Transportation and Economic Development

Final Report: Executive Summary
The report written by Prof. Yorgos J. Stephanedes contains nine volumes. Copies of the report may be obtained in its entirety or by separate volume. The title of each volume is as follows:

1. TRANSPORTATION AND ECONOMIC DEVELOPMENT
   Final Report - Executive Summary

2. TRANSPORTATION AND ECONOMIC DEVELOPMENT
   Final Report

3. TRANSPORTATION AND ECONOMIC DEVELOPMENT:
   THE GEOGRAPHICAL LITERATURE
   Final Report - Appendix I

4. TRANSPORTATION AND ECONOMIC DEVELOPMENT:
   TRANSPORTATION AND THE MINNESOTA ECONOMY;
   TRANSPORTATION/ECONOMY LITERATURE
   Final Report - Appendix II

5. TRANSPORTATION AND ECONOMIC DEVELOPMENT:
   EVALUATING CRITERIA FOR HIGHWAY PROJECT SELECTION
   Final Report - Appendix III

6. TRANSPORTATION AND ECONOMIC DEVELOPMENT:
   THE LINK BETWEEN HIGHWAY INVESTMENT AND ECONOMIC
   DEVELOPMENT - A TIME-SERIES INVESTIGATION
   Final Report - Appendix IV

7. TRANSPORTATION AND ECONOMIC DEVELOPMENT:
   THE LINK BETWEEN HIGHWAY INVESTMENT AND ECONOMIC
   DEVELOPMENT - A TIME-SERIES INVESTIGATION:
   SPECIFIC ECONOMIC SECTORS
   Final Report - Appendix V

8. TRANSPORTATION AND ECONOMIC DEVELOPMENT:
   HEURISTIC DECISION FRAMEWORK FOR
   UPGRADING HIGHWAY WEIGHT LIMITS
   Final Report - Appendix VI

9. TRANSPORTATION AND ECONOMIC DEVELOPMENT:
   SIMULATION OF HIGHWAY INVESTMENT IMPACTS ON
   THE FORESTRY SECTOR IN NORTHEAST MINNESOTA
   Final Report - Appendix VII

Additional copies may be obtained by writing to:

Minnesota Department of Transportation
Research Administration & Development Section
Materials & Research Laboratory
1400 Gervais Ave.
Maplewood, MN  55109
A time series methodology is developed that differentiates the effects of highways on development from the effects of development on highways. This methodology uses pooled time-series and cross-sectional data on highway expenditures and county employment for the 87 Minnesota counties and all 9 economic sectors over the 25-year period 1957-1982 and includes classification of counties based on access, demographic and socioeconomic features. Results from vector autoregressions are tested against modern causality tests of Granger-Sims type. In the wholesale and natural-resource-based service sectors (e.g., tourism), increased highway expenditures result in long-term employment increases. While regionally very substantial, the impacts are distributional, i.e., the statewide impact is negligible. Government role is mostly reactive, increasing funding to counties whose economy is increasing, except in rural areas where government also attempts to stimulate declining economies. Funding decisions are highly sensitive to changes in the economy, especially in rural areas, and (as our evaluation of the Minnesota Department of Transportation [Mn/DOT] project selection process indicates) are primarily influenced by the District recommendation. Further, a new B/C project selection process is developed and tested on highway weight restriction policies in Northeast Minnesota. Both simulation with large I/O model and comparison with actual funding decisions made independently by Mn/DOT indicate agreement with our results. An extensive literature review and 175 references are included.

This report consists of nine separate publications: an executive summary, the final report and seven appendices. The publications are listed on the following page.
TRANSPORTATION AND ECONOMIC DEVELOPMENT

Final Report - Executive Summary

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Submitted to
Research Administration and Development Section
Office of Materials and Research
Minnesota Department of Transportation

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This report represents the results of research conducted by the author and does not necessarily reflect the official views or policy of Mn/DOT. This report does not contain a standard or specified technique.
States have recently assumed a greater role in facilitating economic development. A major part of state programs has been shaped by public investment policies directed to easing transportation-related physical barriers to development. For instance, Departments of Transportation in 36 states explicitly consider regional economic development in highway program selection. The consideration of the economic development criterion rests on the premise that there exists a relationship between transportation investment and the economy. Empirical analysis, however, has led to little agreement in the literature as to the nature of such a relationship. Researchers agree that the more mature, complex and well-connected the transportation system is, the harder it is to predict whether transportation improvements will help the local economy. This result is of particular interest to Minnesota, a state with a transportation system that is both well developed and well connected.

This report summarizes the results of a project undertaken by a University of Minnesota team for the Minnesota Department of Transportation to determine the existence and extent of relationships between transportation and economic development in Minnesota. The interdisciplinary team was directed by the Department of Civil & Mineral Engineering and included experts from Civil & Mineral Engineering, Geography, Economics (Twin Cities and Duluth campuses), Applied & Agricultural Economics, Industrial Engineering & Operations Research, and Regional Economics.

BACKGROUND

Regional economic development impacts of highways have been empirically evaluated in Japan, the Soviet Union and the U.S. The majority of the evaluation studies have used cross-sectional, correlational analysis, which is unable to determine the direction of causality between two variables. For example, a correlation between highways and development may be due to highways following development or highways causing development. By contrast, this project employs time-series analysis, which can come substantially closer to distinguishing between cause and effect as well as estimate the extent of any impact through time.

The traditional view in the literature has been that the improvement of transportation infrastructure is a necessary predecessor to economic development in a region. However, in the last 10 to 15 years studies pointed out that transportation can be a concurrent or resultant of rather than a predecessor to regional economic development. Similarly, the development of transportation was found to exacerbate rather than reduce economic development differentials between the major cities and rural regions in certain countries. In addition, the direction of long run impacts can be different from that of short run impacts. Further, in certain economic sectors, if a state has a good highway net, highway investment is more likely to reallocate employment between different parts of the state than to generate new employment. Previous work has operated at substantially different geographical scales, ranging from large-scale multi-state regional studies to small urban land use projects, and based on a wide range of implicit assumptions, thus leading to inconclusive and occasionally contradictory findings.

In summary, the complexities of the interdependencies between places in a well integrated spatial economic system, such as in Minnesota, imply that the effects
of transportation improvements are complex and hard to predict. However, it has become clear that the best way to empirically evaluate the possible effects of transportation investment on the economy would be to examine situations where transportation investment does seem to temporally precede changes in the local economy, and to determine whether, and in which situations, that impact is likely to be positive, neutral or negative. This is the research direction adopted by this project.

METHOD

We used time-series techniques to pool time-series and cross-sectional data for all 87 Minnesota counties from 1956 to 1982 on state trunk highway construction expenditures and employment (in later research we also analyzed the income data) at the county level. This increased the number of data elements from 26 to 2262 and made this analysis possible. Using these techniques, we analyzed the effects of highway expenditures on employment, and employment on highway expenditures, with respect to different groupings of counties, as well as the state in total, and for different sectors of the economy. For instance, the first county group, defined as "Regional Centers," includes the 7 counties that are economic centers of the state: Hennepin, Ramsey, St. Louis, Stearns, Olmstead, Blue Earth, and Clay. These counties employ 2/3 of the workers of the state, earn 71% of the income and contain approximately half the state population.

Prior to the analysis, we filtered out the domination of individual county size as well as changes reflecting regional or national trends, inflation, and other effects that are common to the grouping of counties under study. One result of this filtering is that the analysis now responds to the question, "Does highway investment above (or below) the normal trend of investment in a county influence economic development beyond the normal trend of the economy in that county?" Following filtering, we analyzed the data using time-series, enhanced with the employment of causality tests (Granger-Sims type). These tests aided us 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 other.

In summary, despite its limitations further discussed in the final report, compared to the literature our analytical method is stronger in several ways:

- By employing time-series analysis, where previous work has depended on cross-sectional techniques, we can directly analyze the ways in which one activity systematically precedes another over time. This allows us to make inferences on the direction of a hypothesized relationship, e.g., whether highways influence employment or employment influences highways.

- By pooling time-series with cross-sectional data, we are able to increase our data base by two orders of magnitude thus making this analysis possible.

- By employing causality tests, we can infer whether a directional influence by a variable on another indicates that the first "causes" the other. Causality tests had never before been applied by transportation researchers in this area. To be sure, we employ causality analysis with caution, fully aware of its limitations. Overall, our results are likely to be on the conservative side.
By classifying counties in groups following similarities in patterns of characteristics, we filter out the effects of exogenous variables and can determine the ways in which any relationships we identify may differ across groups.

Filtering out the effects of exogenous regional and national trends works to address the need for additional explanatory variables, while also increasing the clarity and significance of our conclusions.

By employing advanced time-series techniques (such as vector autoregression) we can extend our analysis to all sectors of the economy, concurrently. If desired, we could further investigate the interactions among sectors of the economy as a result of highway investment.

TIME SERIES FINDINGS

Interactions between transportation and total employment

Regarding total employment (i.e., the summation of employment, by place of work, for all sectors of the economy), we have strong evidence that highways "cause" long-term economic development in excess of the normal trend in the regional centers of Minnesota, where 2/3 of all Minnesotans work and which absorb approximately half of the Minnesota DOT state trunk highway funds. In each of these counties, $1 million above the normal expenditures leads to 100-140 new jobs, each year, over the next ten years. Of these, a few are created in the second year but most are created in the period between the fifth and the tenth year following the highway expenditures.

There is no indication of long-term causal influence in most of the counties that contain the remaining one-third of Minnesota workers, except in certain rural areas. For instance, we have no strong evidence that highways influence employment in the counties adjacent to regional centers -- although there exist indications that the employment effect, if it exists, is likely to be negative. However, our analysis also suggests that highways are helping the residents of the adjacent counties to get to work, and provide jobs and income for them. We do have some evidence of influence in rural areas (all counties that are not regional centers or adjacent to them) but this evidence is strongest in the short term, i.e., the period of construction. Our recent findings indicate that highway investment has long term impacts in rural areas that can use the better roads to improve access of farm products to markets, and access of tourists to the area.

The distributional nature of the effects is evident when analyzing the different parts of the state. In particular, while certain counties are likely to gain from improved roads, others are likely to lose and the statewide effect is not significant; in addition, the statewide effect is very small in size, i.e., over ten years an extra $1 million would create an average of only 5-8 new jobs statewide. 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 state trunk highway funding in Minnesota; however, if Minnesota is viewed in competition with the neighboring states, transportation improvements in the state could result in state economic gains.
Along the opposite causal direction, we found that the influence of total employment on highway investment is highly significant statewide. In addition, the sensitivity of highway investment relative to changes in employment is substantial, i.e. an increase of jobs by 10% above the trend attracts an additional investment statewide of almost double the size in percentage terms -- approximately 18% over ten years (otherwise stated, an extra 100 jobs attract an extra $28,500.) In regional centers, this implies that approximately one of every 60 new jobs is created by Minnesota DOT highway funds. The influence of employment on highway investment is most significant in rural areas. Thus it appears that the economic well being of the rural counties influences state highway investment policy the most.

Interactions between transportation and sector employment

Outside the regional centers there is strong evidence of favorable long-term effects of highway improvements in the wholesale sector of rural counties, where firms may gain from improved access to markets. Our recent research also indicates strong evidence of favorable long-term effects of highway improvements in the service sector of the rural counties that have a strong natural-resource economic base. To be sure, the density of the highway system in these counties of north Minnesota is low with lakes and forests impeding communication. Better roads have the potential to increase service employment by facilitating tourism in the area. Even a small-scale effect can be important to the local economy.

Conclusions regarding the relationship between highways and economic development greatly depend on the way in which development is defined. For instance, findings from our ongoing work indicate that, while improved roads may hurt the employment in certain counties, the same road improvements may support increases in household income in those counties. These findings are in agreement with Census data which indicate that 66% of the state's population works in the Regional Center counties while only 47% lives there, implying that about 19% of the state's population commute on highways to their jobs in Regional Center counties from other counties.

Summarizing the above findings, our analysis indicates that:

- The effect of economic development on highway funding is much greater than the effect of highway funding on economic development.

- The effect of the economy on highway expenditures is positive, i.e. the Minnesota DOT reacts to changes in economic conditions by providing more funding to areas in which the economy is growing. However, our recent research indicates that, in several rural areas, the DOT attempts to stimulate the faltering economy by providing more funding; in terms of job creation, such funding is not as effective as the "reactive" type of funding administered in the rest of the counties.

- For the regions that employ two thirds of Minnesota workers, the Regional Center counties, the effect of highway expenditures on the economy is positive. The effect is also positive in certain rural areas that either have a strong natural resource base (tourism) or can benefit from improved access of their farm products to markets.
A summary of the important long-term interactions between highway expenditures and employment is found in Tables 1 and 2. In the Tables, positive and negative signs indicate the sign of the effect from the time-series equations; percentages indicate the level of significance from the causality tests. In interpreting the findings, consistent sign patterns from the time-series equations are important in accepting the results from causality tests.

Table 1. Long-term effects of highway on employment by sector

<table>
<thead>
<tr>
<th>Sector</th>
<th>Total</th>
<th>Service</th>
<th>Retail</th>
<th>Wholesale</th>
<th>Manufacturing</th>
<th>FIRE</th>
<th>TCPU</th>
<th>Agriculture</th>
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<tbody>
<tr>
<td>State</td>
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<td>+</td>
<td>+</td>
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<td>Reg Ctr</td>
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<td>+5%</td>
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<td>Rural</td>
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<td>+1%</td>
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Table 2. Long-term effects of employment by sector on highway

<table>
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<tr>
<th>Sector</th>
<th>Total</th>
<th>Service</th>
<th>Retail</th>
<th>Wholesale</th>
<th>Manufacturing</th>
<th>FIRE</th>
<th>TCPU</th>
<th>Agriculture</th>
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FIRE = Finance, Insurance, and Real Estate
TCPU = Transportation, Communications, and Public Utilities

Additional understanding of the role of economic indicators in highway funding decisions can be gained by analyzing the Mn/DOT highway program selection process. We performed such an analysis and developed a cost/benefit methodology to aid the highway programming decisions -- with an application to spring load restrictions and the forest industry in Northeast Minnesota.

FINDINGS FROM EVALUATION OF CRITERIA FOR PROJECT SELECTION

This section addresses the question, "What is the relationship (if any) between highway project funding decisions by the Minnesota DOT and specific indicators, including indicators that the Minnesota DOT uses?" The relative scarcity of data only allows cross-sectional analysis, which we criticized earlier. Therefore, results are correlative, i.e., they may indicate a relation between X and Y but cannot specify whether X precedes Y or not.

From the 1985 Mn/DOT project selection data in Major Construction, Reconstruction, Reconditioning, and Resurfacing, this analysis determines the major factors correlated with the decision, "to fund or not to fund" a candidate project; the factors include the selection criteria ("point system") now followed by the Minnesota DOT. The major conclusions indicate:

- The actual relationship between funding decisions and major criteria used to make the decisions is close to the relationship stated by the Minnesota DOT.
- Of all point components, Cost Efficiency (CE) and Sufficiency Rating (SR)
points are most significant in Major Construction and Reconstruction, while Condition Rating (CR) is most significant in Reconditioning and Resurfacing. Goods Movements (GM) and PM (Peak Month) points are not significant.

- The funding decision is very sensitive to FC (Functional Classification) points in Major Construction and Reconstruction, to CR points in Reconditioning and Resurfacing, and to SR in Major Construction and Reconstruction. Any reporting inaccuracies would be highly magnified, 2 to 5 times in these cases.

- The priority each District assigns to the projects it submits for consideration is the most consistently significant factor in the funding decision. The contribution of this factor to the decision often equals that of all other factors combined. Further, the funding decision is sensitive to the District priority; if the District raises its rating by a point (scale 1-10), probability of funding is raised by 10 points (scale 0-100).

- ADT is a significant factor in Reconditioning and Resurfacing but is almost irrelevant for Major Construction decisions. However, ADT-related factors, e.g., Commercial ADT and ADT divided by cost/mile are often more significant than ADT. The sensitivity of funding to ADT is highest in Reconditioning and lowest in Major Construction as expected. For instance, on a 0-100 point probability scale, a 1000-car ADT increase can raise the funding probability 2-6 points in Reconditioning; however, in Major Construction a 10,000-car increase would hardly make a difference in funding.

The Mn/DOT data for 1972-1985 refer only to projects that were funded. As a result, the question we seek to answer is modified to, "Given that a project is selected for funding, what is the relationship (if any) between funding amount and specific indicators, including indicators that the Mn/DOT uses?" Because of data limitations, this analysis considers all 4 project categories together.

- Remarkably, the relationship between ADT and funding per mile has remained stable since 1972. As expected, this relationship is positive, i.e. higher ADT corresponds to higher funding per mile: For every 10-percent ADT increment on a highway to be funded, we can expect a 6-8 percent increment in funds/mile for that project on the average, after adjusting for inflation.

- The relationship between CR (1980 data) and funding is negative as expected, i.e., higher CR corresponds to lower funding per mile; for every 10-percent increment in CR, we can expect a 30-60 percent corresponding decrease in funds per mile for a typical project. Because of the high sensitivity of funding to CR, a half-point error in measuring CR could result in a funding difference of up to $450,000 for a typical 5-mile project.

- Economic indicators such as the District priority rating, ADT, employment, and income (in that order) influence highway investment decisions in a significant and substantial manner, i.e., in most cases, better economic conditions attract, with a lag, increased highway funding.

APPLICATION OF NEW BENEFIT/COST HIGHWAY PROJECT SELECTION METHOD

In this section we develop a method for obtaining a road development program that optimizes the relationship of costs and benefits of the projects selected
for funding while meeting a specified budget constraint. Although we focus in projects that deal with changing the weight carrying limits on state highways, our methodology is formulated in a general manner so that it could be applied to most projects in the highway project selection process of the Minnesota DOT.

Because a regional highway network serves several plants and markets and consists of a large number of links, the benefits resulting from improving a single link of the network are almost never immediately realized. In the case of weight limits, a benefit is realized only when the minimum load limit along a travel route is raised. We apply our analysis to transportation data from the forest industries and the highway system in northeast Minnesota. In analyzing the economic viability of upgrading spring weight restrictions on the state highways of that region, we solve the problem of maximizing the realizable benefits, resulting from the alleviation of weight restrictions or other road improvements, while minimizing incurred construction costs. Benefits and costs are amortized over the time horizon appropriate for each project. The total net benefit is summed over all customers and commodities subject to the available budget over the planning horizon. The algorithm considers two maintenance policy alternatives, (a) a road is upgraded to carry heavier loads or (b) a road is not upgraded but is still used for heavier loads, leading to reduced expected life and an increase in maintenance costs. The set of all feasible projects includes upgrading combinations that lead to the same final outcome but are accomplished in a different sequence. For instance, a 9-ton road may be upgraded to 10-ton directly; alternatively, the 9-ton road may be partially improved at first, e.g., to 10-ton for 10 months.

Our case study focuses on the paper and waferboard product industries of NE Minnesota. Direct benefits would accrue if the network upgrading reduced transportation costs and, thus, made the final production cost of the above forest products more competitive in the nation's markets. As the responses to our industry survey indicated, these industries could, then, increase the production capacity of their plants and, in time, their export market share in the national and international markets. Based on our survey and Mn/DOT data on the principal highways the forest industries use in northeast Minnesota, the highways were segmented into links by load category and estimated remaining life. Our algorithm was then used to prioritize these projects subject to a budget constraint. Based on the algorithm, only the segment of Trunk Highway 33 (TH 33), connecting Interstate 35 (I-35) with Cloquet has a benefit/cost ratio greater than 1. From all candidate upgrading projects considered, the following top 5 were selected in order of priority:

1. TH 33, from I-35 to Cloquet; upgrade to 10-ton road year round.
2. TH 33, from Cloquet to TH 2; and
   TH 2, from TH 33 to Grand Rapids; to 10-ton year round.
3. TH 53, Cook to International Falls; to 10-ton for 10 months.
4. TH 2, Grand Rapids to Bemidji; to 10-ton year round.
5. TH 61, Two Harbors to U.S. border; to 10-ton for 10 months or year round.

[The Minnesota DOT has recently alleviated weight restrictions on TH 2 based on highway engineering criteria (deflection tests) and is considering upgrading TH 33 from I-35 to Cloquet.]

As part of the case study, we have also used an alternative indirect analytical method to assess the economic effects of a transportation policy in Northeast
In particular, we use the Input-Output SIMLAB economic simulation model to assess the possible economic effects on the local forest industry of increasing all spring load restrictions in NE Minnesota to 10 tons year round. The timber industry sectors considered include logging, sawmills, particle board, other wood products, pulp and paper. For our base-case analysis we use the 1977 status quo. At that time, some roads were restricted to 7 tons for part of the year and most allowed 10-ton loads except in spring when they were restricted to 9 tons. We assume that all cost savings are passed onto the purchaser.

For the regional economy as a whole, a 1% decrease in transportation cost can lead to only a small increase in gross output and earnings that should not be expected to exceed 0.02%. However, individual sectors can do better and can reach as high as 0.17% for the particle board sector. (To be sure, the benefits would probably increase if all small forest companies were also included in the analysis.) Tax revenues from this increase could support upgrading a total highway length of between 5 and 50 miles based on current tax and cost estimates, where the low end of the scale supports the earlier benefit/cost analysis conclusions that pointed to the need for upgrading the 5-mile stretch of road from I-35 to Cloquet.

RECOMMENDATIONS

1. The 7 counties that employ two-thirds of Minnesotans and constitute the regional economic centers of the state (Hennepin, Ramsey, St. Louis, Olmstead, Stearns, Blue Earth, and Clay) can demonstrate significant and sizeable long-term employment improvements following increase of transportation investment. This finding is particularly relevant for the state economy in view of the fact that the Regional Center counties earn 71% of the state income, contain approximately half the state population, and absorb nearly half the Minnesota DOT trunk highway funds. In addition, natural-resource base counties in rural north Minnesota can use better transportation to improve their service economy. If government policy is to promote jobs in these counties, better transportation can help.

2. The counties that border the 7 economic centers may demonstrate a worsening job climate, especially in agriculture, with improved roads, especially in the 5 centers away from the Twin Cities. However, if highway improvements enable workers to commute more easily to the nearby centers of economic vitality, income in the border areas may increase. Nevertheless, the transfer of employment from the adjacent counties to the centers is likely to attract new businesses to those centers and away from the adjacent counties in the long term. If government policy is to improve the economy in the areas adjacent to the economic centers, government should clarify which aspect of the economy it wishes to improve using transportation investment; income may improve but jobs may move to the centers.

3. If government policy is to improve employment in all of Minnesota, this should be sought using transportation policies together with other development policies; otherwise, most effects improved transportation may have are relative rather than absolute. E.g., regional center policy makers should be aware of the impacts the improved highways may have on their neighbors. Of course, the relative or distributional nature of certain impacts may well be socially and politically desirable. For instance, even
though increased highway funding in rural areas may have a small benefit/cost ratio in terms of direct dollar benefits and costs, the funding may provide sufficient support to stabilize a declining town and this social effect may be hard to include in a conventional analysis.

4. Strong evidence of favorable long-term employment effects of highway improvements in rural areas was found for the wholesale sector. However, this long-term effect does not last more than 8 years following the highway expenditures. Strong evidence of favorable long-term effects was also found in rural areas that either have a strong natural resource base, e.g., tourism, or can benefit from improved access of their farm products to markets; although such effects would involve few jobs, they could still be important to the local economy. Favorable effects in other sectors of the rural areas were found only in the short term, and most would be construction-related. Therefore, if government policy is to stimulate employment in rural areas, it can accomplish this during the construction of highways. If policy is to achieve long-term improvements, government can improve transportation to achieve this in some sectors; however, in most cases, transportation improvements would have to be accompanied by additional development policies.

5. Highway funding alone cannot stimulate Minnesota agriculture. In order for a positive effect to exist, transportation improvements should be part of a package of agricultural development policy.

6. The current Minnesota DOT project selection process is highly responsive to the recommendations of the individual districts. District recommendation (reflecting, among other factors, current economic conditions) contributes to the process as much as all other selection factors combined. (This conclusion has been drawn from limited but fairly typical data.)

7. Our time-series analysis indicates that the Minnesota DOT is highly responsive to the economic conditions of Minnesota in two ways: First, in most cases the DOT plays a strongly passive, reactive role by increasing highway investment where the economy is improving -- a role that is largely effective. Second, in certain rural counties the DOT plays a stimulative role by providing more funding when their economy is faltering -- a role that is, for the most part, not as effective. In particular, although the evidence indicates that increased highway investment is most effective in favorably influencing the economy of the regional centers of the state and of certain natural-resource and farm-product based rural counties, it is the economic conditions of all rural areas that exert the most significant influence on Minnesota DOT highway funding decisions.

8. As long as the Minnesota DOT plans to continue to place such a substantial weight on the district recommendation, and as long as it continues playing a reactive-supportive role (as it states), use of additional economic criteria in project selection would strongly favor the regional economic centers of Minnesota at the expense of the outlying economies. On the other hand, if the Minnesota DOT is willing to implement effective stimulative policies in certain rural areas that can benefit from improved highways, it must improve its project selection process by including additional economic indicators (e.g., employment, income) as criteria in highway programming. The political climate in Minnesota, with a thriving economy in the economic
centers and a depressed economy in many areas of Greater Minnesota, is to encourage economic development outside the centers. Our analysis indicates that any attempt to further improve the employment of the centers by improving transportation may also have undesirable employment effects on their neighbors. To be sure, such effects would be tempered by the income increase of the residents in the adjacent areas, who can use the improved roads to commute to the centers -- these commuters represent 19% of the state's population -- and may turn into bedroom communities.

9. **Even if the Minnesota DOT continues its reactive-supportive role, as long as it keeps placing such high importance on ADT, adding economic indicators may significantly improve the forecasts of future ADT levels.** Our review of Minnesota DOT's programming selection procedures revealed the importance of accurate ADT forecasts for reconditioning and resurfacing projects. However, these forecasts are usually only extrapolations of past trends. The forecasts can be improved by using time-series techniques such as the ones used here.

10. **Minnesota DOT should optimize the uniformity and consistency in measuring condition and sufficiency ratings.** Highway project selection and funding decisions are extremely sensitive to CR and SR measurements; small recording errors may have a substantial effect in project ratings.