

Distributional Effects of State Highway Investment on Local and Regional Development

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Previous studies suggest that a minimal or restricted relationship exists between transportation and economic development. Conclusions drawn from these studies result from three factors. First, the studies considered the transportation-development relationship at substantially different geographical scales ranging from large-scale multistate regional studies to small land use projects. Second, at the subregional scale most studies used cross-sectional, correlational analysis; however, this type of analysis is unable to determine the direction of the relationship between the two variables. Third, the studies paid too little attention to the long delays inherent in transportation-development interactions. A method that examines the situations in which transportation investments seem to temporally precede changes in the local economy was used in this study. It was found for total employment by using vector autoregressions and causality tests that highways encourage long-term economic development in excess of the normal trend in Minnesota's regional centers and counties under the urban influence of the state.

Where should a state spend money if it wants to positively influence its economy? A research team at the University of Minnesota recently studied this issue, looking at the effectiveness of highway funds in increasing economic development. Researchers examined the employment and income implications for counties in the upper midwestern region of the United States, with emphasis on localities and regions in Minnesota (1,2).

Most states in the upper Midwest are characterized by a geographically dispersed population, requiring investment of funds into transportation infrastructure. Despite federal aid, transportation investment is typically a major component of the state budget [in the United States, state spending for highways totaled \$38.2 billion in 1986, representing 9 percent of the budget, ranking third after education and welfare (U.S. Census Bureau)]; the U.S. Department of Transportation (DOT) bears responsibility for how these funds are spent. In addition, hoping that state policies are more effective than federal ones, some states in the region have been assuming a greater role in the design of economic development programs. Investment policies directed to improving the transportation infrastructure have played a key role in such programs.

Within the United States, 36 states explicitly consider regional economic development as a justification for highway funding and as one factor that influences decisions about the highways in which to invest (3). In the upper Midwest, one of the most

ambitious programs is Revitalize Iowa's Sound Economy (RISE), which provides \$27 million in annual funding dedicated to highway construction and improvement projects intended to foster economic development in Iowa over a 5-year period (4). The consideration of regional development objectives in highway funding is valid, however, only if highways have a significant impact on regional development, that is, create jobs, increase income, and improve community welfare. There is disagreement as to whether, and in what contexts, this is the case.

In Minnesota, government transportation-related policies play both an active and a passive role in regional economic development. Government is a passive player when it improves highways to support economies that are already improving. It has done this, often effectively, in regional centers, where it rewards development and, in turn, acts as a catalyst for more development by removing accessibility barriers and bottlenecks. Government becomes an active player when it improves highways in an attempt to stimulate development in local economies that are deteriorating. Such attempts usually occur in rural areas but are not always effective. Improved roads tend to hurt the economies of rural areas in the long run if such areas are located near regional centers and if no other concurrent policy is instituted to encourage development. Far from regional centers, rural areas stand to benefit from improved roads if they can use them to improve the access of products (timber and farm products, for example) to markets and of tourists to the area.

PREVIOUS FINDINGS

The traditional view in the literature has been that the improvement of the transportation infrastructure is a necessary predecessor to economic development in a region. However, as Sheppard suggests, in the last 10 to 15 years this view has come under heavy criticism from a number of directions (5). Empirical research in a number of countries provided a series of counterexamples that called this view into question. In particular, studies of transportation and economic development plans in the Soviet Union and China, as well as of the development of the railroads in the United States, showed that transportation can be concurrent with or a result of regional economic development rather than its predecessor. Similarly, research into the role of transportation in European and third world countries also uncovered many instances where the development of transportation into the interior exacerbated

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rather than decreased economic development differentials between the major cities and rural regions. Furthermore, the complexities of the interdependencies between places in a well-integrated spatial economic system, such as in Minnesota, may mean that the effects of transportation improvements are hard to predict and not necessarily beneficial (5).

For instance, in the Atlantic region of Canada, increased investment in the area's reasonably mature transportation infrastructure would attract few industries (6). Similar studies of the Ozark plateau of Arkansas found little correlation between highways and economic development (7). In cases in which a relationship was found, the effect was minimal [as in an analysis in the north of England (8)] or very restricted [in Connecticut, Pennsylvania, and elsewhere, it was determined that counties with Interstate highways have an advantage over other counties with regard to population and employment growth but long-term effects were observed only in counties within 25 mi of a metropolitan area (1)]. It is generally acknowledged that there are few places in the United States where transportation infrastructure deficiencies per se strictly preclude economic activities (9).

The inconclusive and occasionally contradictory conclusions on the relationship between transportation and economic development are the result of three major developments. First, previous studies have considered this issue at substantially different geographical scales, ranging from large-scale multistate regional studies on one extreme to small urban land use projects on the other, and on the basis of a wide range of implicit assumptions. There is no reason to believe that the process works in the same manner at all different scales (5). Second, at the subregional scale of analysis (i.e., county and multicounty, up to state scale), which is of interest to us, most previous studies have used cross-sectional, correlational analysis, although such analysis is unable to determine the direction of relationship between two variables.

Finally, previous studies have paid too little attention to the long delays that are inherent in the transportation-economy interactions. For instance, a substantial highway reconstruction project may take 2 years to complete, and it may take another 3 years before regional industries fully realize benefits from the highway improvement by restructuring their transportation operations and increasing their competitiveness in their markets. Indirect effects from these immediate benefits, such as expansion of headquarters and employee relocation, may happen over an additional 3 to 5 years. If a 1- or 2-year waiting period is added before an approved reconstruction project actually begins, the results of an investigation of the possible interactions may differ depending on the year—over a 10- to 12-year period—in which the analysis takes place. The time series analysis takes into account time-related effects such as these and, therefore, is more likely to increase the accuracy and consistency of the findings, and can come closer to distinguishing between cause and effect.

In summary, in a well-integrated spatial economic system, the effects of transportation improvements are complex and hard to predict. The best way to empirically evaluate the possible effects of transportation investment on the economy would be to examine situations in which transportation investment does seem to temporally precede changes in the local economy, and to determine whether, in which situations, and after what length of time that impact is likely to be positive,

neutral, or negative. This research direction was adopted by this project.

DATA SOURCE

Highway expenditure figures used in this study are based on data compiled by the Minnesota Department of Transportation (DOT) as part of the annual project funding system. The data are broken down by county, for all 87 Minnesota counties for the years 1957 to 1982, and are limited to the state trunk highway system, which includes the major highway projects funded by the DOT. The employment data from *County Business Patterns* represent employment in the middle of March for the years 1964 to 1982. In particular, the analysis includes nine different levels of employment (*E*), by place of work, and eight different levels of income (*Y*), by place of residence, as follows:

Manufacturing	<i>E, Y</i>
Retail	<i>E, Y</i>
Service	<i>E, Y</i>
Transportation and public utilities	<i>E, Y</i>
Construction	<i>E, Y</i>
Finance, insurance and real estate	<i>E</i>
Wholesale	<i>E</i>
Agricultural	<i>E</i>
Farm	<i>Y</i>
Earnings by work	<i>Y</i>
Total	<i>E, Y</i>

First, effects reflecting the dominance of the size of a county, regional or national trends, inflation, and other effects that were common across several counties in a group were filtered out. Following a quasi-experimental approach, groups of counties were formed on the basis of county characteristics. Within a group, counties were expected to react more homogeneously to highway changes and may be treated in a similar fashion for policy purposes. Previous research used a primitive classification based on intervals; for instance, a criterion was whether a county in a class included a city with a population of 28,000 or larger (10). In this project, the effectiveness of the classification is increased by forming groups on the basis of characteristics that better reflect the local features of counties. In addition, characteristics are included that reflect the interaction between counties, recognizing that counties depend in part for their growth on their neighbors.

In selecting the features for classifying the 87 Minnesota counties, the objective was to develop a set of not-too-data-hungry features sufficient for extracting the major county characteristics necessary for classification. In particular, features familiar to the transportation policy analyst that (a) could be easily quantified with existing data; (b) could capture the socioeconomic, demographic, and accessibility differences across counties; and (c) were least correlated with each other were sought. To achieve this objective, formal feature extraction through pattern recognition was obtained from the Karhunen-Loeve expansion [principal component analysis (11)]. The standard feature extraction was modified to allow incorporation of input by experts, including several policy makers, geographers, and government decision makers in Minnesota and some neighboring states. The resulting six most

important features, to be used for classifying the Minnesota counties, were as follows:

1. Accessibility within a county, measured by percent county area covered by paved and unpaved roads;
2. Accessibility between counties, measured by number of all roads crossing county border divided by county perimeter, no weight provided for number of lanes per road;
3. Population density;
4. Population dominance, measured by average of population densities of adjacent counties. This feature can indicate the potential for increased travel between counties given improved accessibility;
5. Average salary income per household; and
6. Median age, which can indicate the potential for mobility as, for instance, of people within a certain age bracket who are expected to more easily travel across counties to find work if there is access.

Alternative features could have been considered (e.g., travel time as an access indicator between counties), and every feature has certain strengths and weaknesses. Similarly, adding more features might have incrementally improved the ability of the feature set to capture certain intricate details of a county economy. However, the list, representing the result of the feature extraction subject to the consensus of experts, can be adopted as a working set for county classification.

The filtering was accomplished in several ways. First, all variables of a county (such as county expenditures or employment) were defined relative to the county group to which that county belongs. This definition filters out exogenous events (such as inflation, unemployment, and federal funding) that may have similarly affected all counties in the group. Second, each variable was redefined by subtracting the historical average over the study period (e.g., the time average over 26 years) so that the data from all counties for all the years can be included in the analysis. Third, the dominance of large counties, for which the absolute variation of employment and highway expenditures would be greater than in small counties, was filtered out. Although this filtering does not guarantee that all effects of outside factors were eliminated, it does ensure that the potential influence of the factors considered to be most important was substantially reduced.

Following filtering, time series analysis (vector autoregressions) of the data, enhanced with the employment of Granger-Sims causality tests (12–14), were performed. The tests can be an aid in inferring whether a directional influence by a variable (such as highway expenditures) on another (such as employment) also indicates that the first variable “causes” (i.e., consistently precedes) the second. To be sure, causality analysis was used with caution, because of its limitations (15, 16). In particular, the literature and experience suggested that, in most cases, the causality test was overly strict, occasionally indicating no causality although one would be expected from theoretical or empirical considerations. However, the test can document lack of causality reasonably well when two variables would be expected to be irrelevant. Knowing this, when causality was weak, increased emphasis was placed on consistent vector autoregression results. Overall, although the analysis was certainly imperfect, it erred most likely on the conservative side. In other words, there may exist additional

causalities between variables, that strict application of the tools—causality tests, direct examination of time series plots, and theoretical and empirical expectations—may have missed.

As the foregoing indicates, classifying the 87 counties in groups on the basis of their characteristics was an essential element of the filtering process. In addition, classification made the analysis of the results more meaningful because it allowed focusing on each group of counties separately. In particular, because possible relationships between highway expenditures and economic development would be likely to differ across groups, a separate relationship was developed and evaluated for each group, thus making easier the identification and understanding of possible impacts by group.

Following classification, four county groups were identified (see Figure 1):

1. *Regional Centers.* Counties in this group are characterized by minimum age and maximum value in all other features relative to all cluster averages. These include nine counties, that is, the Twin Cities greater metropolitan area and Olmsted County in the south, where the city of Rochester is located.
2. *Counties under Urban Influence.* Medium value in all six features (28 counties).
3. *Agricultural Counties.* Maximum age and low value in all other features (37 counties).
4. *Natural Resource Counties.* Minimum value in all features and medium age (13 counties).

Although these classifications and the earlier one (10) have several common elements, they also differ in several important ways. In particular, in the new classification the regional centers are not distributed throughout the state as before. Instead, they include the greater Twin Cities metropolitan area plus Olmsted county. Owing to the presence of two major employers in Rochester, the Mayo Clinic and IBM, Olmsted county has a high concentration of health and computer manufacturing services and substantial interaction with the rest of the world via air.

The Minneapolis-St. Paul metropolitan area has been described as a finance, insurance, service, and market center for the upper Midwest. However, with 10 percent of the nation's computer manufacturing in Minnesota, the Twin Cities' reputation in technologically oriented services stems primarily from its involvement in computers. Also contributing to the technological reputation are the companies that have corporate headquarters in the area, tying it with San Francisco-Oakland for seventh place in the nation for the 500 largest U.S. industrial firms. One factor that may have contributed to the impressive development of the service economy is the central location of the Twin Cities within the airline network. Benefiting from this factor, consumer services have also grown, especially tourism and health services.

The rest of the counties that the earlier, population-based classification had identified as regional centers are now in the “under-urban-influence” group. Joining this group are all the counties in the southeast corner of the state. These counties are characterized by light manufacturing and form a southeast-northwest corridor of robust economic activity.

The counties that the previous classification had identified as rural are divided into two groups in agreement with the general character of their economy. Although Minnesota's

- Regional Centers
- ▨ Counties under Urban Influence
- Agricultural Counties
- ▤ Natural Resource-Based Counties

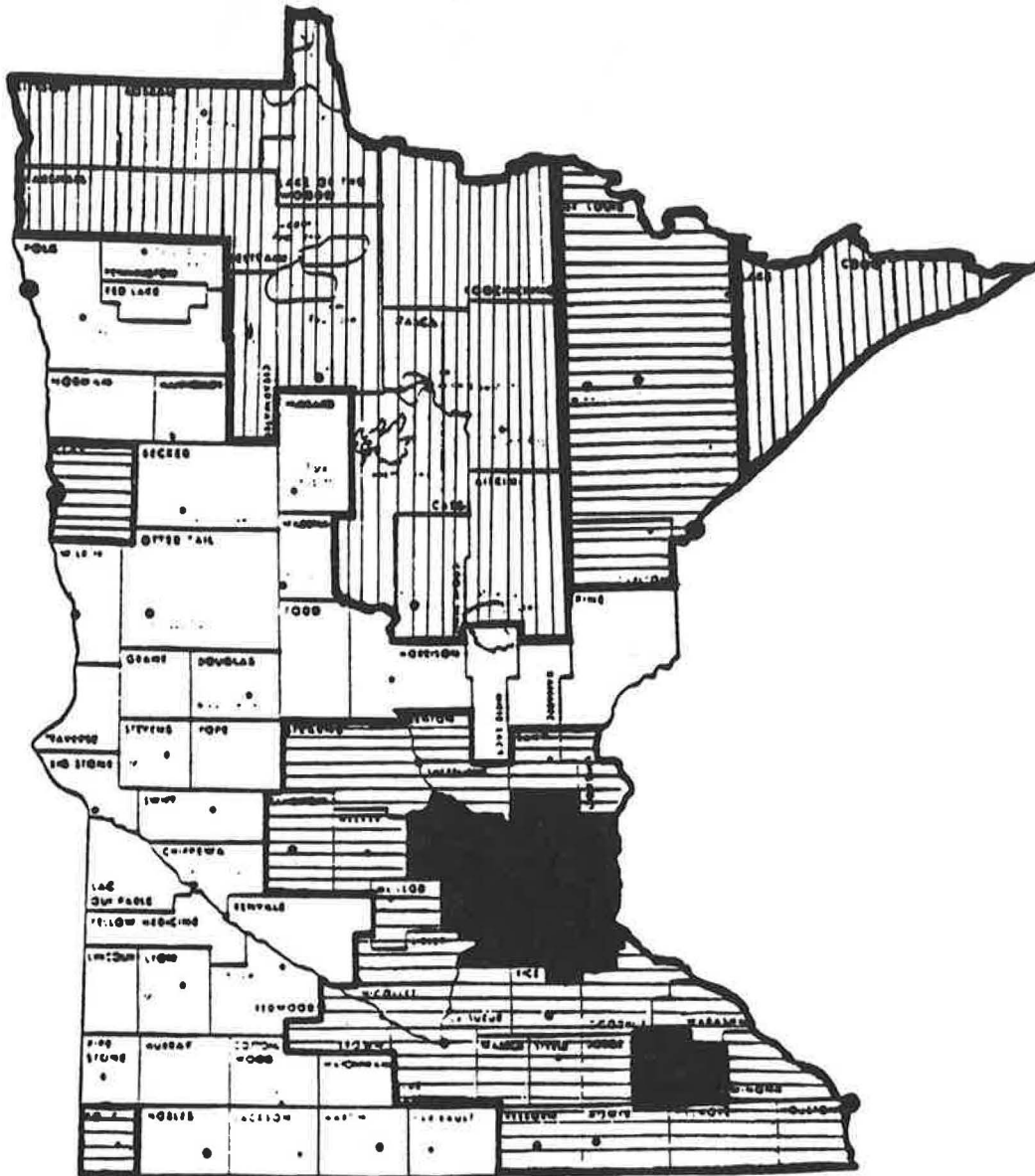


FIGURE 1 Classification of Minnesota counties on the basis of demographic, economic, and locational variables.

economy is diversified, the economy of these areas is specialized. In particular, the north-northeast (natural resource counties) depends heavily upon timber, mining, and tourism, and the west part of the state (agricultural counties) depends on agriculture. Despite the continuing depletion of forests, manufacturing based on lumber products is strong. Although the lumber and wood products industry is evenly dispersed throughout the state, the majority of lumber is harvested in the northeast, where paper producers have also tended to

locate (see Figure 2). For instance, in Carlton and Koochiching counties forestry accounts for 75 percent of the local economy. Tourism services have highest concentration in north Minnesota (see Figure 3). Comparisons of specific economic sectors of Minnesota's economy to that of the United States as a whole are shown in Figure 4.

Although this classification facilitates analysis, it does not fully address certain county peculiarities. For instance, St. Louis could be divided into three parts, each classified in a

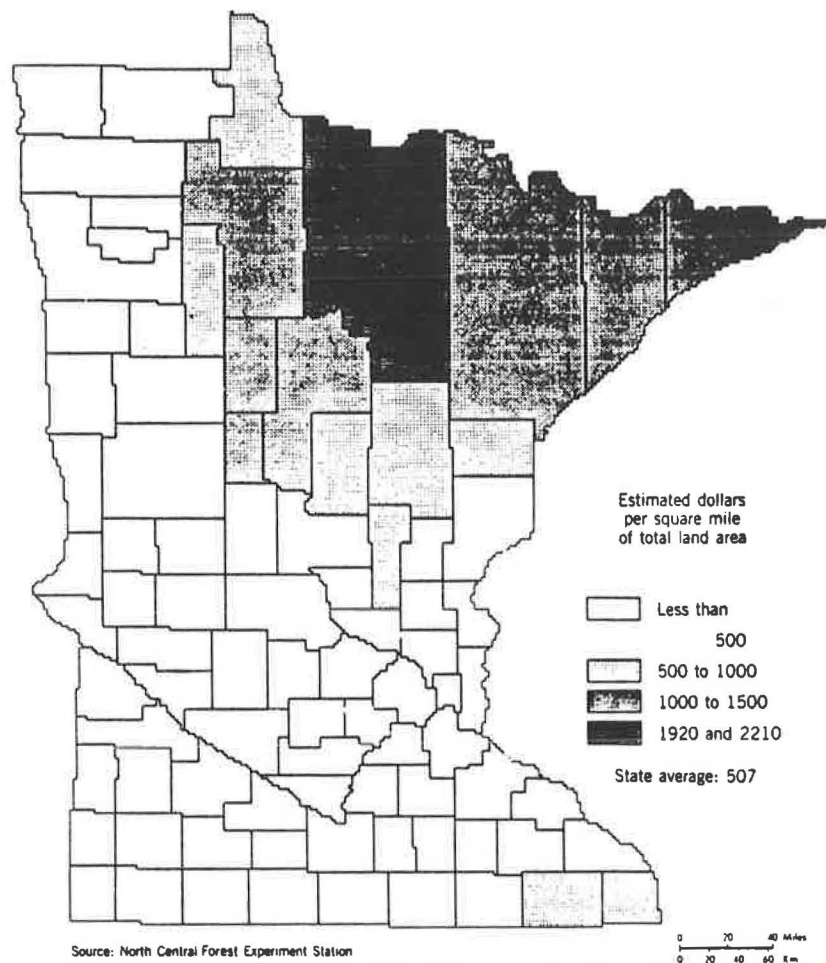


FIGURE 2 Value of timber cut, 1975.

different cluster, if data for each part were available. Further, Clay and Rock are substantially influenced by the neighboring counties Cass (which includes the city of Fargo) and Minnehaha (Sioux Falls) in the Dakotas and, therefore, the Dakota counties could also be included in the analysis. Kittson has a strong agricultural character and, similar to Cook, is strongly influenced by border movements; as a result, the presence of both counties in Group 4 may not be fully justified. If such potential inconsistencies are appropriately treated, the classification could lead to analytical results of higher accuracy.

RESULTS

Influence of Transportation on Economic Development

Regional Centers and Counties Under Urban Influence

Regarding total employment (i.e., the summation of employment for all sectors of the economy), the vector autoregressions and the causality tests provide evidence that highways "cause" (i.e., temporally precede in a systematic manner) long-term economic development in excess of the normal trend in Minnesota's regional centers and counties under urban

influence. These counties include the economic centers of the state and, therefore, are most likely to have the economic activity that is necessary for absorbing the highway improvements. Of the new jobs, a few are created in the 2nd year but most are created in the period between the 5th and the 10th year following the highway expenditures. The effect of a one-time increase of highway expenditures on total employment for the regional center counties is shown in Figure 5. This effect was significant at the 1 percent level by a causality test.

Although these findings are in agreement with the earlier results (10), they provide certain additional details. For instance, they indicate that, within the original regional center group of the earlier study, the counties that are located outside the metropolitan area [i.e., St. Louis (Duluth), Clay (Moorhead), Stearns (St. Cloud), Blue Earth (Mankato), and Olmsted (Rochester)] are as likely to benefit from highway investment as are the metropolitan area counties.

Natural Resource Counties

Improved highways generate income and employment in the natural resource counties and, in particular, in two sectors, service and retail. (Service employment is up to 33 percent

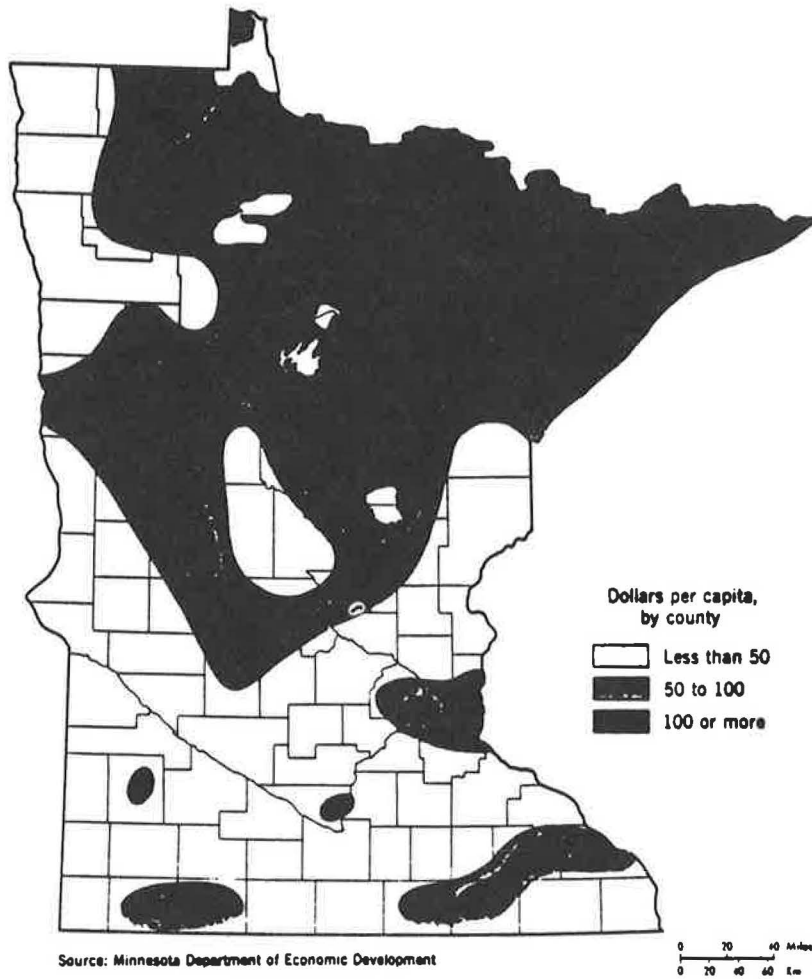
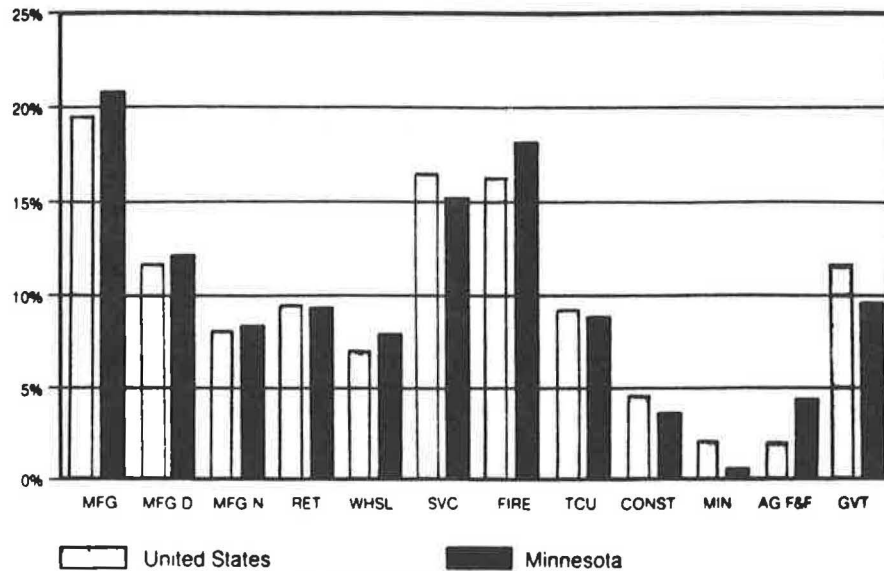


FIGURE 3 Hotel and motel receipts, 1978.

Composition of Minnesota GSP, 1986



Source: Bureau of Economic Analysis, U.S. Department of Commerce.

FIGURE 4 Minnesota economy versus the U.S. economy.

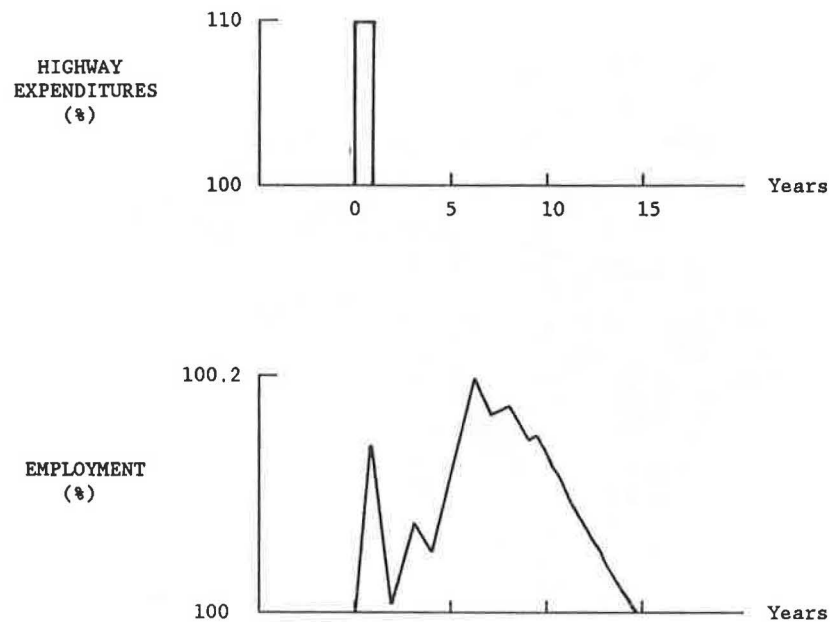


FIGURE 5 Regional center counties: impact of highway expenditures on total employment (percent above trend).

of total employment in these counties, higher than a maximum of 26 percent in the other county groups). Although these effects are in general agreement with the literature, the service effect is also long term, which was not entirely expected. The long-term service effect indicates that the service sector in these counties is eager to provide more jobs to the economy and its expansion can be hampered by the lack of good roads. To be sure, the density of the highway system is low, with only two major highways running through and out of the counties (Highway 62, crossing the northern edge of Lake and Cook, and Highway 29, running right out of the border of Marshall and Kittson). At the northern border with Canada, lakes and forests impede highway communication.

All highway effects on the economy of these counties are positive, indicating a potential for the appropriate use of highway expenditures for economic development in this part of Minnesota.

Retail Impacts

Retail activity is affected by highways in every group of counties. Although highway construction in urban and regional centers can impede business, the effect is stimulative in agricultural and natural resource counties. In the latter counties, retail activity represents a large part of the local economy—up to 31 percent of total employment, compared with a maximum of 25 percent in the remaining counties.

Figure 6 shows the impact of a one-time 10 percent increase in highway expenditures on retail employment in the natural resource counties. As Figure 6 indicates, following the increase in highway expenditures in the first year, retail employment also increases. Although most of the employment increase occurs in the first 6 years, the effect lasts approximately 10 years. The duration of the impact, which is significant at the 1 percent level by a causality test, is as long as that in re-

gional centers (see Figure 5) and much longer than that in the previously defined rural areas [3 years—see discussion by Stephanedes and Eagle (10)].

Further, the maximum impact occurs in the second year, when the employment increase reaches a peak of 2.5 percent in response to the increase in highway expenditures. This compares with a peak of 0.2 percent in the sixth year for the case of the regional centers. The comparison indicates that the effect in natural-resource-based rural counties can be higher by an order of magnitude, in relative terms, than in regional centers. However, as the total employment in the latter is high, the absolute effect in terms of total number of jobs in regional centers is greater.

The finding of a positive retail effect is encouraging for policy makers advocating the potential for improvement in the economy of rural areas if the local highways are improved. The finding also indicates that such potential exists only in rural areas already having a strong resource base in place to take advantage of the highway improvements.

Influence of Economic Development on Transportation

Statewide

The response of highway investment to higher total employment is immediate and positive statewide and, in particular, in the agricultural and natural resource counties, indicating the eagerness of the state government to aid any increasing economic activities in Minnesota. In addition, the sensitivity of highway investment relative to changes in employment is substantial: an increase of jobs by a given percentage (say, 10 percent) above the trend attracts an additional investment statewide of almost double the size in percentage terms—18 percent over 10 years; in other words, an extra 100 jobs would attract an extra \$28,500. Following detailed accounting of this

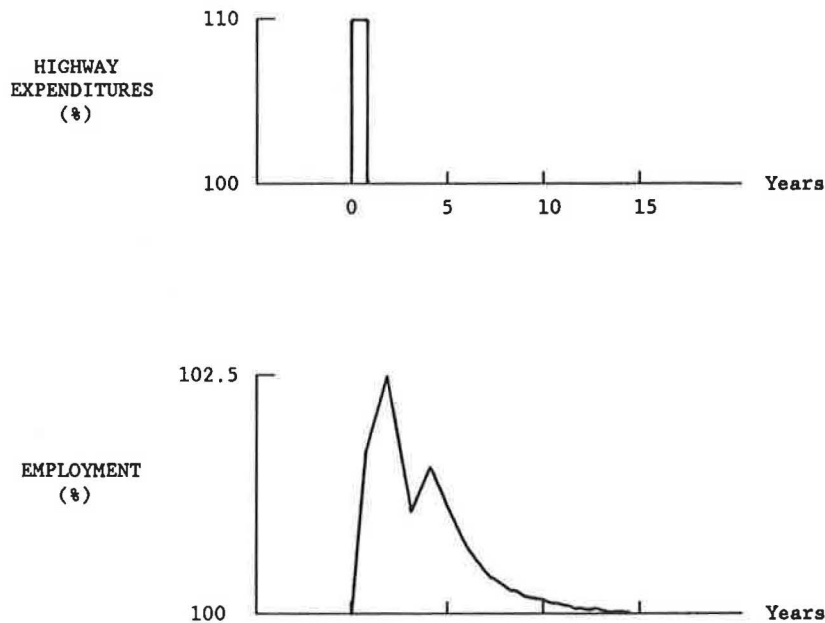


FIGURE 6 Natural resource counties: impact of highway expenditures on retail employment (percent above trend).

effect and the stated influence of highways on employment, at current funding levels and employment, it is estimated that approximately 1 of every 60 new jobs is created by Minnesota Department of Transportation state trunk highway funds.

Government Active and Passive Roles

In general, government reacts to economic improvements and does not seek to play an active role by stimulating a contracting economy. Natural resource counties (and farm-related activities in certain agricultural counties) are the major exception. In these counties, government plays an active role, with a tendency to stimulate the local economy through highway expenditures when income drops. As the results of this analysis indicate, such a policy appears to be effective in the natural resource, but not always in the agricultural, counties.

The effectiveness of the active government role in the natural resource counties indicates that the state policy makers appreciate the needs of the timber and tourist industries in the north-northeast part of the state and their potential benefit from road improvements. At the same time, the local industry is able to take advantage of the improvements. This regional relationship appears to have the ingredients for a success story.

DISCUSSION OF RESULTS

Following the evaluation of the time series results, a sensitivity technique was used to determine whether there are indications that one or more counties have been misclassified, thus influencing the interpretation of the findings. Kittson county, located at the northwest corner of the state, appears not to fit well with the rest of the counties in the natural resource group. Farm income in Kittson appears to substantially affect highway decisions; yet, improved roads have no significant effect

on the Kittson economy. In fact, without Kittson, the impact of highway investment on the counties in this group is greater than that found earlier.

An additional finding was that Beltrami and Marshall were the principal representatives of this group, that is, they carried a major portion of the identified relationships between highways and the economy. Furthermore, except for the unwanted influence of Kittson (and, to lesser extents, Lake and Cook), all counties in this group contributed to these relationships, indicating the strength of the effect on the economy of these counties that use the better roads to improve access of timber and farm products to markets and access of tourists to the area.

In an earlier study (10), several of the natural resource counties had been classified under the "next-to-urban" or "next-to-regional center" heading. Findings from that study indicated that highways have a long-term negative impact on the economy of these counties, seemingly contradicting the current findings. However, the "next-to-urban" or "next-to-regional center" group had also included several of the counties now called "agricultural." It can be inferred that the negative impact observed is limited to the agricultural counties; improved highways in those counties draw business activity away from them and into the regional centers in the long term.

That improved highways tend to help the economy of regional centers and areas under urban influence and to hurt certain of their adjacent counties should not be surprising. In particular, the adjacent counties tend to depend on these areas for the infrastructure necessary for development; better highways may allow agricultural county residents to conduct more of their economic activities in the nearby centers. Further, a comparison of the percentage of people working (66 percent) and living (47 percent) in the regional centers strongly suggests that highways are helping the residents of the adjacent counties to get to work as well as providing jobs for them.

The distributional nature of the effects is evident when analyzing the different parts of the state. In particular, although certain counties are likely to gain from improved roads, others are likely to lose; the statewide effect is not significant. Moreover, the statewide effect is small in size: over 10 years, a 10 percent investment increase would lead to only a 0.01 percent increase in jobs statewide (or, an extra \$1 million would create an average of only 5 to 8 new jobs statewide), most from the spending associated with construction of the highway. This finding is in agreement with conclusions drawn from the geography literature (5) indicating that, where the highway network is good and most services are widely available, any effects of transportation improvements on services are likely to be more dramatic in competition between service locations than on the overall disposition of consumers to purchase goods.

The negligible economic effect of highway funding on a statewide basis indicates that, as long as Minnesota is viewed in isolation from its adjacent states, the potential for statewide economic gains could not be a valid argument on which to base decisions for increased highway funding in Minnesota. However, the findings suggest that highway investment can be used for shaping regional development policy within the state. Similarly, it can be argued that, if Minnesota is viewed in competition with the neighboring states in the upper Midwest, transportation improvements in the state could result in economic gains.

CONCLUSION

This project conducted an analysis of the time-dependent impacts between highway funding and economic development in counties and regions in Minnesota. In particular, it examined the effects of highway funding on local employment and income, and the influence of local economic changes on highway funding. The findings indicate that, in Minnesota, government plays both an active and a reactive (passive) role in regional economic development.

Government is a reactive player when it improves highways to support economies that are already improving. It has done this, often effectively, in regional centers and counties under urban influence, where it rewards development and, in turn, acts as a catalyst for more development by removing accessibility barriers and bottlenecks. Government becomes an active player when it attempts to stimulate development in local economies that are deteriorating. Such attempts usually occur in rural areas but are not always effective: improved roads tend to hurt the economies of rural areas in the long run if such areas are located near regional centers. Far from regional centers, rural areas stand to benefit from improved roads if they can use them to improve access of timber and farm products to markets, and access of tourists to the area. The effectiveness of transportation improvements in rural areas could increase if transportation policies were instituted in concert with other types of development policies, for example, policies that improve the business climate, labor force, and education in the area.

Although highway funding can influence the economy of specific regions in the state, such as the regional centers, certain counties in the southeast, and the natural resource counties in the north, it has negligible economic effect on a

statewide basis if Minnesota is viewed in isolation from its adjacent states. However, the potential for statewide economic gains vis-à-vis the competing states in the upper Midwest could justify increased highway funding in the state. The findings further indicate that highway investment can be used for shaping regional development policy in Minnesota.

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