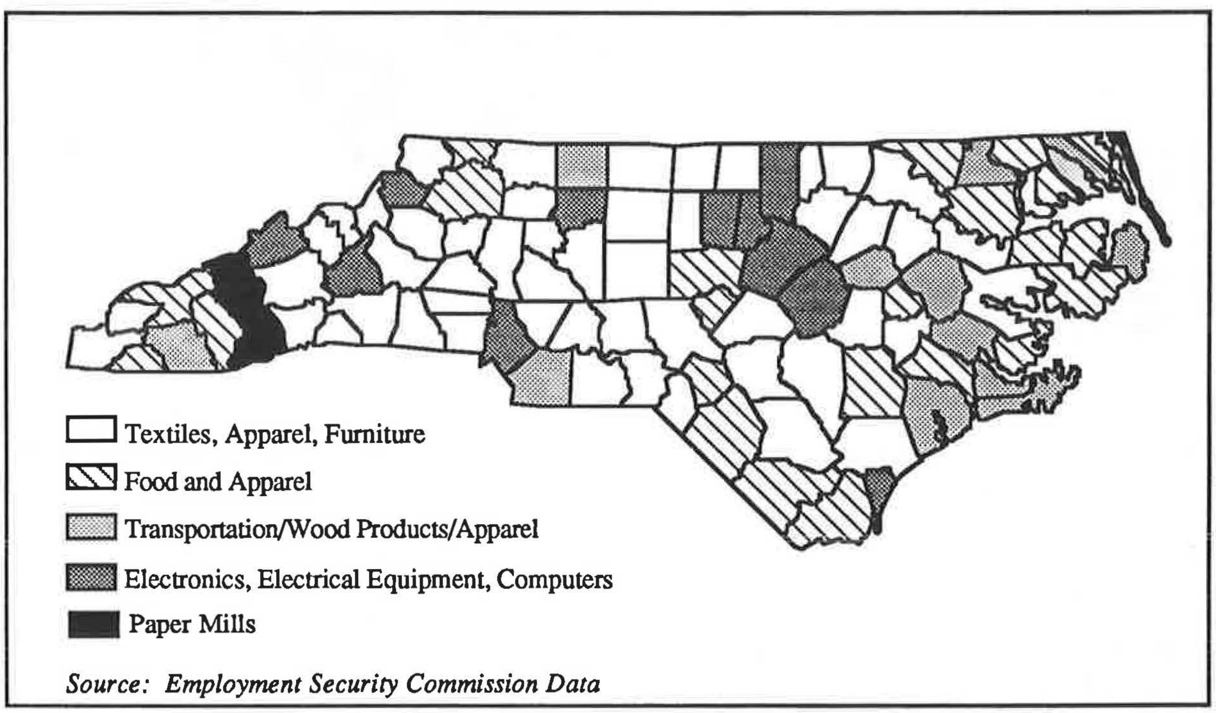

FIGURE 7 Manufacturing types of counties, 1987.

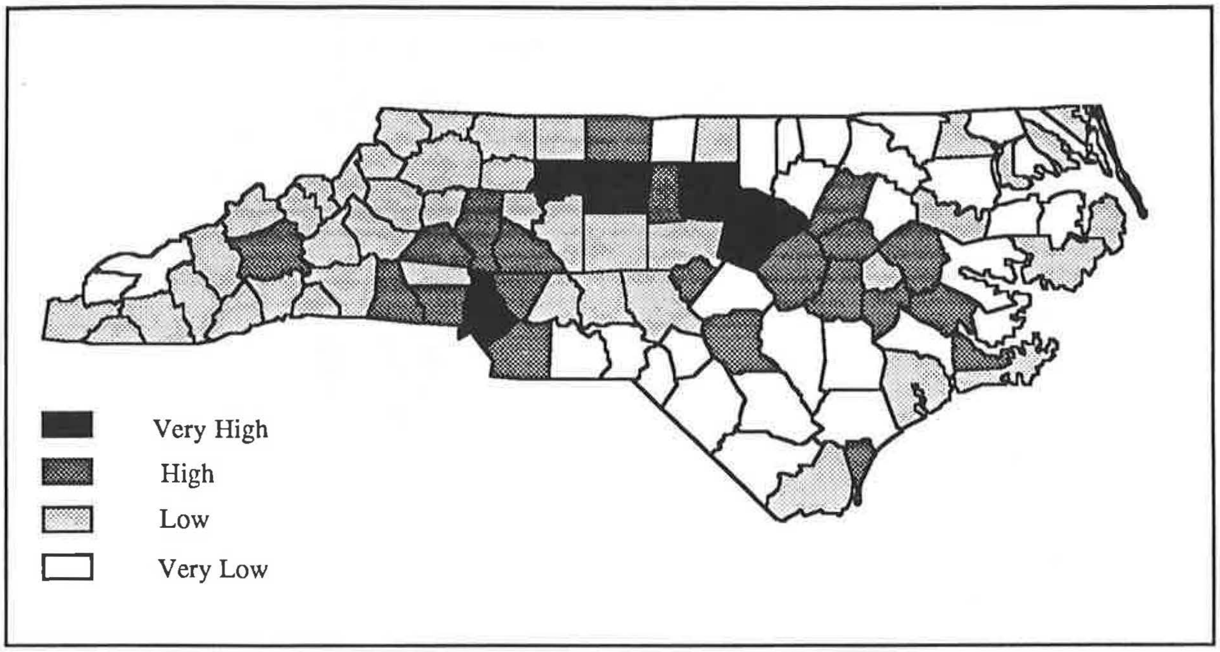

FIGURE 8 Socioeconomic status of counties.

the highest percentage of older persons and a fairly high unemployment rate. They have low health figures, size variables, and personal income, but not as low as Cluster 1.

- *Cluster 3 (Small Metropolitan and Suburban) (high)*—This cluster of 21 counties does not have any highest or lowest variables. These counties have fairly low numbers of persons aged 65 and over and a low unemployment rate. The rest of the variables are moderately high.
- *Cluster 4 (Affluent Metropolitan) (very high)*—This cluster is comprised of six counties: Mecklenburg, Guilford, Forsyth, Orange, Durham, and Wake. These counties have the highest health figures, percentage of population age 16 to 64, size variables, and personal income. They also have a fairly high percentage of nonwhites and families receiving AFDC. They have the lowest percentage of persons age 65 and over and the lowest unemployment rate.

Clusters 2 and 3 are much more similar to each other than are Clusters 1 and 2 or Clusters 3 and 4. Clusters 1 and 4 are the extremes of the variables and are very heterogeneous. Clusters 2 and 3 are in the middle statistically and are more homogeneous than the other clusters.

Transportation Variables

To develop a classification of counties on the basis of transportation variables, a list of about 90 transportation-related items was developed for each county. These include transportation access (distance and service levels) for each mode of travel; transportation expenditures by highway type; accessibility to Interstates, four-lane roads, and other roads; paved road miles; and roadway widths. This information was divided into three types, which were analyzed separately. The three types included the following:

- Internal (within-county) access,
- External (outside-county) access, and
- Fiscal (in-county) investment.

Internal Access Factor analysis of the internal access data set yielded a group of eight variables found to be important in county clustering. These variables described system size and urban-ness, system condition and quality, and traffic and system density. The eight variables include the following:

- Percentage of secondary roads;
- Percentage of urban roads;
- Percentage of primary roads;
- Total miles of road with more than four lanes;
- Interstate status (number of Interstates, number of Interstate exits);
- Percentage of narrow roads (lane widths <12 ft);
- Percentage of paved roads; and
- Total miles on the state highway system.

Cluster structuring of the counties on these eight variables yielded the five-cluster grouping shown in Figure 9. These clusters can be characterized as follows:

- Poor internal access, 26 counties (Cluster 1)
  - —Small system (approximately 570 mi)
  - —Very few four-lane roads, no Interstate
  - —High percentage of rural and secondary roads (72 percent)
  - —Medium percentage of narrow roads (57 percent) but high percentage of paved roads (78 percent)
  - —Prototype counties: Martin, Pamlico, and Jones
- Fair internal access, 25 counties (Cluster 4)
  - —Medium-small system (approximately 580 mi)

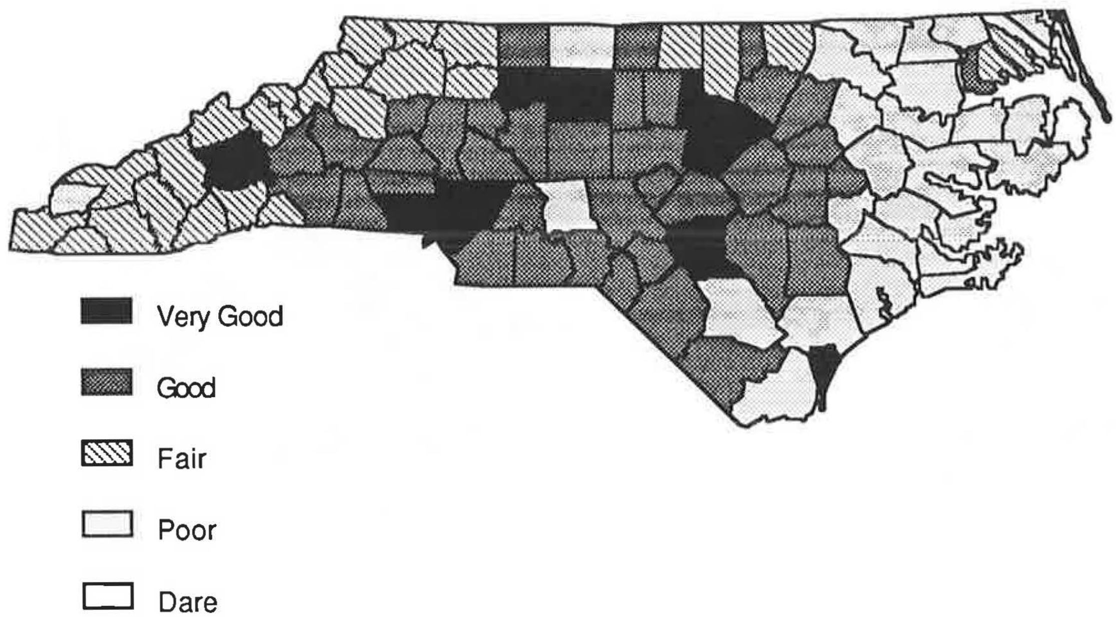

FIGURE 9 Internal access by county clusters.

—Contains at least one Interstate and some four-lane mileage
—High percentage of rural and secondary roads (80 percent)
—Low percentage of narrow roads (44 percent) and medium percentage of paved roads (62 percent)
—Prototype counties: Cherokee, Watauga, and Macon

- Good internal access, 38 counties (Cluster 2)
  —Large system (approximately 930 mi)
  —Contains at least one Interstate and some four-lanc mileage
  —High percentage of urban roads (5 percent) and high percentage of paved roads (82 percent)
  —Prototype counties: Wayne, Stanly, and Duplin
- Excellent internal access, 10 counties (Cluster 3)
  —Very large system (approximately 1,120 mi)
  —Large number of four-lane miles and Interstates
  —Very high percentage of urban roads (15 percent) and high percentage of paved roads (85 percent)
  —Prototype counties: Guilford, Durham, and Mecklenburg
- Special case—Dare County has a small spinal system, but a high percentage of urban roads through Manteo and Kitty Hawk.

Ten counties in North Carolina have excellent internal accessibility, and 38 have good systems. As Figure 9 shows, the counties with good systems are generally located in the Piedmont region, where the four major Interstates in North Carolina are located. The groups with fair or poor systems are located in the mountains and coastal regions.

External Access External access to a county is considered to be important in attracting manufacturing and other businesses because adequate access to production needs and markets is critical to a firm's viability. Straightforward definitions of access were used:

- Highways
  —Number of Interstate miles, number of exits, and closeness to town center
  —Number of four-lane miles of road
  —Number of federal-aid Interstate miles
- Air
  —Distance to major and minor hub airports
  —Number of annual operations at hubs
  —Number of enplanements at hubs
  —Distance to general aviation airports
  —Travel time to major hub
- Train
  —Distance to passenger train station
  —Number of train arrivals and departures
- Bus
  —Distance to bus station
  —County with rural or city bus system
- Port
  —Distance to port city

Unfortunately, data on rail freight access were not readily available.

Extensive factor and cluster analysis of these variables yielded a highly separated set of clusters based on six variables:

- Miles of Interstate open to the public,
- Total four-lane miles of road,
- Travel time to Interstate,
- Travel time to major airport,
- Distance to bus station, and
- Distance to train station.

Figure 10 shows the cluster structure. The 100 counties are grouped as follows:

- Very low external access, 9 counties
  - —No Interstate, average 1½ hr to nearest Interstate,
  - —Average 7 mi of four-lane road,
  - —Average 2¼ hr to major hub airport,
  - —Average 94 mi to train, and
  - —Average 36 mi to bus.
- Low external access, 30 counties
  - —Little or no Interstate, average 74 min to an Interstate;
  - —Average 16 mi of four-lane road;
  - —Average 2 hr to major hub airport;
  - —Average 55 mi to train; and
  - —Contains or close to bus service.
- Moderate external access, 29 counties
  - —Little or no Interstate, average 30 min to an Interstate;
  - —Average 20 mi of four-lane road;
  - —Average 60 min to major hub airport;
  - —Average 41 mi to train; and
  - —Contains or close to bus service.
- High external access, 26 counties
  - —Average 23 mi of Interstate,
  - —Average 48 mi of four-lane road,
  - —Average 48 min to major hub airport,
  - —Average 35 mi to train, and
  - —Contains bus service.
- Very high external access, 6 counties
  - —Average 30 mi of federal-aid Interstate open,
  - —Contains average 153 mi of four-lane road, and
  - —Contains train station and bus service.

The analytical structure of the data shows that the top two groups, containing 32 counties, are more similar to each other than to the other three groups.

Transportation Investment Fiscal investment is a vital part of the transportation overview of each county. The more money a county receives in highway aid, the better the county's transportation system. The fiscal picture for each county was developed from North Carolina Department of Transportation (NCDOT) statistics and investments from the period 1973–1985. Data included the following:

- Secondary expenditures per mile,
- Urban expenditures per mile,
- Primary expenditures per mile,
- Total expenditures per mile,
- Interstate expenditures,
- Secondary expenditures per capita,
- Urban expenditures per capita,
- Primary expenditures per capita,
- Total expenditures per capita, and
- Total expenditures from 1973 to 1985.

Of the 25 variables analyzed, a surprisingly small number (four) were sufficient to explain county expenditure patterns. These are as follows:

- Total Interstate expenditures, 1973–1985;
- Urban system expenditures per mile, 1973–1985;
- Primary system expenditures per capita, 1973–1985; and
- Secondary system expenditures per capita, 1973–1985.

The resulting five-cluster structure is described as follows:

- Low urban mileage and high urban expense rate, 6 counties (Cluster 5)
  - —No Interstate expenditures;
  - —$216,000/mi urban expenditures;
  - —$400/capita, primary expenditures;
  - —$300/capita, secondary expenditures; and
  - —Prototype counties Watauga and Pasquotank.
- Primary system focus, 6 counties (Cluster 4)
  - —No Interstate expenditures;
  - —$48,000/mi urban expenditures;
  - —$2,400/capita, primary expenditures;
  - —$380/capita, secondary expenditures; and
  - —Prototype counties Madison and Dare.

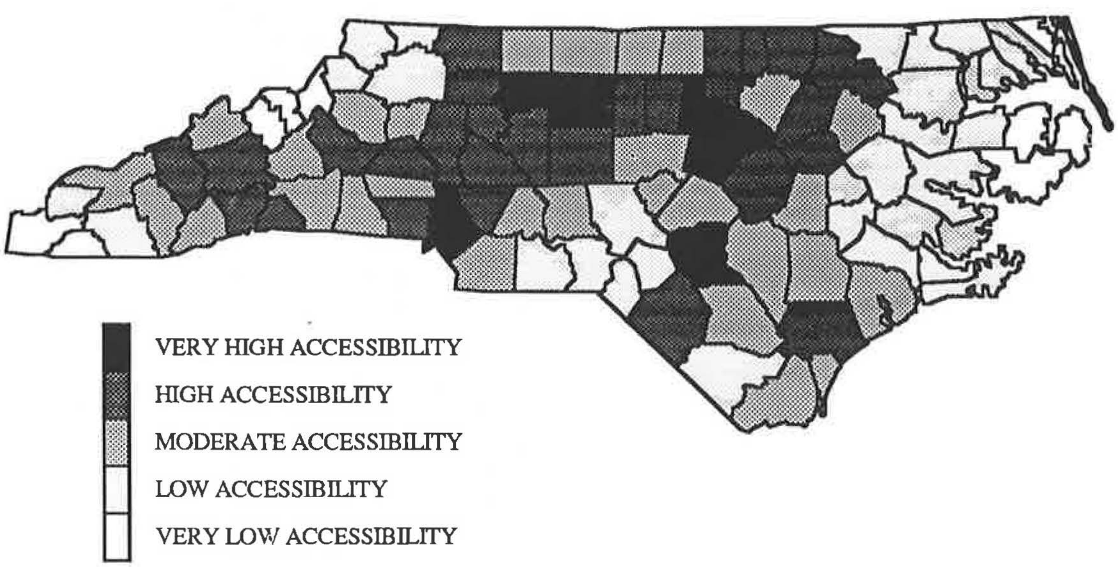

FIGURE 10 External accessibility of counties.

- Various needs, 59 counties (Cluster 1)
  —$6 million Interstate expenditures;
  —$36,000/mi urban expenditures;
  —$250/capita, primary expenditures;
  —$130/capita, secondary expenditures; and
  —Prototype counties Chatham, Lee, and Catawba.
- Primary and secondary focus, 20 counties (Cluster 2)
  —$1.5 million Interstate expenditures;
  —$13,000/mi urban expenditures;
  —$630/capita, primary expenditures;
  —$325/capita, secondary expenditures; and
  —Prototype counties Gates, Carteret, and Caswell.
- Interstate focus, 6 counties (Cluster 3)
  —$84 million average for Interstate expenditures;
  —$55,000/mi urban expenditures;
  —$360/capita, primary expenditures;
  —$125/capita, secondary expenditures; and
  —Prototype counties Mecklenburg and Wake.

Survey of Manufacturers

The survey of manufacturers is currently being piloted. The sampling plan for manufacturing firms will be based on county and industry group (see Table 2). In each of the cells of the table, the universe of firms (N_f) with a universe of employers (E) will be developed from the North Carolina Department of Industry and Commerce data tapes. From each cell, a sample size ($\hat{n}_f$) with an associated employment ($\hat{e}$) will be estimated to ensure statistical reliability and balance. Samples will then be inflated by a factor of 2.5 to account for nonresponse. The actual returns in each cell (n_f) with employment e will then be factored to represent North Carolina manufacturing employment and total firms. That is,

$$\text{Factor}_{\text{firm}} = \frac{N_f}{n_f}$$

$$\text{Factor}_{\text{employment}} = \frac{E}{e}$$

for each cell. About 800 to 1,000 returns are anticipated.

Policy Analysis

Key items related to policies the state might undertake to improve access to counties or to increase manufacturers' satisfaction with sites are identified. As an example, consider a proposal to build a 150-mi loop around Charlotte, about 30 to 40 mi out. Such a loop would make several of the counties more accessible by increasing their four-lane road mileage. A preliminary estimate of changes in mileage, and resulting changes in cluster grouping, are presented in Table 3.

The outer-outer belt would radically increase the accessibility of Lincoln County (moving it from Spot 3 up to Spot 19 in Cluster 1), Cabarrus County (moving it from the bottom in Cluster 2 to Spot 45 in Cluster 1), and Stanly County (moving it from Spot 15 to Spot 25 in Cluster 1). Iredell County would jump from Cluster 2 to Cluster 5, joining five other metropolitan counties as the most accessible in the state.

TABLE 2 SAMPLING PLAN FOR MANUFACTURERS SURVEY

County	Industry Group 1	2	3	4
1				
2	Universe	N_f E		
	Sample	$\hat{n}_f$ $\hat{e}$		
3	Actual	n_f e		
4				
5				

POLICY IMPLICATIONS AND CONCLUSIONS

The study has already yielded a number of important policy findings, which may be of use in other efforts.

First, except perhaps in the smallest of states, a homogeneous state economic structure or transportation-access structure does not exist. Therefore, policies related to these factors should be capable of being targeted at the county, subcounty, and perhaps the corridor level. States must recognize that individual counties will have different needs for transportation access. Different transportation investments in various regions of the state will yield different results. The conclusion argues for a county or regional approach to transportation-investment assessment. In such a context, regional economic models at the state level are not likely to be particularly successful.

Second, although it is possible to develop and manipulate extensive analytical tools during the analysis of transportation and economic development, these tools are not necessary for most studies. The authors' analytical work in recent studies has been relatively straightforward and has focused almost entirely on the use of aggregate relative trend statistics by county. The use of analytical tools such as factor and cluster analysis may aid the investigation but are certainly not essential. Thorough study planning and straightforward, descriptive analysis results can yield a great deal of valuable information.

Third, perhaps not surprisingly, transportation access was found to be a nonprimary variable in overall siting decisions. An affirmative location decision will not occur in the absence of good accessibility, but, conversely, the presence of a good highway is not apt to be a decisive factor. The transportation systems in many states are extensively developed and provide good access to distant markets by high-level Interstate systems. As noted earlier, the virtual completion of the Interstate

TABLE 3 EFFECT OF CHARLOTTE LOOP ON COUNTY ACCESSIBILITY

	Without Outer-Outer Belt			With Outer-Outer Belt		
County	Four-Lane Roads (mi)	Cluster	Position	Four-Lane Roads (mi)	Cluster	Position
Cleveland	48.20	1	38	63.20	1	40
Lincoln	20.58	1	3	30.58	1	19
Iredell	66.94	2	23	77.94	5	5
Cabarrus	39.81	2	1	52.81	1	45
Stanly	14.31	1	15	26.31	1	25
Union	28.40	1	26	59.40		35
Gaston	68.43	2	9	75.43	2	4

system has made good highway accessibility a reality for many previously less well served areas. Although the most rapid economic growth is likely to continue in those regions that are the most accessible, increasing the accessibility of other regions will not necessarily accelerate their growth. Furthermore, the most accessible regions also have infrastructure, markets, labor supply, and other assets to attract economic growth. At the site scale, transportation access is critical to a firm's success; in the aggregate, at a county or state level, it has a less discernible impact.

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