Transportation and Economic Development: Transportation and the Minnesota Economy; Transportation/Economy Literature

Final Report: Appendix II
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: SPECIFIC ECONOMIC SECTORS
   Final Report - Appendix V

8. TRANSPORTATION AND ECONOMIC DEVELOPMENT:
   HEURISTIC DECISION FRAMEWORK FOR
   UPGRADING HIGHWAY WEIGHT LIMITS
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9. TRANSPORTATION AND ECONOMIC DEVELOPMENT:
   SIMULATION OF HIGHWAY INVESTMENT IMPACTS ON
   THE FORESTRY SECTOR IN NORTHEAST MINNESOTA
   Final Report - Appendix VII

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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: TRANSPORTATION AND THE MINNESOTA ECONOMY; TRANSPORTATION/ECONOMY LITERATURE

Final Report - Appendix II

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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.
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transportation can stimulate economic development in particular Minnesota regions, with application in Northeast Minnesota.

If transportation investment could influence economic activities, it could do so in several ways. However, five would be particularly important, i.e., transportation may,

(a) influence the location of firms,
(b) allow resources to be developed,
(c) ensure high productivity levels in the primary sector,
(d) affect commuting patterns, and
(e) be combined with (or replaced by) other forms of communication in the service sector.

While several economic sectors could be influenced, transportation investment could make a major contribution if it could affect the movement patterns in sectors of the Minnesota economy in which the state (or a particular region) is strong, e.g., agriculture (in Minnesota 2.0 times as intense as the nation), timber manufacturing (1.1 times), business administration (1.5), health services (1.2), and computer manufacturing (5.2); in particular, in the expanding service and high-technology industries, on which the future of the Minnesota economy relies substantially.

Although the quality and cost of transportation have been identified as two of the primary barriers to economic development, very little research has explored the broad interrelationships between transportation and economic development. The majority of the empirical literature on freight transportation indicates that transportation investment has little effect on economic development today. Whereas some economic effects from transportation were identified, most were close to metropolitan areas. Even then, the industries affected were not manufacturing firms, but rather firms whose functions were to service the highway users, e.g., gas stations, restaurants, and motels, and were
merely relocating. In addition, even if there was a correlation between transportation and development, the direction of causality of that correlation could be that highways follow economic development rather than highways causing development. Further, while passenger transportation may affect local sales, the labor pool and the cost of labor, the cost of providing better service may not make the overall investment attractive.

While the small-scale empirical studies on freight transportation conclude that transportation has little effect on today’s economy, the large-scale regional models indicate that transportation can affect the economy. This presents a contradiction within the literature - one that this project will address and try to resolve. A possible explanation for the discrepancy may be that the large-scale regional models estimated transportation relationships for specific sectors, whereas the small-scale studies were more generally oriented. With different sectors of the economy changing in different directions as a result of transportation, the net overall effects may be insignificant even though, by sector, the transportation effect is significant. In fact, the few small-scale studies concluding economic effects from freight transportation, did analyze specific parts of the economy.

To address the above stated goals, the project has undertaken several interrelated tasks. Implementing a (macro-)analytical method to predict the economic impacts of transportation policies, with application in N.E. Minnesota, is the objective of one such major task. Based on several criteria and, most important, data availability, a method employing a large-scale input-output model has been selected to help accomplish this task. The method had previously been applied in N.E. Minnesota, so that much of the data collection for this region is complete. While additional data are available from several sources, analytical methodologies are also developed to estimate transportation flows, when necessary, from existing data.
I. INTRODUCTION

Federal budget deficit increases and spending reductions are likely to significantly restrict the flow of federal aid to regional economic development programs over the next years. As such programs are phased out, state assistance to economically distressed regions will become increasingly important. Responding to this challenge, states will seek efficient methods to stimulate regional economic development in distressed areas. While there exist a wide range of policy options for providing stimuli directly within the economic sector, the effectiveness of such policies depends, in part, on the availability of a supporting infrastructure. Transportation investment has long been an important factor contributing to the condition of the infrastructure nationally and at the state level.

Inadequate transportation facilities and services may hamper the effectiveness of development policies and, in a competitive environment, may also act to encourage economic decline. As with other public programs, transportation projects can improve the competitive position of a region and induce or accelerate its economic development.

Use of resources in transportation investment does, of course, preclude their concurrent use in other types of investment. Similarly, transport investment in a particular region deprives other regions of useful resources. Therefore, while a given investment may be beneficial when viewed from a strictly local perspective, its net contribution to the economy of the state or
a larger region may be negligible. On the other hand, the reallocation of resources accompanying the investment may lead to improved efficiencies and net gains with the larger system as well.

In summary, as state governments increase their share in supporting transportation projects, each project's contribution to the local and state economic development will become increasingly important. The state may extend its evaluation of transport policies beyond the short-term effects on passenger and commodity transport efficiency and effectiveness, to the long-term impacts on the economy. To accomplish this, state decision makers must be able to identify and measure the impacts of transportation projects on economic development.

The main objective of the Phase A report of this research is to locate, analyze and systematically organize information about the relationship between transportation and economic development with the aim of specifically determining how transportation can stimulate economic development in particular Minnesota regions. The specific objectives include:

1. Critical review of previous work in the field of transportation/economic development.
2. Identification of relevant empirical findings and methods of analysis in transportation/economy studies.
3. Analysis of data availability and requirements.

The report begins with an overview of Minnesota's economy in Chapter II. Previous work in the field of transportation/economic development is critically reviewed and relevant empirical findings and methods of analysis are identified in Chapter III. An implementation plan for this study, including analysis of data availability and requirements, is presented in Chapter IV. Finally, the conclusions from the work in Phase A are summarized in Chapter V.
II. TRANSPORTATION AND THE MINNESOTA ECONOMY

II.1 INTRODUCTION

Transportation investment may be able to influence economic activities in Minnesota in several ways. However, five are particularly important:

(a) Transportation may influence the location of firms. With regard to manufacturing plants, transportation is essential for access to inputs and for getting plant output to market. Choice of location can be near the inputs, markets, or somewhere in-between depending on the character of the production and distribution processes and the quality and quantity of the transport infrastructure.

(b) Transportation may affect commuting patterns. An improvement in transportation can increase access and decrease travel time and travel cost to employment centers. These effects may enlarge the regional labor pool and, therefore, increase the attractiveness of a region to firms.

(c) Transportation may allow resources to be developed. Lack of accessibility to a resource may prevent that resource from being developed. In addition, high transportation costs may make the development of a resource uneconomical. For example, in Northeast Minnesota, much of the timber goes unharvested because vehicles cannot get to the timber. Further, costs are sufficiently high so that only the "easy-to-get" timber is harvested. If
transportation costs were decreased, the "harder-to-get" timber might also become economical to harvest.

(d) Transportation may be necessary for ensuring high productivity levels in the primary sector. In the forest industry, for instance, access to the raw material allows efficient management of forests.

(e) In the service sector, transportation could be combined with (or replaced by) other forms of communication to increase the effectiveness of particular activities as, for instance, is increasingly the case in information processing.

If these effects occur, they are subject to substantial time lags. The time lags are important considerations for policy making. For example, in Northeast Minnesota, where mining has been predominant, water (Great Lakes) and rail links have been developed to transport the ore to the steel manufacturers. However, in recent years, mining activity in this area has greatly diminished causing massive layoffs. The present surplus of labor in the area, combined with the existing transportation infrastructure, may be able to attract new industry to the area to replace the decrease in mining activity. However, the transformation process of these hypothesized effects will probably be slow. Thus, if that process is not to be hampered, it may be necessary to maintain the existing transportation infrastructure during the period of transformation to maintain its attracting features.

II.2 CLASSIFICATION SCHEME

In order to better appreciate any possible impact of transport policies on the Minnesota economy, it is first necessary to consider the important components on which that economy is based. The Minnesota economy can be broadly divided into three major sectors:
(1) Primary (agriculture, mining, forestry),

(2) Secondary (raw materials processing and manufacturing), and

(3) Tertiary (retailing, wholesaling, professional services, information services).

The state continues to derive a fairly large proportion of its income from agricultural and mining activities. At the same time, it has developed a sizeable and diverse manufacturing economy that continues to grow. Growth in the manufacturing sector has come from both high-technology industrial segments, such as computers, electronics, and instrumentation, as well as more conventional industrial activities.

The service sector is well developed and still growing rapidly; as Fig. 1 illustrates, more than half of the state income is derived from the tertiary economic activities of service, trade, finance, and government. Many observers have predicted that the future of the Minnesota economy relies substantially on the expanding service and high-technology industries. Owing to the importance of these activities, increasing attention should be placed on their interaction with transportation and the ways they can benefit from proper use of transportation services and their substitutes.

While Figure 1 presents a picture of Minnesota's economy today, it is useful to look at how this picture has changed over time and how Minnesota compares to the nation as a whole. Table 1 presents this information, where the economy is classified into nine sectors -- (a) Farming, (b) Mining, (c) Construction, (d) Manufacturing, (e) Trade, (f) Finance, Real Estate, and Insurance (FIRE), (g) Transportation, Communications, and Public Utilities (TCPU), (h) Services, and (i) Government. Percentages of the economy engaged in each sector for both the Minnesota and United States economies and the ratio of Minnesota's percentage to the U.S. percentage are presented. When the ratio is less than one, Minnesota is less intensively involved in that sector than is the
Fig. 1 Distribution of earned income by sector (Steinhauser and Flynn, 1983)
Table 1. Minnesota compared to United States (percent of total employment) - usual economic classification scheme

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<tbody>
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<td>9.1</td>
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<td>6.8</td>
<td>3.0</td>
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<td>3.9</td>
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<td>1.56</td>
<td>2.1</td>
<td>1.7</td>
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<td>1.04</td>
<td>5.1</td>
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<td>5.2</td>
<td>4.8</td>
<td>1.08</td>
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<td>29.8</td>
<td>.70</td>
<td>21.6</td>
<td>28.8</td>
<td>.75</td>
<td>23.5</td>
<td>25.8</td>
<td>.91</td>
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<td>18.2</td>
<td>1.15</td>
<td>18.8</td>
<td>16.8</td>
<td>1.12</td>
<td>18.6</td>
<td>17.0</td>
<td>1.09</td>
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<td>10.9</td>
<td>.96</td>
<td>13.3</td>
<td>13.5</td>
<td>.99</td>
<td>13.3</td>
<td>14.1</td>
<td>.94</td>
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<td>9.2</td>
<td>1.16</td>
<td>10.3</td>
<td>9.1</td>
<td>1.13</td>
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<td>.94</td>
<td>9.5</td>
<td>10.0</td>
<td>.95</td>
<td>11.2</td>
<td>11.7</td>
<td>.96</td>
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<tr>
<td>Government</td>
<td>6.4</td>
<td>8.4</td>
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<td>8.4</td>
<td>10.7</td>
<td>.78</td>
<td>10.5</td>
<td>13.3</td>
<td>.79</td>
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Table 2. New classification scheme for primary and secondary sectors

<table>
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<tr>
<th>Sector</th>
<th>Primary industries</th>
<th>Secondary industries</th>
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</thead>
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<tr>
<td>Agriculture</td>
<td>Farming</td>
<td>Meat packing</td>
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<tr>
<td></td>
<td>Ranching</td>
<td>Grain milling</td>
</tr>
<tr>
<td>Timber</td>
<td>Logging</td>
<td>Saw milling</td>
</tr>
<tr>
<td>Minerals and Fuels</td>
<td>Mining</td>
<td>Furniture mfg.</td>
</tr>
<tr>
<td></td>
<td>Oil drilling</td>
<td>Metal fabrication</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Refining</td>
</tr>
</tbody>
</table>
On the other hand, when the ratio is greater than one, Minnesota is more intensively involved. Several conclusions can be made from Table 1:

1. *While the labor needs of farming have been falling over the last several years, Minnesota farming intensity still is over twice that of the United States as a whole.*

2. *Because of the Iron Range, Minnesota is more involved in mining than the nation as a whole.*

3. *Minnesota is less manufacturing oriented than the United States as a whole, but its position seems to be improving.*

4. *While Minnesota has increased its intensity in service industries, it is not more service-oriented than the nation as a whole.*

Although the above conclusions can be reached from Table 1, many questions relating to transportation are difficult to answer given the classification scheme used in that Table. For example, one factor influencing manufacturing enterprise location is proximity to raw materials. If a classification scheme related the secondary sectors to the primary sectors that supply the raw materials to the secondary industries, one could observe this influence. Such a reclassification scheme that transforms the original detailed data into a matrix form is shown in Table 2. The new classification is important in transportation economics since transportation of the primary goods to the secondary firms is a major determinant of where secondary industries will locate.

While several other schemes exist, the adopted classification scheme of tertiary industries is similar to one suggested by Noyelle and Stanback (1983). This scheme is presented in Table 3. The major objective in setting up this classification is the separation of local activities from activities that involve or may involve exporting or importing goods or services from the region. While the major structure of Noyelle and Stanback's setup has been retained, some changes have been made. In particular, the usual classification of TRADE
Table 3. Classification scheme of tertiary sector

<table>
<thead>
<tr>
<th>DISTRIBUTIVE SERVICES</th>
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<td>Transportation</td>
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<td>Retail trade</td>
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<th>FINANCE and INSURANCE</th>
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<td>Legal services</td>
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<tr>
<td>Real estate</td>
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<tr>
<td>Membership organizations</td>
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<td>Misc. professional services</td>
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<th>BUSINESS COMPLEX</th>
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<tr>
<td>Business services</td>
</tr>
<tr>
<td>Legal services</td>
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<tr>
<td>Real estate</td>
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<tr>
<td>Membership organizations</td>
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<td>Misc. professional services</td>
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<table>
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<th>MAINLY CONSUMER SERVICES</th>
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<tr>
<td>Auto repair</td>
</tr>
<tr>
<td>Misc. repair</td>
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<th>UNCLASSIFIED</th>
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<td>Government</td>
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Adapted from Noyelle and Stanback (1983)
has been changed to DISTRIBUTIVE SERVICES, including wholesale trade, retail trade, and transportation. Finance and Insurance are classified separately from Real estate since finance and insurance activities often go beyond a particular locality whereas real estate is a local service.

We will use this classification scheme in our discussion of the economy of Minnesota today. For a brief overview of the economic history of Minnesota see Appendix 1.

II.3 MINNESOTA'S ECONOMY TODAY

Today, Minnesota's economy is very diversified except for the northeast section of the state, which depends heavily upon iron ore mining, and the rural areas that are strongly dependent on agriculture. In addition, the economy is weaker in border areas that face the competition of more advantageous business climates in neighboring states. Table 4 shows how Minnesota's overall economy compares to that of the United States. (Note, while MN and US data are rounded off, MN/US ratios are presented with more precision. Furthermore, the ratios are illustrated in Fig. 2 for all sectors and selected subsectors of the economy.) This Table uses the classification scheme discussed earlier to classify the employment of the state. In the Table, and elsewhere in this report, we use employment within an industry as an indicator of the intensity with which the economy is involved in the industry. Further, we use the term, labor intensity, to refer to the percent of the total work force that is employed in a particular industry. In what follows, we will use this Table to discuss how the primary sector of the economy is linked with the secondary sector. We will also discuss the parts of the economy that Minnesota is strong in and the parts with which it is weak.
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<td>0.1</td>
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<td>edible crops</td>
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<td>1.6</td>
<td>1.14</td>
<td>1.3</td>
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<tr>
<td>inedible crops</td>
<td>1.2</td>
<td>4.7</td>
<td>0.25</td>
<td>0.7</td>
</tr>
<tr>
<td>Timber mfg</td>
<td>4.8</td>
<td>4.6</td>
<td>1.02</td>
<td>3.1</td>
</tr>
<tr>
<td>Mining mfg</td>
<td>10.3</td>
<td>18.1</td>
<td>0.57</td>
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<tr>
<td>fuel extraction</td>
<td>0.9</td>
<td>2.5</td>
<td>0.36</td>
<td>0.9</td>
</tr>
<tr>
<td>metallic mining</td>
<td>8.9</td>
<td>14.6</td>
<td>0.61</td>
<td>8.2</td>
</tr>
<tr>
<td>nonmetallic</td>
<td>0.5</td>
<td>1.0</td>
<td>0.47</td>
<td>0.6</td>
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<tr>
<td>Misc. mfg</td>
<td>0.6</td>
<td>1.0</td>
<td>0.66</td>
<td>0.4</td>
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<tr>
<td><strong>Tertiary sectors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>DISTRIBUTIVE SERVICES</td>
<td>25.1</td>
<td>22.6</td>
<td>1.07</td>
<td>19.2</td>
</tr>
<tr>
<td>transportation</td>
<td>2.5</td>
<td>3.0</td>
<td>0.85</td>
<td>2.1</td>
</tr>
<tr>
<td>wholesale trade</td>
<td>6.9</td>
<td>5.7</td>
<td>1.21</td>
<td>4.7</td>
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<tr>
<td>retail trade</td>
<td>15.7</td>
<td>14.8</td>
<td>1.06</td>
<td>12.4</td>
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<td>FINANCE and INSURANCE</td>
<td>3.7</td>
<td>5.5</td>
<td>1.05</td>
<td>3.2</td>
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<td>BUSINESS COMPLEX</td>
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<td>4.8</td>
<td>0.87</td>
<td>5.5</td>
</tr>
<tr>
<td>administration</td>
<td>1.8</td>
<td>1.7</td>
<td>1.04</td>
<td>2.3</td>
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<tr>
<td>business services</td>
<td>0.9</td>
<td>1.2</td>
<td>0.79</td>
<td>1.5</td>
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<tr>
<td>legal services</td>
<td>0.2</td>
<td>0.2</td>
<td>0.86</td>
<td>0.2</td>
</tr>
<tr>
<td>real estate</td>
<td>0.7</td>
<td>1.0</td>
<td>0.69</td>
<td>0.6</td>
</tr>
<tr>
<td>organizations</td>
<td>0.3</td>
<td>0.3</td>
<td>0.76</td>
<td>0.5</td>
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<tr>
<td>CONSUMER SERVICES</td>
<td>8.0</td>
<td>9.8</td>
<td>0.82</td>
<td>9.7</td>
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<td>lodging places</td>
<td>1.0</td>
<td>1.0</td>
<td>1.05</td>
<td>0.9</td>
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<tr>
<td>personal services</td>
<td>1.2</td>
<td>1.7</td>
<td>0.72</td>
<td>1.0</td>
</tr>
<tr>
<td>business services</td>
<td>0.3</td>
<td>0.4</td>
<td>0.86</td>
<td>0.4</td>
</tr>
<tr>
<td>legal services</td>
<td>0.2</td>
<td>0.3</td>
<td>0.66</td>
<td>0.2</td>
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<tr>
<td>health services</td>
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<td>0.9</td>
<td>1.31</td>
<td>3.6</td>
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<td>0.3</td>
<td>0.1</td>
<td>2.20</td>
<td>0.7</td>
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<td>utilities</td>
<td>2.6</td>
<td>2.8</td>
<td>0.92</td>
<td>1.7</td>
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<td>social services</td>
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<td>0.0</td>
<td>1.00</td>
<td>0.0</td>
</tr>
<tr>
<td>motion pictures</td>
<td>0.4</td>
<td>0.4</td>
<td>0.84</td>
<td>0.1</td>
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<td>amusement services</td>
<td>0.6</td>
<td>1.3</td>
<td>0.30</td>
<td>0.5</td>
</tr>
<tr>
<td>religious org.</td>
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<td>0.2</td>
<td>1.15</td>
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<td>UNCLASSIFIED</td>
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<td>0.7</td>
<td>0.87</td>
<td>0.3</td>
</tr>
<tr>
<td>GOVERNMENT</td>
<td>16.0</td>
<td>15.4</td>
<td>1.04</td>
<td>14.6</td>
</tr>
</tbody>
</table>

Sources: County Business Patterns, U.S. Census of Population, Agriculture, and Government.
Fig. 2 Percent of total employment in economic sectors: MN/US ratio
(source: Table 4)
II.3.1 Links between Primary and Secondary sectors

II.3.1.1 Agriculture

Minnesota started out as a primary economy, with farming, lumbering, fur trading, and, later on, iron-ore mining. Today the percent of our labor resources devoted to these activities is substantially less than in the 19th century. Part of this is due to the natural diversification of an economy as it develops. In addition, some of our resources have been depleted: fur-bearing animals, lumber, and iron ore. The labor needs of these industries have also diminished because of technological changes. This is especially true of farming, which in 1956 used 14% of Minnesota's labor whereas in 1982 it used only 6%. This has been true on a national level as well. Thus, despite the decline in farm labor utilization, Minnesota is almost twice as farm-intensive as the nation as a whole. This is mainly due to livestock and edible crops; Minnesota grows very little tobacco and cotton which account for much of the nation's inedible crops.

The employment included in the primary agricultural sector includes only those actually farming the land (both employed and self-employed), and those in explicit agricultural services. It is estimated that, for each of these workers, there are two more jobs created in the economy for servicing the farmers. In addition, the manufacturing uses agricultural products. Employee statistics from Minnesota processed food plants in 1978 are illustrated in Figure 3.

As in the agricultural primary sector, manufacturing industries that use agricultural products have been decreasing in labor intensity because of technological developments. Thus, today only 2.5% of Minnesota's labor is utilized for such manufacturing whereas, in 1956, 5.9% was so utilized. In overall agricultural manufacturing, Minnesota is less intensively involved than is the nation as a whole. The reason is that there is very little textile
**Figure 3**

**PROCESSED FOODS**

1978

Plant employees
- 25 - 49
- 50 - 99
- 100 - 249
- 250 - 499
- 500 or more

Plants with fewer than 25 employees are not shown.

*Includes dairy, bakery and confectionary products; canned, frozen and dehydrated foods; fats and oils; fish; specialty foods (Standard Industrial Classifications 2021-2045, 2051-2079, 2091-2094 and 2096-2099)*
milling and apparel manufacturing since cotton is not grown in Minnesota. With regard to manufacturing industries that use livestock and poultry (such as meat packing), Minnesota in 1956 was almost twice as labor intensive as the nation as a whole. However, in 1982 Minnesota had fallen to be on par with the nation. This occurred because many of these plants exited Minnesota in search of better business and labor conditions, as evidenced by Hormel Foods and Wilson Foods in southeastern Minnesota.

Manufacturing industries that use edible crops have the same labor intensity in both Minnesota and the nation as a whole. This is of concern in that Minnesota produces over twice as much edible crops as the nation. Transportation may be affecting this. For example, milling of grain diminished in Minnesota because the railroad rate structure favored the transportation of grain over the transportation of flour.

II.3.1.2 Timber

Logging was one of Minnesota's major industries in 1900. Today, because of the depletion of forests, logging comprises less than 1% of the state's economy. Minnesota is almost half as intensively involved in logging as the nation. In addition, Minnesota logging intensity is steadily diminishing. The remaining logging industry is located in the northern part of the state.

Despite the poor showing of the logging industry, manufacturing utilizing lumber products is quite strong in Minnesota. This may be partly due to the historic availability of lumber. While the majority of the lumber is harvested in northeast Minnesota (see Fig. 4), the lumber and wood products industry is evenly dispersed throughout Minnesota as Fig. 5 indicates. Paper producers, on the other hand, have tended to locate closer to where timber is cut (see Figure 6). In 1982, 3.4% of Minnesota's labor was utilized in these manufacturing industries. However, in Northeast Minnesota the portion of the economy tied to
Figure 4
VALUE OF TIMBER CUT
1975

Estimated dollars
per square mile
of total land area

- Less than 500
- 500 to 1000
- 1000 to 1500
- 1920 and 2210

State average: 507

Source: North Central Forest Experiment Station
Figure 5
LUMBER AND WOOD PRODUCTS*
1978

Plant employees
- 25 - 49
- 50 - 99
- 100 - 249
- 250 - 499
- 500 or more

Plants with fewer than 25 employees are not shown

*Includes Standard Industrial Classifications Group 24

Source: Dun and Bradstreet, May 1, 1978
Figure 6
PAPER AND ALLIED PRODUCTS*
1978

Plant employees
- 25 - 49
- 50 - 99
- 100 - 249
- 250 - 499
- 500 or more

Plants with fewer than 25 employees are not shown

*Includes Standard Industrial Classifications Group 26

Source: Dun and Bradstreet, May 1, 1978
forestry is much greater than it is for the whole state. For instance, in Carlton and Koochiching counties the portion of the economy tied to forestry is as high as 75%, including indirect effects.

II.3.1.3 Mining

Minnesota's mining industry is dominated by the iron ore mining in the northeast section of the state. Although overall Minnesota mining in 1982 was only .58 as much as the nation as a whole, the metallic mining (iron ore) was 7.4 times as intensive as the nation. While substantial layoffs have occurred in Minnesota's iron ore industry in the last few years, those layoffs have also occurred in other areas of the nation. Thus, Minnesota's importance to the domestic iron ore production has not been diminished.

The reasons for the layoffs in the iron industry have been national in scope. Competition from abroad has placed American steel at a disadvantage. This competition is favored by several factors. In particular,

(a) Mining operations in developing countries face substantially lower labor costs and many of these countries have higher quality ores.

(b) European countries subsidize their steel mills and are thus able to sell their products for less.

(c) The steel mills in the United States are, in general, of poorer quality than those in Europe.

(d) The high valuation of the U.S. dollar, caused by an anti-inflationary monetary policy and the high government deficit, gives foreign countries an advantage in the production of steel.

In the very long run the latter factor is likely to change, bringing back the U.S. steel industry to some degree. When the steel industry does come back, Minnesota's Iron Range will also come back. However, in the short to medium term (10 years at least), these changes are not likely to occur. Also, even
when the U.S. dollar is devalued, the other factors [(a), (b), and (c)] will prevent the iron-ore mining business from returning to its 1970s level.

With almost all the iron ore mined in Minnesota being shipped out of state via Lake Superior, Minnesota's manufacturing that uses the steel produced from iron ore has been less than that of the nation as a whole; however, that has been changing so that in 1982, Minnesota's metallic manufacturing was almost at par with the nation. Metallic manufacturing is important since it constitutes about half of the nation's manufacturing.

A proposal has been made for a mini-steel mill, partially state-supported, to be built in the northeast part of the state. If such a mill were constructed and the steel made available to firms in Minnesota, much transportation costs could be saved. A major component of the cost of iron ore to the steel mills in the east is the freight. If Minnesota firms purchase their steel from these eastern steel mills, additional freight is incurred. If steel were made in Minnesota, much of these freight costs would be avoided, and this might encourage manufacturers who use steel to be more likely to locate in Minnesota.

II.3.2 Finance & Insurance

Minnesota's history describes the Twin Cities as becoming a finance center for the Northwest. However, today Minnesota is only on par with the nation in finance and insurance. Thus, Minnesota can be described as only self-sufficient in (not a net exporter of) finance and insurance. This may be partially due to the increased ability of distant places to communicate as technology has developed our communications systems. Thus, a bank in North Dakota can conduct business with a major California bank almost as easily as it can with a Minneapolis bank. However, when noting the concentration of financial activities in New York City, the fact that Minnesota holds her own in finance is to Minnesota's credit.
II.3.3 Business complex

The Minneapolis-St. Paul metropolitan area has been described as a service and market center for the Upper Midwest. However, Minnesota's involvement in trade is about the same as for the nation as a whole. The intensity of business services in Minnesota is actually less than for the U.S. as a whole.

These business services include computer services. The evidence is that Minnesota is actually behind the nation and not gaining in computer services. In 1976 Minnesota's computer-services industry employed 5,547 workers, which amounted to less than .36 of a percent of working Minnesotans. For the nation as a whole, over .47 percent of all workers were employed in the computer services industry. Thus, Minnesota was at about 75% of the national level. By 1982, the computer services industry in Minnesota dropped to 5,163 workers or about .28% of all Minnesota workers. For the nation as a whole, .57% of all workers were involved in computer services. Thus, Minnesota's position has actually declined from 75% of the national level to less than half.

Despite Minnesota's low relative position in the computer services industry, the Twin Cities' economy is considered to be technologically-oriented. The Twin Cities' reputation in technology stems primarily from its involvement in computer manufacturing. Today, about one-tenth of the nation's computer manufacturing is done in Minnesota. This represents a computer-manufacturing intensity in Minnesota which is five times greater than that of the nation as a whole, as shown in Figure 7.

Also contributing to the Twin Cities "technological orientation" is in part due to the companies who are in the area or who have corporate headquarters in the area, e.g. Honeywell, Sperry, Control Data, Cray, and 3M. However, much of the manufacturing done by these companies is done outside of Minnesota. For example, 3M has recently had 13 plants started up. Ten of these plants could
Fig. 7 Relative intensity in computer manufacturing (percent of total workers)

Sources: County Business Patterns, U.S. Censuses of Population, Agricult., and Government
I have located in Minnesota, but none of them were. The reason 3M gave was the poor state-imposed business conditions such as high workers’ compensation premiums and high corporate taxes (Mnpls.Trib., 1983).

The Twin Cities area does have a relatively high number of large company headquarters. In 1975, Fortune’s Magazine’s "First 500" and "Second 500" U.S. corporations included 24 firms headquartered in the Twin Cities area. The Metropolitan area tied San Francisco/Oakland for seventh place in the nation for the number of corporate headquarters for the 500 largest U.S. industrial firms.

This is reflected in Table 4 in that in 1982 Minnesota’s worker intensity in administration or management was over 1.5 that of the nation. Thus, in 1982 4.7% of the Minnesota’s economy was involved in administration activities. One could say that Minnesota is exporting management services to other states. One factor that may have contributed to this is the Twin Cities central location within the airline network (illustrated in Figure 8).

II.3.4 Consumer Services

The consumer services, with the exception of tourism and health services (see Fig. 9), are mainly directed at the local population. For most of those services, Minnesota is at par with the nation. Health services for Minnesota are a little more intensive than they are for the nation as a whole. This is due to the University of Minnesota and the Mayo Clinic in Rochester. The services at these hospitals are extended to those beyond their local boundaries and even across state boundaries. Thus Minnesota health services are being exported out of state.

II.3.5 Summary

In general, Minnesota’s economy is quite diversified except for the northeast section of the state, where iron ore is the predominate although
Figure 8

U.S. AND INTERNATIONAL PASSENGER FLIGHTS ON SCHEDULED AIR CARRIERS
From Minneapolis-St. Paul
July 1979

Metropolitan Centers served:
- First order
- Second order
- Third order
- Fourth order
- Fifth order
- Small U.S. trade centers served
- Foreign trade centers served

Passenger air traffic (including commuter flights) from Minneapolis-St. Paul as of July 15, 1979:

- Non-stop
- One-stop
- Two or more stops

Non-stop flights per day:

- 1 or 2
- 3
- 6
- 9
- 17
- 30


*Data for Asia, Europe and South America as of August, 1979

Direct air service less than five days per week

Commuter service only
Figure 9
HOTEL AND MOTEL RECEIPTS
1978

Dollars per capita, by county
- Less than 50
- 50 to 100
- 100 or more

Source: Minnesota Department of Economic Development
somewhat latent industry, and the rural areas of the state which are heavily
dependent on agriculture. Agriculture is twice as important to Minnesota’s
economy as to the nation’s economy. Administration of businesses is also more
prevalent in Minnesota than the nation as a whole. As a result, Minnesota’s per
capita income has been rising in recent years to the point where it is on par
with the nation’s per capita income; whereas a decade ago, Minnesotans received
less income on average than Americans in general.
III. TRANSPORTATION/ECONOMY LITERATURE

III.1 INTRODUCTION

The entity known as the National or State Economy is arguably the largest and most complex system over which man has attempted to exert some degree of influence. Over the past thirty-five years, and particularly since the mid 1960’s, there has been an increasing effort by both engineers and economists to use improved analytical tools in the field of economics, both at the level of the individual firm (microeconomics) and the level of national and state policy formulation (macroeconomics) (Zarrop, 1981).

Despite the wealth of literature analyzing ways to improve the economy, relatively little work has examined whether such improvements can be accomplished through selection of appropriate transportation policies. Yet, according to the Congressional Budget Office (1978), the quality and cost of transportation can be one of the primary barriers to economic development (Table 5). The literature in transportation/economic development addresses only a few of the potential interactions between the two fields. Interestingly, much of the previous research on transportation impacts on the economy has been limited to urban areas. (See Appendix 2 for specific examples.)

Most of the literature is descriptive or empirically oriented and has been undertaken to solve a specific problem, forecast or assess specific impacts, or evaluate particular projects or policies. Very little research has explored the broad conceptual interrelationships between transportation and economic development (U.S.DOT, 1980).
Table 5. Barriers to economic development

PRIMARY

Availability and cost of land
Availability and quality of labor
Availability of capital and managerial expertise
Proximity of markets
Quality and cost of transportation

SECONDARY

Federal taxes
State and local taxes
Crime
Air pollution
Financial incentives
Water and waste treatment
Natural resources

Source: Congressional Budget Office (1978)
This chapter reviews the previous work on identifying impacts of transportation on economic conditions. For both freight and passenger transportation, enterprise location plays an important role, and thus the pertinent literature on enterprise location theory is reviewed first. Next to be reviewed is the literature on the impacts of freight and passenger transportation. The literature concerning large-scale regional models is presented last.

III.2 ENTERPRISE LOCATION

Both freight and passenger transportation may affect economic development through enterprise location. Freight-transportation costs may determine whether a firm will locate close to its inputs, close to its market, or somewhere in-between. Passenger transportation improvements between two communities may increase the labor pool available in both communities and attract more firms to the area. While the literature on enterprise location is primarily concerned with manufacturing firms, other firms, such as certain service industries, are also important.

Variables affecting industry location could be classified into three types, i.e., i) fiscal, ii) internal or firm-specific and iii) resource related. The major variables considered in the past studies are listed in Table 6. Detailed discussion of specific studies and their conclusions can be found in Appendix 2.

Fiscal variables are controlled by the community. The internal variables are firm-specific; a locating firm may select different sites based on whether it is locating a branch, regional headquarter or corporate headquarter, or it may choose different sites based on its size (number of employees), or based on whether it is public, proprietorship or partnership (ownership type). Fiscal and internal variables are not of direct interest in this study. Therefore, a limited discussion of selected literature regarding their possible impacts on economic development has been included in Appendix 2.
Table 6. Variables affecting the location of industry

<table>
<thead>
<tr>
<th>Type of variable</th>
<th>Specific variables considered</th>
</tr>
</thead>
<tbody>
<tr>
<td>fiscal</td>
<td>local business tax</td>
</tr>
<tr>
<td></td>
<td>per capita police and fire expenditures</td>
</tr>
<tr>
<td></td>
<td>per capita sanitation expenditures etc.</td>
</tr>
<tr>
<td>internal</td>
<td>variables related to specific firms such as: size of firm branch, headquarters or regional office ownership of the firm</td>
</tr>
<tr>
<td>resource related</td>
<td>availability, proximity and cost related to labor</td>
</tr>
<tr>
<td></td>
<td>land</td>
</tr>
<tr>
<td></td>
<td>raw materials</td>
</tr>
<tr>
<td></td>
<td>markets</td>
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<td></td>
<td>industrial concentration</td>
</tr>
<tr>
<td></td>
<td>transportation service</td>
</tr>
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</table>
Resource related variables deal with availability, cost and proximity of inputs for manufacturing, distribution and other activities of the locating firms. Along with land, labor, raw material and markets, many studies have also considered the industrial concentration of a community (measured by the fraction of the labor force employed in manufacturing) to explain the location of industry.

In particular, industrial concentration is considered because the locating firms are believed to search for agglomeration economies by selecting sites closer to the firms of related industries. Further, access improvements to markets and raw materials are considered since they can effectively decrease the time and/or cost to reach such locations by improving transport facilities - only recently a Boise-Cascade plant closed with 600 jobs being lost in International Falls, Minnesota and the management cited "long shipping distances to Sun Belt markets" and high-cost transportation service as major reasons for this and possible future similar decisions. As another example, Spring Hill’s central location on major rail and highway routes within 500 miles from most prospective markets apparently helped tip GM’s decision on locating the Saturn plant (WSJ, 1985).

III.3 FREIGHT TRANSPORTATION IMPACTS ON ECONOMIC CONDITIONS

The economy can be affected by freight transportation in many ways. In particular, the transportation costs and accessibility may affect the locations where firms locate. Furthermore, transportation may permit or make economical the development of certain resources which otherwise would not have been developed. The recent empirical evidence is mixed on whether changes in freight transportation can have impacts on economic development. Several studies have claimed to find such impacts, whereas other studies have concluded that any impacts are insignificant.
For instance, Lichter and Fuguitt (1980), in their study of interstate highways in the United States, found that counties having interstate highways consistently had an advantage over other counties with regard to population and employment growth. The effect on employment was primarily with regard to service employment - both nonlocal and tourist-related. The effect on population growth was strongest in less remote areas and varied inversely with the distance from a metropolitan area. This is in agreement with Humphrey and Sell (1977) who, in their study of controlled access highways in nonmetropolitan Pennsylvania, found that population growth was increased by the highways but only within 25 miles of a metropolitan area.

Briggs (1981) studied all nonmetropolitan counties in the U.S. and examined the relationship between freeway location and migration and employment change between 1950 and 1975. He found a correlation between counties having freeways and the counties' growth rates. In agreement with Lichter et al, tourist services was the industry most closely associated with the freeways. Manufacturing and wholesaling activities were not found to be clearly associated with the freeways. In agreement with these findings, the Pennsylvania Study (Twark et al, 1980) estimated that service stations, restaurant and motel expansion were the most frequent form of new development likely to take place at an interchange site.

In Canada, the Atlantic Region Study (Wilson et al, 1982) concluded that increased public expenditures in transportation infrastructure "...are not likely to attract new industry where a reasonably mature transportation system is properly in place and maintained." Similarly, Kuehn and West (1971), in their study of the region around the Ozark Plateau, concluded that there was little correlation between highways and economic development. They point out that, even if there was a correlation, the direction of causality of that correlation may be that highways follow economic development rather than economic development resulting from highways.
Although some of the above studies found economic effects from transportation, most found that these effects occurred primarily close to metropolitan areas. Further, even when these effects did occur, the industries affected were not manufacturing firms, but rather firms whose functions were to service those using the highways, e.g. gas stations, restaurants, and motels. These firms often were merely relocating from areas through which the highway users previously would stop.

While the above findings do not indicate any significant links between highways and economic growth, some literature has claimed to find links between freight transportation and economic development of a more substantive nature. For example, Dogdson (1974), who investigated the effects of motorway investments on regional growth in North England, concluded that there is a strong relationship between employment growth rate and transportation cost. However, other policies, not transportation related, could provide a stronger stimulus to regional growth. In agreement with Dogdson, Gaegler and March (1979) concluded that manufacturing employment and population increased more in the towns near the Connecticut Turnpike than in the control towns away from the turnpike and Interstate 95.

Similar results from Georgia-Kansas Study (Jones and Sharp, 1978) indicated that the market costs for products in the four producing zones of northern Mississippi would become more competitive as a result of planned accessibility, highway, railway and intermodal transfer improvements. Further, in St.Louis Lin and Hansen (1976) found that industries that are highly sensitive to line-haul transport improvements were also highly sensitive to terminal facility improvements.

The studies so far mentioned are concerned with highways. Studies of the effects of railroads have had similar results. For instance, Sammon (1979) concluded that "... many branch-line abandonments often mark the end of a series
of unfavorable regional economic events." In Minnesota, railroad abandonments had little or no effect on the financial positions of the grain elevators in the area the railroads formerly served. Nevertheless, a study by Smart, Hellesen, and Eichner, found impacts from railroad abandonments to range from negligible to severe, leading some mining operations to relocate. However, in a DOT study, the Massachusetts Institute of Technology found no evidence of any measurable adverse economic effect from the railroad abandonments in the 9 counties investigated (Sammon, 1979).

As a final note, preliminary results from a study of the northwest Indiana region (Sinha et al., 1983) indicate that transportation-related state policies can have two major effects, i.e. they (a) can affect economic development (including the transportation sector of the economy) directly and/or (b) can affect transportation systems directly and thereby accelerate economic development.

To summarize, the empirical literature on freight transportation and economic development is contradictory but the majority of the studies indicate that transportation investments today have little effect on economic development. Historically, by increasing accessibility, transportation has played a major role in developing this country. However, today we have a well-developed transportation system and thus, as long as it continues to provide good accessibility, transportation improvements may no longer contribute significantly to economic development. This is what the above literature would indicate. Nevertheless, the literature on large-scale regional models, summarized in section III.5 (and discussed in Appendix 3 in more detail), presents a different picture.
III.4 PASSENGER TRANSPORTATION IMPACTS ON ECONOMIC CONDITIONS

While freight transportation may directly affect enterprise location, passenger transportation can indirectly affect enterprise location through its effect on labor conditions. Passenger transportation improvements in nonurban areas have a potential greater than that of urban transport improvements to increase the labor supply to a particular location. For instance, by providing commuting services (e.g., transit, vanpools) to a nonurban region, a transport system can bring workers in from areas to which this region was not very well accessible.

Enterprise location literature cited in Appendix 2 demonstrates that labor factors, especially the pool of labor available to the firm, have major effects on the locational decisions of firms and hence on economic growth. If a transportation improvement were to increase the labor pool available to a particular area, then the probability of firms locating in that area should increase if the firms considering locating in the area were also informed. This would be especially true in rural areas where labor tends to be less expensive and firms more labor intensive (Lonsdale, 1969). Erickson (1976) investigated this effect when studying industry locational patterns in the nonmetropolitan region of Wisconsin. In particular, he identified 120 rural manufacturing enterprises with five or more employees (most were branch establishments), which were established in the region between 1969 and 1975 and were still operating in mid-1975. Sixty percent of the branch establishments indicated that the attributes concerning the pool of labor strongly dominated the other factors when the decision of where to locate the firm was made.

Stephanedes and Eagle (1982) also studied this effect and found that transportation costs and accessibility do affect where jobseekers look for work, and that firms are affected by the size of the labor pool available to them. They identified two ways that transit policies can affect the regional economy:
(a) by providing transportation to employment centers for the carless,

and

(b) by decreasing the commuting cost to a job so that an individual is

more likely to accept the job rather than stay unemployed.

In either way the direct economic effects of public transit on the economy would
be positive. However, careful consideration of the negative effects of the
costs for operating the transport service as well as possible transport
substitutes is needed before the net effects can be estimated.

These results are in general agreement with those of the Connecticut
turnpike study (Gaegler et al, 1979) which investigated the long-term social and
economic impacts of a turnpike in the eastern Connecticut region. In
particular, when transportation accessibility is uniform to a particular
factory, the area containing 90% of the factory workers’ residences takes the
shape of a circle. Gaegler et al, however, found that the 90%-worker areas took
on elliptical shapes with the longest diameter lying along the highway. Thus,
employees were willing to drive more miles when they could use the highway, a
result that the Stephanedes and Eagle study would have predicted. (In rural
areas people often commute 15-30 miles one way as Lonsdale (1969) found.)
Changes in population and manufacturing employment were also found by Gaegler to
be related to increases in accessibility afforded by the turnpike.

Various other economic impacts from transit systems have been cited in the
literature. Results from specific studies discussing possible effects of
transit on welfare payments, and household income are highlighted in Appendix 2.
In the same Appendix, conclusions regarding employment impacts of transit
service are presented. In summary, these conclusions indicate the expectation
that a high unemployment rate in a region that does not offer substantial job
opportunities can be decreased by a public transport system that provides
commuting services to nearby employment centers with an excess number of job
openings.
Local sales may be affected by transportation changes. A discussion for the U.S. Department of Transportation (1974) concluded that upgrading intracommunity transit increases local sales of goods and services. On the other hand, upgrading intercommunity transit between communities of different size tends to siphon some of the sales away from the smaller communities and towards the larger ones.

Property value has also been affected by public transportation. A study by Mudge (1974) and one by Mudge and Allen (1974) demonstrated that the Philadelphia-Lindenwold Mass Transit Rail Line had a positive impact on nearby residential property values in suburban South Jersey. However, they further concluded that this may have had a negative impact on property values of nearby areas too far from the line to use it.

Based on this overview, it is concluded that passenger transportation may influence economic development in several ways. Local sales may be affected, the labor pool may increase and the cost of labor may decrease as a result of better transport service, thus attracting more enterprises to a region. However, the cost of providing better service may not make the overall investment attractive.

III.5 LARGE-SCALE REGIONAL MODELS

In the last 20 years, several large-scale regional models have been developed. These models are concerned with regional economic forecasting and policy analysis. Several of the models include a transportation element that seems to play a significant role in the analysis. Some have been used to analyze transportation policies, and in particular the Harris model's theory (Harris, 1973) is strongly dependent on the role of transportation costs. Most of these models use the input-output (I/O) method as a basis, with the exception of Harris who uses his own theoretical foundation for his model.
While all models indicate that transportation can influence economic development, only three (Roberts and Kresge, 1968; Amano and Fujita, 1970; Sakashita, 1974) explicitly include a transportation module - and not one of the three has been tested in the U.S. A brief analysis of these models is presented in Appendix 3.

III.6 SUMMARY

While the small-scale empirical studies on freight transportation conclude that transportation has little effect on today's economy, the large-scale regional models indicate that transportation can affect the economy. This presents a contradiction that exists within the literature - one that this project will address and try to resolve. Several possible explanations for the discrepancy include:

(a) The large-scale regional models estimated transportation coefficients for specific sectors, whereas the small-scale studies were more generally oriented. With different sectors of the economy changing in different directions as a result of transportation, the net overall effects may be insignificant even though, by sector, the transportation effect is significant. The few small-scale studies concluding economic effects from freight transportation, did specifically define a part of the economy they were studying.

(b) Because different sectors of the economy affect each other, an identification problem may have existed in the small-scale models, which the larger scale models took into account.

(c) The effects identified by the large-scale models may be passenger-transportation related; if so, they would not contradict the small-scale empirical studies on freight transportation.
The purpose of this review was to determine whether transportation projects have economic impacts that other construction projects do not have. These impacts, if they occur, must stem from changes in transportation services. The review did not, therefore, discuss the (short-term) induced economic effects resulting from the construction of transportation projects. For similar reasons it did not consider the possible economic effects of the taxes used to finance transportation projects.
IV. IMPLEMENTATION PLAN

IV.1 INTRODUCTION

Two of the principal goals of the second phase of this project are:

(a) to determine whether there are significant links between transportation and regional economic development, and

(b) if transportation is found to affect economic development, to evaluate the effects of various transportation policies of interest to MnDOT on the economy of a particular Minnesota region such as Northeast Minnesota.

To address the above goals, the project has undertaken two interrelated major tasks. Implementing a (macro-)analytical method to predict the economic impacts of transportation policies is the objective of the first task. This task began in Phase A and will be revisited, as necessary, in Phase B. While methods employing a large-scale model may provide an overall picture of the economic impacts of transportation, such models are macroeconomic in nature and thus can only analyze general transportation policies. For example, a policy that reduces transportation costs by 10% for the area under analysis could be analyzed by a large-scale model. However, an analysis of a specific highway project would not benefit significantly from the use of such a method.

To provide information that can be useful for the (micro-)analysis of specific transportation policies (and can lead to evaluation of specific projects), a second major task is undertaken. Analyzing the ways in which
transportation affects commodity and passenger flows is the main objective of this task. This analysis will be largely descriptive and will use various methods and concepts from transportation engineering, statistics and operations research rather than rely on large-scale modeling techniques. The details of our plan for completing this task are presented in section IV.3. The plan to implement a (macro-)analytical method is presented in the next section.

IV.2 IMPLEMENTATION OF (MACRO-)ANALYTICAL METHOD

Below are the steps that are necessary for completing the (macro-)analytical method implementation task:

(1) Criteria determination for method selection. A method employing a large-scale model must be selected from amongst the several discussed in Chapter III. Criteria need to be specified as a basis for that selection.

(2) Method selection. Based on the criteria determined in step (1), a method will be selected for the analysis. Presently, the methods using the SIMLAB and Amherst models are being seriously considered. If time permits, both methods may be employed and the results compared.

(3) Region and policy selection. Responding to the project monitor's recommendation, we will concentrate our analysis in the Northeast region of Minnesota. Policies to be analyzed must be suited for the region selected and still be within the scope of the large-scale model employed in the analysis.

(4) Application. The selected method will be applied to one or two Minnesota regions. Data must be collected (including the flows described in section IV.3) to adapt the method to these regions.
### Table 7. Summary of analytical methods

<table>
<thead>
<tr>
<th>Study Region</th>
<th>Reliability</th>
<th>Application</th>
<th>Data Needs</th>
<th>Dynamic Policy</th>
<th>Sensitivity</th>
<th>Calibration</th>
<th>Only Method</th>
<th>Freight Regr. I/O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlantic</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Region</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>St. Louis</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North England</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Amherst</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Georgia</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polensie</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Harris</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connecticut</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colombia</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minnesota</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N.W. Ind.</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amanc</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sakaske</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIMLAB</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
with increased flexibility for making decisions under changing conditions in the state of the economy. Of all studies reviewed in Chapter III, only two employ dynamic principles in modeling transportation and economic development relationships. These are, the Northwest Indiana (Sinha et al, 1983) and the University of Minnesota Study (Stephanedes and Eagle, 1982).

In the Minnesota Study, Stephanedes et. al. determined ways in which transport policies that may vary through time (hence called, "dynamic transport policies") act to enhance rural mobility and economic development. While its scope was quite limited, useful concepts were developed which can be employed to facilitate the transition from a static to a dynamic method if essential time lags are known. The method was validated in Austin and Albert Lea, Minnesota. Additional tests in DuBois and Brockway of Northcentral Pennsylvania indicated that the developed model has potential for transferability.

The major drawbacks of most of the multiregional I/O models presented in Appendix 3 are their assumptions on fixed trade structure. More specifically, such models fail to allow the trade and technical coefficients to change over time in response to changes in transport costs, wage rates, land prices and capital costs. The Amherst I/O Model is an exception in that the intensity of factors is endogenous to the model and may vary.

The Colombia and Japanese models have each developed a number of transportation submodels such as mode choice, distribution and assignment. (Figure 10 illustrates the common characteristics of these models.) These submodels determine inter- and intraregional flows of passengers and commodities using the information obtained from the economy sector, assign these flows on the existing network, check network capacity, determine congestion effects if any, estimate transport time and cost variations, and finally determine the revised transport costs which are fed back into the economic sector for further analysis. All models are flexible enough to treat different policies directly and have a
Figure 10. Model Comparison
built-in time lag, which is realistic since the economy sector reacts to the changes in the transport sector only after a specified time interval.

Even though the structure of the Colombia and Japanese models is very logical, the models have not been applied and tested in this country and may not be suitable for implementation in this project for they treat a whole state as a region. The latter reason is crucial, because it implies that these models would have to be applied twice; i.e., first at the national level and, second, at the state level. This requirement could create a very rigid and cumbersome method, both in terms of data needs and ease of application. On the other hand, the Amherst models do not need such special treatment, since they are created to address U.S. problems and are built to generate regional coefficients from the national data.

The lack of emphasis on causal relationships and feedback loops is the major drawback of the Amherst method. In their absence, model application does not allow a complete understanding of the impacts of proposed transport policies, and does not guarantee that any estimated economic impacts will actually be realized. However, these drawbacks may be corrected by redefining the specific component relationships necessary to explain flows that are most important to the Minnesota economy. For instance, systematic methods are needed for estimating highway flows of grain shipments based on changes in shipping costs by travel distance and shipment size. Only through use of such methods can the Amherst model be used for policy analysis. In addition, specific control systems techniques (see Appendix 6 for definition) can be employed to assure that any proposed policies are feasible and that estimated or desired economic impacts can be realized.

At present, the Amherst and SIMLAB models appear to offer the most potential for analysis. The Amherst model is currently being used by the Minnesota Department of Revenue, and can be made available for use to MnDOT and
the University of Minnesota. SIMLAB, on the other hand, has advantages over the Amherst model in that it has been developed in Minnesota, and thus those who helped in its development are more available than is the case elsewhere. In addition, SIMLAB has been applied in Northeast Minnesota and Region 6E, so that much of the data collection and calibration for these regions has already been completed.

IV.2.3. Region and policy selection

While the modeling technique to be tested and that which will be developed will be applied to Northeast Minnesota for policy purposes, a different region can be selected, if time allows, for model calibration. The economy of that region should be more stable and well defined, and the area of application should offer uniform transport access. Region 6E (Willmar) is an example of a region that would be suitable. Upon recommendation of the project monitor, policy analysis will concentrate in policies that may help the economy of northeast Minnesota. In particular, emphasis will be placed in evaluating highway weight restriction policies.

IV.2.4 Data requirements

To allow a comparison of data needs among the major methods that have been reviewed, Table 8 summarizes the most important data required. Most models are data-hungry, a result of (a) the large number of variables included in their economic sector and (b) their use, with the exception of the Minnesota study, of aggregate or only partially disaggregate data. To be sure, the need for large amounts of data can be reduced by using disaggregate information, thus making efficient use of the data base. In addition, various control systems methods can be employed for effectively reducing the number of variables in the analysis.
Table 8. Data requirements of major analytical methods

<table>
<thead>
<tr>
<th>Study/Model</th>
<th>Data Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlantic region study</td>
<td>Geographic and demographic regional characteristics, information on industrial sectors, plant size, market orientation, freight costs and plant location factors.</td>
</tr>
<tr>
<td>St. Louis study</td>
<td>Total industrial output, transport cost, imports, exports, industrial production capacity, final demand, unit production cost.</td>
</tr>
<tr>
<td>Pennsylvania study</td>
<td>Average Daily Traffic (ADT), property values, population, country population density change, number of service stations, restaurant seats and other commercial development.</td>
</tr>
<tr>
<td>North England study</td>
<td>Total employment, population, vehicle trip volume, transport cost, access cost, line-haul distance, rate of employment growth.</td>
</tr>
<tr>
<td>Amherst model</td>
<td>Employment, wages, state taxes, consumer price index, data on export production and import goods and services, household consumption patterns, corporate taxes, population, national I/O tables, elasticity of export employment to relative cost, etc.</td>
</tr>
<tr>
<td>Georgia-Kansas study</td>
<td>Network information, mode information, commodity flows, measure of service-dependability, unit transportation costs, travel times.</td>
</tr>
<tr>
<td>Polenske model</td>
<td>Regional input-output data, interregional trade flow data, final demands, regional consumption of goods, investments and governmental expenditures.</td>
</tr>
<tr>
<td>Harris model</td>
<td>Transport data, i.e., shipment size, weight, type of good, line-haul distance, modal information, vehicle-miles, capacity.</td>
</tr>
<tr>
<td>Connecticut study</td>
<td>Population, employment, wages, retail sales, travel times.</td>
</tr>
<tr>
<td>Colombia study</td>
<td>I/O table, transport costs, network information, wages, production costs, personal income, final demand, industrial output, total revenues, investments, profits, labor costs, exports, taxes, link costs, employment, etc.</td>
</tr>
<tr>
<td>Minnesota study</td>
<td>Disaggregate data on socioeconomic characteristics, transportation data and economic data.</td>
</tr>
<tr>
<td>Amano model</td>
<td>I/O table, industrial investment, capital stocks, transport cost, import coefficient, final demands, population, employment, traffic capacity, personal income, production cost, trade patterns, etc.</td>
</tr>
<tr>
<td>Sakallthita model</td>
<td>Private capital stocks, final demand, transport time, distance and cost, national production, employment, population, total demand and supply, commodity and passenger flows/assignment, etc.</td>
</tr>
</tbody>
</table>
A wide variety of socioeconomic, demographic and transportation/traffic-related data for the State of Minnesota are available from a variety of sources. The Minnesota Department of Energy and Economic Development compiles an extensive amount of data on population, industry, employment, transportation, commercial/industrial taxes, community services, education, and locational services for a great number of communities throughout Minnesota. These Community Profiles, along with the County Business Patterns available through the U.S. Dept. of Census, can be a major source of information for the analysis in this project. The Community Profiles are categorized by Region; in turn, the Minnesota Regional boundaries are completely defined by the counties they contain, thus allowing cross-reference with the County Business Patterns. In previous work in this area (Stephanedes and Eagle, 1982), the principal investigator employed the regional boundaries to effectively analyze dynamic problems of transportation/economy interactions at the regional, county and community levels. These boundaries will also be adopted here. Additional data will be found from other sources such as the Minn DOT, Chambers of Commerce, regional planning offices (where regions are still in operation; for instance, regions 4, 7W and 10 are defunct now), Grain Exchange, and the Interstate Commerce Commission.

It should be noted that, with the closing of the Minneapolis Grain Exchange, accessing grain-related data could be hampered. In addition, certain data that could be useful to this and similar projects are not available. Examples of such data include information on service availability time (e.g., equipment delay) and reliability (e.g., percent shipments arriving by a given date) by commodity, shipping mode (such as truck, rail and barge) and geographical region. These service variables were for the first time included in effective grain shipment policy models by Saleh and Stephanedes (1983, 1984a, 1984b), who determined that these variables significantly influence grain flows on highway and rail networks.
Surveys can be conducted to develop disaggregate bases, when needed to complement the above information and ensure more efficient use of data and better accuracy of the results. For instance, a survey of manufacturing firms in the Northeast can be conducted to determine the degree to which the existing transport structure serves their needs.

IV.2.5 Data availability

IV.2.5.1 Economic data

Data needed for the economic sector of the large-scale models are presented in Table 9. As the Table indicates, the County Business Patterns (CBP) provide annual data on the employment of the various sectors of the economy, with the exception of government and farming employment that can be obtained from the Censuses of Government and Population, respectively. While the detail in the CBP is impressive, the CBP are based on samples and have been found to consistently understate employment. Thus it is important that the data from the CBP be adjusted to be consistent with the employment figures from the Regional News Bulletins, that are benchmarked and balanced with the state and national total employment figures.

IV.2.5.2 Transportation data

The extent of availability of various transportation data has been determined in the course of completing several projects by the Transportation Division at the Civil Engineering Department of the University of Minnesota. With regard to grain transportation, for instance, one project needed four types of data, i.e., (1) grain flows, (2) transportation costs, (3) transportation times, and (4) equipment delay times. Many of these data had to be acquired from surveys and contacts with elevators and carriers. By talking to the elevators, for example, the production at each zone, the demand at each
## Table 9. Economic data availability

<table>
<thead>
<tr>
<th>INDICATOR</th>
<th>SOURCE</th>
<th>FREQUENCY</th>
<th>DATA PROBLEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>employment by sector</td>
<td>County Business Patterns</td>
<td>Annual</td>
<td>employment does not include farmers, self-employed or government employees.</td>
</tr>
<tr>
<td>farm commodity supply</td>
<td>Census of Agriculture</td>
<td>Every 5 years</td>
<td></td>
</tr>
<tr>
<td>government employment</td>
<td>Census of Government</td>
<td>Every 5 years</td>
<td></td>
</tr>
<tr>
<td>unemployment rates and wage rates</td>
<td>Regional Economic New Bulletin</td>
<td>Monthly</td>
<td>data based on small samples</td>
</tr>
<tr>
<td>farming employment</td>
<td>Census of Population</td>
<td>Every 10 years</td>
<td>data very infrequent</td>
</tr>
<tr>
<td>GNP deflator</td>
<td>Federal Reserve Bulletin</td>
<td>Monthly</td>
<td>none</td>
</tr>
<tr>
<td>commodity supply</td>
<td>Dept. of Commerce Commodity Tables</td>
<td>1972 only</td>
<td>data dated</td>
</tr>
</tbody>
</table>
destination, and the transportation rates were determined. While transportation
times were easily available, data on the equipment delay time (i.e., the delay
between the time a carrier is called and the time that carrier arrives for
transporting a good) were hard to obtain. However, the literature has found
delay time to be very significant as it increases inventories, a major expense
of the grain shippers and receivers. Finally, some data were obtained from
publications of the Minneapolis Grain Exchange. However, in 1984 the
Minneapolis Grain Exchange closed so future availability of those data is no
longer guaranteed.

The Census of Transportation is an additional source of transportation
data. The 1977 Census of Transportation consisted of three volumes, i.e., (i)
Truck Inventory Survey, (ii) Transportation Commodity Survey, and (iii)
Passenger Flows Survey. The most useful of the three volumes is the
Transportation Commodity Survey, which gives the commodity flows among the
states, and among various SMSA’s including the Twin Cities Metropolitan area.
For 1977 these data were balanced to the 1977 Census of Manufacturing, and thus
their reliability should exceed that of the 1972 Transportation Commodity
Survey.

IV.3 COMMODITY AND PASSENGER MOVEMENT PATTERNS

The second major task that this project has undertaken, is to analyze the
transportation effects on flows. The plan to complete this task is presented
below:

1. Collect data for analysis. Existing data on flows and transportation variables such as cost, travel time, and equipment delay
will be collected. Data that cannot be obtained will be
estimated. If it is possible, the data should be collected for more than one time period, for example 1972 and 1977. These data should be on a substate level, preferably on a county level.

(2) **Descriptively analyze data.** Commodity flows will be reviewed and compared to transportation variables to learn of any relationships that may exist. If data are obtained for different years, changes in the commodity flows will be compared to changes in transportation variables.

(3) **Statistically analyze data.** Statistical methods will be used to investigate correlations between flows and transportation variables that are indicated in the descriptive analysis.

The collection of data will consume the majority of the time in the completion of this task. This chapter discusses the data that exist on commodity and passenger flows in Minnesota.

Information on grain movements has been contributed, to a large extent, by one study set (Alley, et. al., 1979a,b,c,d). For flows of other commodities, however, little direct data exist. The missing data can be estimated using data from the County Business Patterns, the Commodity Transportation Survey, transportation-cost estimates, and input-output coefficients. However, that estimation procedure requires a substantial amount of data collection and computer time. Thus, for non-grain flows, only the methodology for determining such flows on a substate basis is presented.

Information on commuting patterns is available from the 1970 Census of Population, in a volume by the State of Minnesota. This volume classifies employees who reside in a particular county by the county they commute to. The commuting patterns for all Minnesota regions as well as those for some counties are presented in the last section of this chapter.
IV.3.1 Commodity flows: Grain

Movements of grain into or within the state use either railroads or trucks. Movements of grain out of the state use primarily rail and water transportation, and trucks are used to a small degree to move grain to Wisconsin and Illinois. Duluth/Superior and the Twin Cities (defined to include Red Wing and Winona) are the destinations for most of the grain moving into or within the state. Almost all of the grain Duluth/Superior receives is then exported, mostly by vessel, to other countries. While the Twin Cities reships much of the grains that it receives, some is used or processed locally. What the Twin Cities does ship out of the state goes by rail to eastern or southern states, by rail to the Pacific Northwest export ports, or to the Gulf of Mexico export ports mostly by barge (Alley et al, 1979a,b,c,d,1983).

Lately, the trend in transportation modes for grain moving to Duluth/Superior and the Twin Cities is consistently toward increasing rail volume (Alley, et. al., 1983). The increased rail shipments from country elevators have reduced the wear and tear on primary roads. However, the movement of grain to regional subterminals requires heavy vehicles to travel longer distances over rural and secondary roads, which have weaker structures than the primary roads. Because of this shift from primary to secondary roads, road wear may increase even though trucks are driving fewer miles in the transport of grain.

In their 1979 study, Alley et. al. examined the grain movements of wheat, corn, soybeans, oats, flax, and rye. A summary of their detailed findings for each grain is presented in Appendix 4.

IV.3.2 Methodology for estimating commodity flows

Alley et. al.'s determination of grain flows is an unusual case. For most commodities, direct data on flows do not exist on a substate, non-SMSA level.
However, methodologies are available to estimate commodity flows from data that do exist. For instance, one such methodology uses the 1972 Department of Commerce Commodity Tables, but its estimates are net flows (Maki, 1981). Another methodology estimates gross flows using the County Business Patterns, the 1977 Commodity Transportation Survey, and the national input/output matrix (Stevens, et. al., 1982).

This section briefly describes a methodology similar to that used in the Amherst model to obtain estimates of commodity flows by solving a transportation problem that uses the demands, supplies, and transportation costs by county for each commodity. The estimates are commodity flows from county i to county j (i can equal j). The flows are not broken down by mode. A detailed description of this methodology is presented in Appendix 5.

The methodology involves estimating the demands and supplies of each commodity by county, estimating transportation costs, and determining the most efficient flows to get supplies to the demands. In the first step of the method, data on each county's supply of each commodity must be obtained from the Census of Agriculture or other sources. If such data cannot be found, then the employment data from the County Business Patterns can be used to estimate the supply, by using the I/O coefficient for that commodity. For example, if we know that 167 workers are employed in Polk County in the production of butter, and that each pound of butter uses 0.1 hour of labor on average, then we can estimate the amount of butter produced each year in Polk County:

\[
(167 \text{ workers} / .1 \text{ labor-hr/lb}) \times 40 \text{ hrs/wk} \times 52 \text{ wks/yr} = 3,473,600 \text{ lb/yr}.
\]

Demands in each county for each commodity must be estimated next. If the data do not exist, estimates can be obtained from examining consumption demand, industrial demand, and governmental demand separately. The consumption demand may be estimated by multiplying the number of consumers in a county by the typical consumer's demand for each commodity. The industrial demand can be
estimated by multiplying the supplies by the I/O coefficient for the use of that commodity. For example, let us suppose that we wish to determine the industrial demand for electrical equipment in Polk County. Let us also suppose that the I/O coefficient for electrical equipment used in butter production is five cents worth of electrical equipment per pound of butter produced. Then the value of the new electrical equipment that the butter industry in Polk county would use would be $173,680. To obtain the total industrial demand for electrical equipment for Polk county, this computation must be done for all commodities and services produced in Polk county.

While the proposed methodology may be subject to certain sources of error, it is probably the best alternative when no other data on commodity flows exist. Although the methodology has not yet been implemented in this project, it should be noted that the builders of the Amherst model did use a similar estimation procedure. Undoubtedly, some adjustment to the method will be made during implementation.

Transportation costs are finally estimated. Since the methodology does not distinguish amongst modes, a representative transportation cost must be determined for shipping a unit of a commodity from county i to county j, for every i and j. Once this is done and the demand and supply estimates are adjusted so that aggregate demand equals aggregate supply, a transportation problem can be solved determining the most efficient flows.

By defining certain regions of the country outside of Minnesota as counties, this methodology can also produce estimates of commodity flows from each Minnesota county i to region j. Since certain data exist on interstate commodity movements in the Commodity Transportation Survey, it is important that these data be used in this procedure. The details of how such data can be employed by the methodology are presented in Appendix 5.
IV.3.3 Passenger flows

Data by county on the number of people working within and outside their county of residence can be obtained from the U.S. Censuses of Population. However, these data do not reveal the county in which these people work, when the county is not the one in which they reside. Nevertheless, for 1970, the Minnesota Office of Planning and Development did compile a breakdown of workers by the counties in which they work using the raw census data. This breakdown reveals a set of commuting patterns that is more detailed than that in the U.S. Census. These commuting patterns are presented in Figure 11, for the movements between regions, and Figure 12, for travel in counties in the Northeast and Northwest section of Minnesota as well as region 6E. Unfortunately, it seems that no such breakdown was compiled for the 1980 Census.
Figure 11 Regional commuting patterns in Minnesota

Source: Minnesota Office of Planning and Development
Figure 12 County commuting patterns in selected Minnesota regions

Source: Minnesota Office of Planning and Development
V. CONCLUSIONS

Findings from previous work indicate that economic development can be influenced by numerous fiscal, internal and resource related factors. Market access, labor cost, labor pool size, industrial concentration, and access to raw materials are the most important of these that could be affected by transport policies.

Transport investment can influence the above variables in several ways but mainly by:

(a) Influencing the location of firms,
(b) affecting commuting patterns,
(c) allowing resources to be developed, and
(d) ensuring high productivity levels in the primary sector. In addition,
(e) in the service sector, transportation could be combined with (or replaced by) other forms of communication to increase the effectiveness of economic activities as, for instance, in information processing.

While there is a wide range of transport policies that could be used to stimulate a regional economy, the main objectives of such policies include generating new firms in the region, averting closing of existing firms, and pursuing proper diversification of the economy to achieve a desirable mix of economic components.
Most existing methods for analyzing the potential influence of transportation policy actions on economic development have been developed to analyze and evaluate the effects of specific investments and, therefore, are not appropriate for application in evaluating broad-based policy schemes. A select number of large-scale input-output models, which are appropriate, were reviewed and at least two of these, the Amherst and SIMLAB models, have been found suitable for responding to the needs of this project.

However, the Amherst and SIMLAB models are characterized by a number of drawbacks that are common to most models in this category. For instance, they do not place emphasis on explaining the cause-effect relationship between transportation and the economy and, as a result, do not help the user to reach a satisfactory understanding of policy effects nor do they offer assurances that these effects can be realized. They are data-hungry and employ aggregate data, i.e., "averages", thus not making use of the substantial variability in the data prior to aggregation (i.e., prior to "averaging"). Further, they assume that the transport and economic structure respond uniformly and fully to policies being implemented, and that most estimated impacts will be realized without delay and without being influenced by market imperfections. However, it is exactly such imperfections or "inertia" in the economy that often are the major cause of undesirable effects such as high unemployment.

Finally, the major disadvantage of both models, as well as all other available methods that could be readily employed in this project, is the lack of a transportation sector. Such a sector would be a necessary component in any comprehensive simulation method that seeks to determine possible impacts of transportation policies on the economy.

The transportation sector should be able to interact between transport policy makers and models of the economy by translating the specific characteristics of the policy to be implemented into information an economic
model can understand. In the case of changes in highway weight restrictions, for example, this could be accomplished by (a) identifying the commodities (e.g., grain) that constitute the bulk of movements on the critical links, (b) determining the effect of the new regulations (or deregulation) on the transport cost, shipment size, frequency and other characteristics of such movements, (c) estimating future flows (e.g., grain movement assignments) based on the changes in these characteristics and the resulting shippers' decisions regarding shipment destination and mode choice, and (d) determining the impacts on the condition of the existing network resulting from the new flows. The above information would then be entered in the appropriate components of the economic model (e.g., SIMLAB), ensuring that all effects are taken into account but none is double-counted. The impacts on the economy of the communities that are affected by the changes in the flows would finally be forecast and evaluated.

The above example demonstrates the necessity for understanding the ways in which a transportation policy specifically affects transport supply (e.g., level of service and cost) and demand, before attempting to forecast and evaluate the economic impacts of that policy. This understanding should be based on systematic methods that develop a clear, logical relationship between cause (transport policy) and effect (behavior of highway users). Such methods should be sensitive to changes in policy and service characteristics, so that they may be used in a wide variety of decision-making situations with confidence. They should not be data-hungry; instead, they should use data efficiently, thus substantially decreasing their cost of implementation. And they should be easily updated, so that they remain applicable through periods in which the economy undergoes substantial changes; for instance, during periods of changing energy costs, inflation, employment and industrial concentration.

Development of causal relationships that address specific policies and industries, is essential for an additional reason. In particular, it is
essential for determining the impact of transportation policies at a micro-scale (i.e., one relating to detailed actions such as building or expanding the roads needed by a new plant; maintaining or abandoning a highway link or rail segment; allowing heavier use of a highway link; etc.). While development of a transportation module in Phase B will go a long way towards establishing a systematic link between transportation policies and changes in transport costs and flows, the scope and time limitations of the current project do not allow development of detailed causal links for individual policies and industries. Rather, this project will address such policies at a macro-scale (e.g., one addressing these actions as they relate to a county or set of counties) only.
APPENDICES
APPENDIX 1

BRIEF ECONOMIC HISTORY OF MINNESOTA

The references for the material discussed in this section can be found in the Reference section of this report. The major references include, Folwell (1921), Christianson (1935), Blegen (1963), and several issues of Minnesota History.

1. Fur trading

The first industry in Minnesota was fur trading, and was started by two British companies along the Red River, in the northwest part of the state. During the War of 1812 the two companies were fighting for control of the region. The Hudson Bay Company had tried to establish a farming colony there with Swiss immigrants, but the North West Company conspired to force the colonists out. Development of trading posts in the southeastern part of the state occurred after Fort Snelling was built in the 1820s. The first headquarters of the American Fur Trading Co., which controlled most of the fur trading in the southern part of the state, was first located in Mendota across from Ft. Snelling on the Minnesota River. Later, the American Fur Trading Co. moved its headquarters to St. Paul because of St. Paul's river-navigation advantages.

To get the furs from the Red River Valley to their markets, every spring a train of ox carts were driven from the Red River valley to St. Paul. Their path became the first major long distance road in Minnesota. Many Swiss immigrants, who were forced to flee the Red River Valley because of the North West Company's harassment, followed the ox carts as they exited the region. While many immigrants continued south, some remained and settled around St. Paul.
When Minnesota's economy became more fully developed, fur trading in the area diminished almost completely. Partly this was due to the overkill of the fur-bearing animals in the area, but mostly it resulted because the Indians, on whom the fur-trading business depended, were forced out of Minnesota.

2. Lumbering

The second major industry to enter Minnesota was lumbering. People looked at Minnesota's vast forests, which at that time covered 70% of the state, and thought of them as a limitless source of timber. The existence of the Mississippi, the Minnesota and the St. Croix Rivers provided the necessary transportation of the lumber. This transportation was both from where it was cut to the mills, and from the mills to where it was to be used. Lumber mills were set up at convenient places along these rivers -- Stillwater along the St. Croix, and Winona and St. Anthony (now N.E. Minneapolis) along the Mississippi. Important to the location of the St. Anthony mills was the St. Anthony Falls which provided water power.

The lumber was used locally, in what was often a rapidly developing economy, and also used elsewhere such as in St. Louis. Initially the lumber was shipped by steamboat on the Mississippi River. Later, when the railroads were built connecting Minnesota with the East, much lumber was shipped by rail. Both by rail and river, some of the cargo was lumber, but also some was merely logs, with the processing of the logs being done at the destination rather than in Minnesota.

At first the lumber cut was relatively close to the lumber mills, but as the nearby forests became depleted, the logging operations were extended further and further north. When the available forests no longer were along the Mississippi river, the lumber mills of Minneapolis (St. Anthony) began to be shut down. This process did not occur until after 1899, and by that time, the
Minneapolis economy had become sufficiently diversified to be able to expand into other areas.

The city of Duluth was initially started by a small lumber mill, although its early major development occurred as a result of the railroad connecting St. Paul to Duluth. When the lumber industry moved north, Duluth's importance increased because of its shipping and railroad connections.

Today, while the lumber industry still exists in the north, its size has shrunk considerably since the forests have been depleted. Forest fires have contributing to this depletion. It has been estimated that more Minnesota forest has been destroyed by fire than by the lumber industry. Contributing even further to the depletion of timber, logging firms, seeing that the timber was threatened by fire, worked faster at depleting the forests in order that the timber not be lost to fire.

Local taxes was an additional factor that encouraged the depletion of timber. The local governments would tax the holders of forested lands on an ad valorem basis. However, the timber, which is harvested after the trees have grown for many decades, added value to the lands. Thus, there was an incentive to cut the timber as soon as possible, which the logging companies did. Often the logged land, having been stripped of its value, was allowed to be taken over by the local government because of unpaid taxes.

3. Farming

Initially, farming in Minnesota was largely prevented by Indian treaties and government (military) regulation. The regulations stated that it was illegal to settle outside the triangle ceded by the Indians in the treaty of 1837 and laying between the Mississippi & St. Croix rivers. Some farming was done in this area, but because the area was narrowly defined, only farming for local consumption was done. However, as the town of St. thony Falls developed
on the east bank of the Mississippi, its residents started coveting the rich land across the river. Several individuals used their influence to be granted exceptions to the military regulations. After the area east of the Mississippi was ceded by the Indians in 1851, it became expected that the regulation preventing settlement in this area would be taken off. This led to many illegal homesteading in the anticipation of the removal of the regulation. In 1854, the area east of the Mississippi was opened up and those who had illegally settled there were able to get their land at the government's standard $1.25 per acre. Shortly thereafter Minneapolis was born.

After 1854 agriculture in Minnesota took off. In the first years, since much of the labor was spent clearing the land, Minnesota was still dependent upon imports for much of its subsistence. With the passage of the Homestead Act in 1862, a booming agricultural economy was given an additional boost. During the Civil War, the price for wheat increased inducing its production for export. Another reason wheat, rather than other farm goods, was produced was that it was about the only crop that could be transported far distances without spoiling.

After the Civil War wheat farming boomed. The farms were located quite close to the rivers because it would often cost more to transport the crops to the rivers than it would cost to transport the crops on the rivers to their eventual destination, often out of the state. Rural roads existed primarily from their use with little construction. As a result the roads were very difficult to travel. When it rained, the roads became impassible from the mud.

When railroads were extended into Minnesota's rural areas, farms were located near the railroads just as they had initially located near rivers. Still, often more cost was incurred getting the crops to the railroad terminal than was paid to the railroad. When the weather turned wet, causing rural roads to become impassible, railroad cars would be standing empty for lack of cargo. When good weather conditions returned, the railroads often did not have enough cars to transport all the crops.
In the later part of the 19th century, the land in southern Minnesota became depleted because of the repeated plantings of wheat in that area. Some of the farmers moved on to the Red River valley, where wheat was again the main crop. Many of those who remained diversified their crops. Others started raising livestock or poultry.

As roads became more developed and the automobile/truck age came about, the closeness to railroads became less important; land values adjusted accordingly. Trucks and better rural roads enabled farmers to become less dependent on railroads. Because of their flexibility, trucks have been used more and more for the complete farm-destination trips. As this has occurred, more and more railroad lines have been abandoned. While many complaints have been heard about these closings, the economies of the areas have not been significantly affected because of the close substitution between truck and rail.

Today, farming in Minnesota is very diversified. Corn has replaced wheat as the major grain produced. This resulted in large part to the development of a corn hybrid that would grow in the Minnesota climate. The state ranks high in the nation with respect to agricultural produce as can be seen in Table A1.

4. Grain milling

The first grist mill in Minnesota was started by Ft. Snelling. The flour from the mill came out very dark and thus was very shortly abandoned. The first operational grist mill started in 1854. Because at that time little wheat was being raised in Minnesota, much of the wheat had to be imported from out of the state. In the 1860s, when wheat became the main cash crop of Minnesota farmers, grain milling started to expand in the state. Because of the advantage of the water power of St. Anthony Falls, many of these grain mills located in the Minneapolis area that also benefited from technological advances in the milling process. As railroads linked Minnesota with the rest of the East, Minneapolis
Table A1. Minnesota's 1975 rank among states in agricultural production

**Cash farm income - 1975**

<table>
<thead>
<tr>
<th>Description</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>6</td>
</tr>
<tr>
<td>Crops</td>
<td>6</td>
</tr>
<tr>
<td>Livestock and Livestock products</td>
<td>6</td>
</tr>
<tr>
<td>Government payments</td>
<td>7</td>
</tr>
</tbody>
</table>

**Crop production - 1975**

<table>
<thead>
<tr>
<th>Crop Name</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oats</td>
<td>1</td>
</tr>
<tr>
<td>Timoth seed</td>
<td>1</td>
</tr>
<tr>
<td>Sweet corn for processing</td>
<td>2</td>
</tr>
<tr>
<td>Hay (all)</td>
<td>2</td>
</tr>
<tr>
<td>Sugar beets</td>
<td>2</td>
</tr>
<tr>
<td>Flaxseed</td>
<td>3</td>
</tr>
<tr>
<td>Green peas for processing</td>
<td>3</td>
</tr>
<tr>
<td>Rye</td>
<td>3</td>
</tr>
<tr>
<td>Red clover seed</td>
<td>5</td>
</tr>
<tr>
<td>Barley</td>
<td>5</td>
</tr>
<tr>
<td>Corn for grain</td>
<td>5</td>
</tr>
<tr>
<td>Soybeans for beans</td>
<td>7</td>
</tr>
<tr>
<td>Wheat (all)</td>
<td>8</td>
</tr>
<tr>
<td>Potatoes (all)</td>
<td>9</td>
</tr>
</tbody>
</table>

**Livestock and Livestock products**

<table>
<thead>
<tr>
<th>Description</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creamery butter manufactured during 1975</td>
<td>1</td>
</tr>
<tr>
<td>Nonfat dry milk manufactured during 1975</td>
<td>1</td>
</tr>
<tr>
<td>Turkeys raised during 1975</td>
<td>1</td>
</tr>
<tr>
<td>American cheese manufactured during 1975</td>
<td>2</td>
</tr>
<tr>
<td>Milk cows on farms, Jan. 1, 1976</td>
<td>3</td>
</tr>
<tr>
<td>Home produced, 1975</td>
<td>4</td>
</tr>
<tr>
<td>Milk produced on farms during 1975</td>
<td>4</td>
</tr>
<tr>
<td>Hog marketings, 1975</td>
<td>5</td>
</tr>
<tr>
<td>Hogs on farms, Dec. 1, 1975</td>
<td>5</td>
</tr>
<tr>
<td>Pig crop, 1975</td>
<td>5</td>
</tr>
<tr>
<td>Cattle and calves on feed, Jan. 1, 1976</td>
<td>9</td>
</tr>
<tr>
<td>Chickens on farms, Dec. 1, 1976</td>
<td>9</td>
</tr>
<tr>
<td>Cattle and calves marketed, 1975</td>
<td>10</td>
</tr>
<tr>
<td>Cattle and calves on farms, Jan. 1, 1976</td>
<td>10</td>
</tr>
<tr>
<td>Eggs produced, Dec. 1974 - Nov. 1975</td>
<td>10</td>
</tr>
<tr>
<td>Lamb crop, 1975</td>
<td>13</td>
</tr>
<tr>
<td>Stock sheep and lambs on farms, Jan 1, 1976</td>
<td>14</td>
</tr>
</tbody>
</table>

Source: Minnesota Department of Agriculture crop and livestock reporting service
became the major grain milling center of the nation. However, when railroads became regulated, the rate structure hurt Minnesota's mills. Rates were set so that wheat was less expensive to ship than flour. Thus, the Minneapolis mills were bypassed in favor of mills in Buffalo, New York. Thus, the great "Mill City" today only has two grain mills, although the vast majority of the grain mills in Buffalo were financed by the Minneapolis mill owners. Today under deregulation, rates could change again and, with the proper incentives, mill location may change once again.

5. Distributive services

Initially, the economy of Minnesota consisted primarily of lumbering and fur trading. However, as the various communities developed, their economies diversified. This was especially true for the Twin Cities area that evolved into a center on which much of the Upper Midwest depended. Other Minnesota communities were trying to obtain a major trade center status, e.g. Stillwater, St. Peter, Mendota, Winona. However, the Twin Cities had many advantages which eventually won out. Three major factors that led to the Twin Cities dominance in the region were: (a) All transportation corridors; rivers, roads, and railroads; converged in the Twin Cities area. (b) The cities were located far enough from St. Louis and Chicago to enable them to grow as a center in their own right. (c) Business leaders from the Twin Cities pushed for their cities to become centers. St. Paul became involved in wholesale trading as early as 1858 and thus had a jump on Minneapolis which began wholesale trading in about 1865. In addition, St. Paul was the effective end of navigation on the Mississippi river in the mid 1800's when water transportation was dominant and water power was available at St. Anthony Falls.
6. Transportation

The earliest form of transportation in Minnesota was the river. The furs that were purchased from the Indians were shipped down the Mississippi to their destinations. Minnesota lumber was shipped either as processed lumber or as logs. When wheat farming began in Minnesota, the wheat was transported by river. As more and more goods were produced for export, however, Minnesota's residents called more and more for the railroads to come to the state. In 1854, responding to such requests, Minnesota asked Congress to provide a land grant to encourage railroad development. Because of a mishandling of the legislation, the grant was delayed until 1857, and then the 1857 economic depression prevented any railroad development. After still another foiled attempt on building Minnesota railroads in the early 1860s, railroad building in Minnesota became quite rapid and by 1873, the railroad accessibility in Minnesota was substantial.

Railroads connected Minnesota with Chicago, and also extended west. Because it was in competition with Minneapolis for milling of grains, Chicago was able to lobby the railroads for relatively favorable rates for farmers to ship their grains directly to Chicago rather than have an intermediate stop in Minneapolis for milling into flour. To counter this, the Minneapolis millers grouped together to support a railroad that was built to by-pass Chicago. When this was done, Minneapolis millers obtained the advantage. This led to Minneapolis becoming the major grain milling city in the country.

A little later, a railroad connected St. Paul to Duluth, thus allowing shipments through St. Paul and the Great Lakes. This increased St. Paul's advantage in commerce temporarily, but Minneapolis countered by connecting to that line. When railroads became regulated, the rail line hurt Minneapolis and helped Duluth in that the rate structure was such that it was less expensive to ship the grain through Duluth without milling, than it was to mill the grain in
Minneapolis and then ship the flour to its destination. This led to the diminishment of Minneapolis' prominence in the milling of grain.

Roads in Minnesota during the turn of the century were in very poor shape. Even the roads within the Twin Cities were often impassible during wet weather because of mud. With the development of the safety bicycle in the late 1800s, a call for paved streets and roads was heard by bicycle users. Later, when people started owning automobiles, the call became louder. Even when streets within the city limits were improved with gravel, bricks, wood planks, or paving, the rural roads were still often very crude. Automobiles in those days were quite unreliable, with people spending more time underneath the cars than in them. When these cars were driven out into the country, the poor rural road conditions made matters worse. Things were so bad, that driving out into the country was considered quite daring. However, as more people began owning automobiles, the pressure for improving road conditions increased. In the early 1900s a Highway Commission was set up. In 1921 the trunk highway system was set up, and roads were developed.

Today, the quality of almost all developed roads in Minnesota far exceeds that of their counterparts in the later part of the 19th century. Poor road conditions did hinder the economic development of rural areas in the 19th century, by limiting accessibility, especially during wet weather. Today, on the other hand, when we speak of poor road conditions, we complain about pot holes and bumps on the road that lead to discomfort or wear and tear on our vehicles. Whereas the link between transportation and economic development in the 19th century was with regard to accessibility, the issues facing highway planners today involve accessibility to a much lesser extent. Most of the limits to Minnesota accessibility today are due to winter weather conditions:

(a) Spring weight limits restrict accessibility with regard to large trucks.
(b) Cold weather freezes waterways (e.g. the Mississippi River and Lake Superior) preventing their use for a large part of the year.

In agricultural movements this results in high inventories at elevators.

(c) Severe weather may close highways and airports.

However, many of the transportation investments that are being made today do not have significant effects on accessibility since the transportation system is already well developed. For such investments, care is needed when extrapolating historical links between transportation and economic development into the future.

7. Finance & Insurance

Minnesota's banking industry started in St. Paul, with her first bank in 1853. Banking then slowly developed. Before 1880 the banking was "small time," in that major businesses or Minnesota towns would go to New York or Chicago for financing. However, in the 1880s they began turning to the Twin Cities for financial aid. In the 1890s chain banking began after both Minneapolis and St. Paul became reserve areas in 1889. In the early 1900s banks in the Northwest United States kept reserves in Twin City banks. This was reflected in official policy when in 1914 the Federal Reserve Bank of Minneapolis was created.

Financing for farming businesses developed slowly in Minnesota. Small steps were achieved when in 1874 and 1876 two small farm mortgage houses opened in Minneapolis. Little more developed until 1900, and then a faster development occurred. In 1916 the Federal Farm Loan System opened an office in St. Paul. An office of the Federal Intermediate Credit Bank located in St. Paul during 1923. Thus St. Paul developed into a finance center specializing in farm finance and serving the north, east, and southeast. Minneapolis, on the other hand, became noted for general finance and primarily served the area to the west.
APPENDIX 2

EMPIRICAL FINDINGS

1. ENTERPRISE LOCATION

1.1 Fiscal variables

Among the fiscal variables, the effect of local business taxes on industry location has been found to vary widely. Many studies using either econometrics or survey methods have been unable to discover a significant relationship between taxation and industry location. Early studies of this kind were summarized by Due (1961). Grieson et al. (1977), developed a theoretical and econometric model to estimate the effect of local taxes on the economic activity of a locality (measured by change in employment). They applied the model to the New York City area and found that the manufacturing industry employment is generally more elastic to local taxes compared to the nonmanufacturing industry employment. However, Erickson (1980), who used fiscal and resource related variables to explain relocation of industry from the central business district (CBD) to suburban sites did not find fiscal variables such as net effective property tax rate, per capita fire and police expenditures, and per capita sanitation expenditures to be significant determinants of industry relocation. He claims that the unimportance of the tax distribution of relocating firms may be due to lack of variation of taxes among suburban municipalities. For the problem he addressed, he concluded that these fiscal variables are not significant. It should be pointed out that both the Erickson and Grieson studies addressed metropolitan area industry relocation; their conclusions may not be applicable to nonmetropolitan areas.

1.2 Internal variables

There has been somewhat sketchy discussion in the literature about internal factors that affect choice of location. Erickson (1976) has found that branch
plants are more likely to locate in rural areas than regional or corporate headquarters. Size of the firm and ownership of the firm also can affect where the firm locates. However, the impact of these two variables is not clear. The study of internal factors is important if designing a policy to attract a certain profile of firms to a given region is a major development objective.

1.3 Resource related variables

In the study mentioned earlier, Erickson estimated demand for land for each of 56 municipalities in the Milwaukee SMSA by studying firms that relocated from the Milwaukee CBD. He found that the firms in all industry sectors are attracted to the municipalities which have a high concentration of firms in the same industry, and which have available supply of labor. In addition to these factors, manufacturing firms were found to relocate because of nearby highways (transportation resource) and high proportion of vacant land while nonmanufacturing firms were found to relocate to agglomerate, i.e., cluster together with similar businesses. Table A2 lists the resource related variables addressed in the Erickson study. Erickson concludes that among resource related variables, concentration of industry, availability of labor, availability of highways, and percentage of vacant land in the municipality, were important in determining relocation by the manufacturing firms. While numerous results and conclusions are quoted from the Erickson study, a significant difference between the scope of that study and this project must be emphasized, i.e., Erickson is concerned with the determinants of firm relocations from the CBD to suburban sites. This project is concerned not only with relocation but also birth and death of firms in a given region.

Studying the locational decisions of mobile home manufactures, Wheeler (1976) concluded from the questionnaires sent to 280 plants in nine southeastern states the following ranking of the most important locational factors:
Table A2. Resource related variables considered by Erickson (1980)

- Concentration of industry
- Population density (measure of market potential)
- Distance from CBD (measure of land cost)
- Availability of labor force for particular industry
- Percentage of land in commercial use
- Percentage of land in industrial use
- Percentage of vacant land

Table A3. Variables considered by Oster (1979)

- Firm size
- Concentration of firms of similar type
- Firm ownership type
- Labor availability
- Percentage of local sales
- Percentage of local raw materials
- Branch plant or headquarters
1. Access to market
2. Labor supply
3. Access to raw materials
4. Labor cost
5. Presence of highways

In a different study concerning the location patterns in nonmetropolitan regions of Wisconsin, Erickson (1976) found by a survey that, when asked what was the principle community attribute which attracted the establishment to its location, the majority responded that it was the pool of workers from which to draw its employees. In a study of the locational pattern of cotton industry mills in the U.S. over a ten year period, Chang (1979) considered three factors: (1) proximity to cotton producing area, (2) average hourly wage of production workers in manufacturing, and (3) number of persons employed in manufacturing per 1000 population as a measure of level of industrialization. He found that the wage rate and level of industrialization (also, industrial concentration) had a significant impact on the location of cotton mills. To be sure, care should be taken when using these observations to make generalized inferences about different industries in different areas in the U.S. For instance, wage level is an important factor in determining operating costs of cotton mills but its importance may not be as high for certain other industries. Sharon Oster (1979) studied the search behavior of firms by a survey method. In her study, several variables (listed in Table A3) were considered to identify how firms search for alternative sites. Concentration of firms of similar type (industrial concentration) and unskilled-to-total-labor ratio were found to be more important than other variables.
2. TRANSPORTATION IMPACTS ON ECONOMIC CONDITIONS

2.1 Urban areas

McDonald and Grefe (1977) concluded that BART had no measurable effect on the number of firms locating in the Bay area. However, this was not surprising since the labor pool had not changed; the relative stability in the labor pool resulted since job accessibility was minimally affected by BART.

Recent experiences in Buffalo (ICC, 1979) and Maryland (Taggart et al., 1978) illustrate the importance of transportation in formulating industrial development strategies.

Buffalo's five flour mills produce 10% of the nation's bread flour and employ 1600 workers. Buffalo gained prominence by linking the grain freighters on the Great Lakes with dependable, less expensive rail service to the northeastern flour markets. (Historical note: Minneapolis lost flour milling activities to Buffalo in the early part of this century for transportation reasons, although it retained the headquarters of milling companies.) Changes in freight transportation, however, including the rise of trucking and reduced rail rates in other areas, have made other flour routes more cost-competitive. Obsolete loading facilities, inadequate street conditions, poor Conrail service, local rail tracks, high labor costs, high taxes and less efficient production techniques compounded the problem.

To alleviate the flour industry difficulties, Buffalo convinced Conrail to improve its equipment, rails and service. In addition, it requested a longer navigation season and made substantial terminal improvements. These actions have reduced shippers' transportation costs and have turned an unprofitable Conrail line into a profitable one. The flour mills and other industries now have cheaper, more reliable shipping service than only a few years ago.

The Maryland Department of Transportation undertook a study to estimate the socioeconomic impacts of a set of multimodal transportation programs proposed
for Maryland. The programs evaluated included the Port of Baltimore, Baltimore-
Washington International airport, rail (commuter and intercity) facilities, mass
transit, interstate, primary and secondary highway systems. The cost of
implementing the proposed programs was $10 billion (1976 dollars). The total net
personal income the plan would have generated was estimated to be almost $18
billion over the 1978-2000 period. By 2000, the equivalent of 80,000 jobs would
have been created. Additional results could have included a redistribution
effect on the location of economic activity in the state, with all regions
experiencing net positive income, employment and population impacts. To be
sure, such claims of net job creation and positive growth could not be validated
and may not be accurate.

2.2 Transfer payments

The Appalachian Regional Commission (1970) reported that a 19-month
project which provided free bus transportation to Beckley, W.V. from nearby
rural areas resulted in users collecting an average of eight dollars a month
more in welfare payments, food stamps, and social security benefits. The reason
this occurred was that the bus enabled more people to get to Beckley where they
had to go to apply for and collect the payments. Dennis Moore (1976) concluded
about the Warren, Pennsylvania area that families were unable to get to town to
pick up surplus food even though they were eligible. To be sure, any net
benefit estimates should consider the cost of providing the public transport
service as well as the cost of providing alternative means to accomplish the
same task. Transfer payments, for instance, could be transmitted to the
eligible recipients without the need of transport. Further, it could be argued
that transportation could best be employed to increase the probability of
employment rather than decrease the incentive to seek a job.
Transfer payments do not always increase as a result of public transport. If unemployment decreases because of transport improvements, compensation payments will also decrease. A study concerning the rural area around the City of Honolulu concluded that welfare payments decreased because unemployment decreased (Barton-Aschman, 1972); however, in that case, this was a desirable effect.

2.3 Unemployment

Chavis (1974) analyzed the characteristics of several counties around the Richmond, Virginia area. One of this study's conclusions concerned the employment impacts that could occur if public transport serviced the Charles City area (pop. 6000). Charles City was experiencing a 9% unemployment rate with 70% of those unemployed being without an automobile. Also, the majority of the work force had jobs outside Charles City County, indicating that many of the job opportunities are outside the county. Chavis indicated that, if public transport were available, many of these carless unemployed would be able to get employment in the employment centers outside Charles City County.

A second study by Brown (1973) forecast the impact on the economic conditions of the Bluegrass Area Development District if transit became available. Nearby were employment centers in Lexington and Dansville, Kentucky. Also nearby in Madison County, four new firms were supplying 1000 new jobs which resulted in the State Employment Service stating that jobs were available for anyone who wants them "if they could get there". However, 19.2% of the households in the Bluegrass area did not have access to automobiles and 7,600 of the 37,000 work force were still unemployed. Without public transport, many of the unemployed did not have the means to get to Madison County, Lexington, or Dansville, and hence they were not able to obtain employment. In fact, the most common reason, given by the unemployed as to why they were not out looking for a job, was that they had no means of transport to do so.
Both studies indicated the expectation that a high unemployment rate in a region that does not offer substantial job opportunities can be decreased by a public transportation system which provides commuting services to nearby employment centers with an excess number of job openings.

Even the unemployed with access to a car may be affected by public transportation. In rural areas employment opportunities are often some distance from a person's home. The cost of commuting can often become so great as to make it not worthwhile to have the job. Noble (1972), using a 1970 cost per mile of $0.12, demonstrated that commuting by car 30 miles one way would eat up 30% of a gross annual income of $6,000. Noble indicated that there must be a certain amount of after-tax, after-travel-cost income being derived from a job before an individual will consider it worthwhile to take the job. Public transport (e.g., transit, vanpools, carpool ride matching) might increase this net income by decreasing the commuting costs. Of course, any net benefit estimates should include the cost of making the transport service available.
LARGE-SCALE REGIONAL MODELS

1. Polenske model

Polenske (Coulter, 1977; Polenske, 1972; Polenske et al., 1974, 1975) employed the I/O method in her research at the Economic Development Administration, in which she analyzed the effects of interindustry, interregional trade flows on the economy. The Polenske model requires three component sets of data for implementation. The first is a set of I/O tables for each state under analysis, the second consists of interregional trade for each commodity and the third component is a set of final demands for each state. Final demands include consumer expenditures, private investment, governmental expenditures and net foreign exports. After assembly of the three components, I/O techniques are used to forecast interindustry purchases and trade flows. Such forecasts are an important element in predicting the demands that will be placed on a transport system and are, therefore, needed for making decisions on highway and other transport investments. The forecasts are based on the assumptions of unchanged technologies and structures of trade between states and are, thus, more useful for short-run than long-run analyses. The Polenske model has been successfully applied in northern and middle Atlantic states, the California-Oregon-Washington region and some Pacific states.

2. Harris model

Forecasting regional growth and evaluating effects of alternative highway and other transport systems are the main objectives of the Harris model. Using national forecasts obtained from the Interindustry Forecasting Model of the University of Maryland (INFORUM, Almon et al., 1974), the choice of industrial location, a principle feature of this econometric model, is forecast as a
function of the relative prices that industry faces at different locations. Capital costs, land, labor and transport costs are examples of these relative prices. Transport cost changes are optimized using national and regional transport rate information such as data on shipments by size, weight, type of goods, distance and mode. This task is facilitated by a regional highway congestion index which measures the amount of traffic congestion on principal roads within a region.

Harris' work has received widespread attention and has been used to evaluate numerous economic and transport policies. These include:

1. Regional economic effects of national highway systems (Harris, 1974);
2. Energy savings from having truck shipments go by piggyback for shipments over 100 miles (Harris, 1974);
3. Regional effects of individual highway segments (Harris, 1976 & TCCFRD, 1976);
4. Regional effects of arbitrarily locating the communications industry (TCCFDR, 1976);
5. The on-shore impacts of offshore oil wells (Grigalunas, 1975 and Reinfeld and Collahan, 1975);
6. Impacts of opening new coal mines (Krutilla and Fisher, 1978);
7. Impacts of cutbacks in natural gas in Maryland (Donnelly and Parhizgari, 1975);
8. Impacts of reduced agricultural production in Southwest (Bender et al, 1976);
9. Effects of auto industry on the Detroit economy (SMCG, 1977);
10. Impacts of the Public Employment Program in selected geographical areas (NPA, 1974); and

Currently, there are four operating versions of the model, each addressing a different geographic unit, i.e. counties, BEA's, SMSA's and rest of economic areas, and DOT transportation zones.

3. Colombia model

The Colombia model (Roberts and Kresge, 1968) was developed to explore the interface between the entire economy of Colombia and its transportation system. This macroeconomic model handles an enormous number of variables. It operates with yearly periods and takes into account drastic economic changes (e.g. severe inflation). Demand is estimated on the basis of individual commodities, and the model uses an I/O table to compute the industrial production required to match the demand. Disaggregation of the results is accomplished by geographic region as is the practice in transport planning. The major drawback of this model is that a large number of variables must be manipulated and calibrated before the desired regional information can be obtained. On the other hand, its advantage is the provision of a built-in procedure for generating forecasts, extrapolations or interpolations to fill gaps in the data. The estimated regional information is used by the transport sector to determine the flows of commodities over a given network. Any changes in transport technology, network topology and link characteristics affect the technology coefficients of the I/O table, and this is how the impacts of different policies are determined.

The Colombia model was calibrated for Colombia and tested for the period 1956-1966 by comparing actual time-series figures for consumption, investment, imports, exports and GNP with figures generated by the model. The major conclusions of this application was that cost savings of total output may be achieved in response to transport facility improvements and other transport
policies. The savings, on the order of 1 to 2 percent, are not impressive in percentage terms, but may be substantial in absolute terms. It was also concluded that the context of general economic policies determines crucially the impact of alternative transportation improvements on the growth of gross domestic product.

4. Japanese models

In Japan, Sakashita (1974) sought to determine the effects of the spatial and intertemporal allocation of transport and other public investments, while Amano and Fujita (1970) analyzed the effects of interindustry and interregional flows using econometric models to provide time continuity. Amano and Fujita modified the I/O structure and traced the regional and national economic impacts of improvements in transportation facilities. Their hypothesis is that a transportation facility lowers both the monetary and nonmonetary costs of transportation. The lower costs change the transportation service purchase coefficients and the trade coefficients and affect regional output and trade flows. It is assumed that only the trade coefficients between the two regions, where transportation costs are changed, are affected by cost change. Further, the trade and technical coefficients are independent of changes in wage rates, land prices, local taxes and capital costs.

The transport model of Sakashita examines the effects of transport time and cost on the total regional demand and total regional supply. Regional demand and supply determine inter- and intraregional flows which, in turn, affect traffic assignment. Modifications of inter- and intraregional flows are traced out by varying the time and cost variables. The model provides a detailed output in the economic sector.
5. **NCHRP regional economic models**

Two large-scale econometric models were developed at the University of Massachusetts, Amherst for the NCHRP (Stevens et al., 1982). They represent a significant contribution to the field of Transportation/Economic Development.

The first, the Input - Output Model (IOM), divides the economy into 500 sectors and performs particularly well in determining short term economic impacts, such as those caused by the construction of transportation facilities, in a state. The second, a large-scale econometric Forecasting and Policy Simulation Model (FPSM), deals with 29 economic sectors and is especially designed to determine long-term economic effects which result from changes in transportation and/or other costs. An important characteristic of these models is their ability to be readily updated and easily adapted to substate or multistate regions.

The IOM traces the effects of changes in the economy via a systematic set of repeated calculations which can be performed in a short time. The model allows the user to specify a direct set of changes, and automatically calculate and sum up all the employment, income and other resulting outputs. These outputs include all direct, indirect and induced effects of the initial direct change.

The FPSM determines the effects of cost (including transport) changes for industries in a region and the ways in which these affect the regional employment, wages and income. The FPSM, like the IOM, calculates the indirect and induced economic impacts but can further trace the dynamics of such changes for up to 13 years into the future. The FPSM is driven by a national forecast of employment, wages, income, consumer price index and other variables. Applied at a state level, the FPSM consists of an aggregated (29 sector) version of the IOM.
Both models are based on the assumption that the transportation system influences the locational advantages of a region in serving markets of outside regions. In addition, it is assumed that the indirect or "multiplier" effects of economic changes in a region depend upon the degree the region is self-sustained rather than dependent on other regions. The multiplier effects are measured via a set of coefficients called, "Regional Purchase Coefficients (RPC)", which represent an original contribution of this model. The RPC's capture all the "leakages" of indirect and induced purchases within and outside a region and regionalize the IOM to perform at a state level.

In terms of their data needs, the above models can be classified as extremely data-hungry. But it appears that most of the required data can be readily obtained from local and national transport and economic agencies.

The basic structure of the Amherst models differs substantially from that of the Colombia model and the Japanese models (see Fig. 10) which treat the transportation sector in much more detail. In particular, the Colombia model allows higher emphasis on transport policies, takes into account the structure of the transportation network and places special weight on mode choice of traffic flows. The Amano model elaborates extensively on the assignment of traffic volumes on the network and the Sakashita model examines in detail how the transport time and cost affect the economic output of particular regions and the traffic flows within (intra-) and between (inter-) regions.

6. IPASS and SIMLAB models

The Interactive Policy Analysis Simulation System (IPASS) (Olson et al, 1984) and the Regional Economic Impact Forecasting and Simulation (SIMLAB) (Maki and Hwang, 1979) are among the most important econometric models developed by the staff of the Dept. of Agriculture and Applied Economics, Univ. of Minnesota.
The IPASS model, a more versatile version of SIMLAB, is a recursive analytical tool that forecasts growth and development of an economy. The economic forecasts are based on production forecasts which, in turn, are derived from an ordinary I/O model. IPASS allows the user to introduce changes, interactively, in selected parameters based on different assumptions about socioeconomic variables. The user can then analyze the impact those changes would have on the economy by comparing the results of the alternative situations with the original forecast.

The model requires comprehensive data on the economic and social situation for the initial year. This data base includes statistics on employment, population, earnings, productivity and output. IPASS has potential use in applied research as well as policy analysis. However, it does not include a transportation sector in its production module and, therefore, cannot be employed to readily analyze the impact of transportation policies on the regional economy. The economic model in SIMLAB, which is also interactive, consists of the following modules: market, investment, demand, production, value added, employment, labor force, population and household. The production module is central to the system performance as it links the regional economy to the rest of the nation.

SIMLAB has been used in quantitative studies of the direct, indirect and induced socioeconomic effects of new industry development. Most recently, it has been used in studies of industrial renewal in the Twin Cities Metropolitan area, irrigated agriculture in West Minnesota, peat land development in Northern Minnesota, copper-nickel development in Northeast Minnesota and the importance of the mineral industry in the state of Minnesota. Besides Mower and Itasca counties, SIMLAB is available for four Minnesota planning regions, i.e., Northwest, Headwaters, Arrowhead and Metropolitan Council, and the state of Minnesota.(Maki and Hwang, 1979)
The two region I/O model (Maki and Hwang, 1979) uses the basic philosophy of SIMLAB. When using the model, the study region is designated as region A, and the rest of the nation as region B. The I/O tables of SIMLAB are aggregated to about 100 industrial sectors and the two-region model calculates the dollar values of all interindustry and intersectional flows of goods and services bought and sold within the specified region and the rest of the nation. The model requires about 140 K of computer core memory and executes in about 90 seconds of central processor time at a cost of less than 50 dollars. Various data problems often make multiple runs necessary.

In addition to the above, the Dept. of Agriculture and Applied Economics has also developed I/O models for analyzing the labor market in Minnesota and tracing economic effects in Minnesota Development Region Six East. Owing to time and monetary constraints, the I/O model for Region Six East was developed using a number of nonsurvey techniques. For example, the direct coefficients for the model were not obtained through a survey; instead, they were derived from one of the nine Texas substate models. The Region Six East I/O model was used to analyze the effects of the severe drought in 1976, the effects of increased government payments to households and the effect of increased exports (Maki and Hwang, 1979).

Despite their usefulness, small-area I/O models, such as the above, do have shortcomings. A large number of errors usually creep in when interpreting data and fitting them into the model. Additionally, it often is not clear how the economic changes, simulated and forecast by the models, should be measured.
1. Wheat movements (Alley, et. al., 1979a)

While it ranks only ninth amongst states in wheat production, Minnesota is the major gathering point for Upper Midwest wheat. In 1979, wheat shipments from the Dakotas and Montana accounted for 75% of the total amount of bushels shipped into or within Minnesota. These shipments were equally split between rail and truck. However, trucks were used to a greater extent to move wheat within the state, whereas railroads accounted for 59% of wheat shipments originating outside of the state.

Duluth/Superior is the major Minnesota terminal destination for wheat, attracting 55% of the total wheat shipments in 1979 (See Figure A1). Most of the rest of the shipments (37% of the total) went to the Twin Cities. Of the wheat shipped to Minnesota terminals, 22% was processed within the state. Over 80% of the flour produced in the state was shipped to out-of-state destinations. Most of these shipments were by rail.

Wheat comprises 36% of all grains shipped out of Minnesota by weight. Duluth/Superior shipped 68% of all out-of-state wheat shipments, of which 90% was by vessel on Lake Superior. Almost all the rest of the out-of-state wheat shipments were transported from the Twin Cities, 64% of which was by barge down the Mississippi River. Duluth/Superior vessel shipments were distributed to foreign markets and the State of New York, while the Twin Cities barge shipments were transported almost entirely to Gulf of Mexico ports for export to other countries.
Figure Al
1979 UPPER MIDWEST COUNTRY ELEVATOR WHEAT SHIPMENTS TO DULUTH/SUPERIOR (1,000 bushels)

[Alley et. al., 1979a]
2. Corn movements (Alley, et. al., 1979b)

In 1979, Minnesota contributed roughly 13% to the total U.S. corn sales. Of the corn shipments to terminal elevators, 89% originated within the state and 10% came from Iowa, Wisconsin and South Dakota. Trucks were used in 80% of all shipments, with the rest being shipped by rail. Terminal elevators in the Twin Cities Superior received 70% of all corn shipments into and within Minnesota, while Duluth/ Superior received 22%. Of the shipments to the Twin Cities, 94% came by truck, whereas railroad shipments accounted for 73% of the shipments to Duluth/ Superior. The largest portion of rail shipments to Duluth/ Superior originated in the South-central and South-west CRDs of Minnesota.

Corn comprises 43% of all tons of grain shipped from Minnesota. Corn shipments were exported from Duluth/ Superior, the Twin Cities, and country elevators. The corn shipped from Duluth/ Superior comprised 15% of the total out-of-state shipments. Almost all of these shipments were by vessel on Lake Superior. The Twin Cities, Red Wing and Winona terminal elevators shipped 50% of the out-of-state shipments, 92% of which traveled by barge to the Gulf of Mexico export ports. An additional 6% was carried by railroads to the Pacific Northwest export ports (See Figure A2). Country elevators located in South-central, South-west and West-central CRDs shipped directly out of state by rail, 35% of the total out-of-state corn shipments. These shipments were mostly to the Gulf of Mexico and Pacific Northwest export ports.

3. Soybean movements (Alley, et. al., 1979c)

Shipments from southern Minnesota comprised 92% of 1979’s soybean shipments into and within Minnesota. Trucks were the means of transport for almost all soybean shipments. Other soybean shipments were primarily trucked from South Dakota, Iowa and Wisconsin (See Figures A3 and A4).

Soybeans represent 9% of all tons of grain shipped out of Minnesota in 1979. A little over half of the soybeans shipped into or within the state were
1979 MINNESOTA TERMINAL ELEVATOR SHIPMENTS TO OUT-OF-STATE DESTINATIONS
(1,000 bushels)

Total Shipments: 222,739

- R = % Rail: 6
- T = % Truck: 1
- W = % Water: 93

Includes terminal elevators in Superior, Wisconsin.

Includes Canada.

Shipments to unknown locations outside Minnesota.

(Alley et al., 1979b)
Figure A3

1979 UPPER MIDWEST COUNTRY ELEVATOR
SHIPMENTS TO TERMINAL ELEVATORS IN THE
TWIN CITIES, RED WING AND WINONA
(1,000 bushels)

R = rail
T = truck

FROM SOUTH DAKOTA

<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>T</th>
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<tbody>
<tr>
<td>930</td>
<td>46%</td>
<td>54%</td>
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FROM IOWA

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<tr>
<th></th>
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<tr>
<td>1,424</td>
<td>100%</td>
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FROM WISCONSIN

<table>
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<tr>
<th></th>
<th>R</th>
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<tr>
<td>594</td>
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TOTAL RECEIPTS

<table>
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<tr>
<th></th>
<th>R</th>
<th>T</th>
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<tbody>
<tr>
<td>52,643</td>
<td>5%</td>
<td>95%</td>
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</tbody>
</table>

(Alley et. al., 1979c)
Figure A4

1979 UPPER MIDWEST COUNTRY ELEVATOR SOYBEAN SHIPMENTS TO MINNESOTA SOYBEAN PROCESSORS IN DAKOTA, MANKATO AND SAVAGE
(1,000 bushels)

FROM NORTH DAKOTA
1,294
R - 100%
10,743
T - 100%
6,612
T - 100%
16,532
T - 100%
20,318
T - 100%
2,202
T - 100%

FROM SOUTH DAKOTA
1,092
T - 100%

TOTAL RECEIPTS
60,883
T - 100%

FROM IOWA
2,100
T - 100%

R = rail
T = truck

(Alley et al., 1979c)
then shipped out of state. Water and rail modes of transportation accommodated 74% and 19% of these shipments, respectively. Less than 4% of out-of-state shipments were from Duluth/Superior. Country elevators shipped 26% of the shipments. Two-thirds of these country-elevator shipments went to the Gulf of Mexico. The Twin Cities, Red Wing and Winona shipped by barge 70% of the out-of-state shipments to the Gulf of Mexico, from where the soybeans were exported to other countries.

4. **Barley movements** (Alley, et. al., 1979d)

Minnesota is the fourth-ranked state in the production of barley. Nevertheless, 64% of the barley shipped into or within the state in 1979 came from the surrounding states. North Dakota alone provides 55% of these barley shipments. (See Figure A5). Duluth/Superior received 35% of these shipments with an equal amount being received by rail and by truck. The Twin Cities received 63% of the shipments into or within Minnesota; 90% is received by rail and 10% by truck. About 31% of the barley shipped to or within Minnesota was malted within the state.

Barley comprises 5% of all grains shipped out of the state. Of the out-of-state shipments of barley, 51% was transported from Duluth/Superior, half of which is exported to other countries by vessel. The Twin Cities shipped 38% of the out-of-state shipments, the majority being shipped to maltsters in Wisconsin. Of these shipments 96% were by rail. Country elevators directly transported by rail 11% of the total out-of-state shipments to maltsters in Wisconsin and further east.

5. **Oat movements** (Alley, et. al., 1979d)

Minnesota was the second oat producing state after South Dakota in 1979. Most of the oats produced are used on the farm as livestock feed. Of the oats that are shipped into or within the state, half originated in the Dakotas. Duluth/Superior receives 7% of these shipments, 62% of which is transported by
FIGURE A5

UPPER MIDWEST COUNTRY ELEVATOR BARLEY SHIPMENTS TO MINNESOTA DESTINATIONS, 1979

(1,000 bushels)

R = rail
T = truck

437, R - 100%

31,582, R - 59%, T - 41%

2,097, R - 97%, T - 3%

5,167, R - 88%, T - 12%

48,979, R - 83%, T - 17%

145, R - 100%

130, R - 100%

TOTAL SHIPMENTS

88,537, R - 76%, T - 24%

(Alley et. al., 1979d)
trucks. The remaining 93% goes to the Twin Cities, with 69% being transported by rail. The West-central, North-west and South-west CRDs accounted for 84% of the in-state shipments (See Figure A6).

Oats, sunflowers, flax, and rye together comprised less than 1% of all the tons of grain shipped out of Minnesota in 1979. Oat movements out of Minnesota were generated almost exclusively from the terminal elevators in the Twin Cities. Water and rail were the dominant transportation modes and accounted for 50% and 42% of the oat shipments, respectively. States bordering the Gulf of Mexico were the predominant destinations (See Figure A7).

6. **Sunflower movements** (Alley, et. al., 1979d)

In the last decade, sunflowers have emerged as an important cash grain in Minnesota and the Dakotas. North Dakota provided 59% of the sunflower movements into and within Minnesota. Of all shipments into and within Minnesota, Duluth/Superior received 79% with the rest going to the Twin Cities (See Figures A8 and A9). Truck was the predominant transportation mode and accounted for 81% of the sunflower shipment into and within Minnesota. Roughly 76% of the sunflower movements into or within the state were exported from Duluth/Superior. Western Europe purchased 84% of the exported sunflowers (See Figure A10).

7. **Flax movements** (Alley, et. al., 1979d)

U.S. flax exports have been negligible and flax has lost its importance as a cash crop in the last years since synthetic paints have replaced paints that used flax oil as a base. The Dakotas produced 79% of the flax received in the Twin Cities (See Figure A11), the recipient of the flax movements into and within the state. Trucks were used in 93% of all flax shipments.

8. **Rye movements** (Alley, et. al., 1979d)

Since 1965, U.S. rye production has been declining because of low demand. Nevertheless, only the Dakotas and Georgia produce more rye than Minnesota. Over 70% of rye shipments in Minnesota originated in the Dakotas. Of the rye
FIGURE A6

UPPER MIDWEST COUNTRY ELEVATOR OAT SHIPMENTS TO THE TWIN CITIES, 1979
(thousand bushels)

From North Dakota
5,586
R - 65%
T - 35%

From South Dakota
9,096
R - 78%
T - 22%

2,418
R - 61%
T - 39%

4,415
R - 74%
T - 26%

736
R - 51%
T - 49%

120
T - 100%

2,103
R - 74%
T - 26%

314
R - 33%
T - 67%

528
R - 8%
T - 92%

TOTAL RECEIPTS
25,316
R - 69%
T - 31%

R = rail
T = truck

(Alley et. al., 1979d)
FIGURE A7
TERMINAL ELEVATOR OAT SHIPMENTS
TO OUT-OF-STATE DESTINATIONS, 1979
(1,000 bushels)

Total Shipments
16,884
R = % Rail - 42
T = % Truck - 8
W = % Water - 50

1 Shipments to locations east of the Mississippi River.
2 Shipments to unknown locations outside Minnesota.
FIGURE A8
UPPER MIDWEST COUNTRY ELEVATOR SUNFLOWER SHIPMENTS TO DULUTH/SUPERIOR, 1979
(THOUSAND HUNDREDWEIGHT)

FROM NORTH DAKOTA
16,600
R - 24%
T - 76%

FROM SOUTH DAKOTA
2,866
R - 16%
T - 84%

5,158
R - 14%
T - 86%

22
T - 100%

3,240
R - 22%
T - 78%

TOTAL RECEIPTS
27,886
R - 21%
T - 79%

R = rail
T = truck

(ALLEY ET. AL., 1979D)
FIGURE A9

UPPER MIDWEST COUNTRY ELEVATOR SUNFLOWER
SHIPMENTS TO THE TWIN CITIES*, 1979
(thousand hundredweight)

*Includes Red Wing.

R = rail
T = truck

(Alley et. al., 1979d)
FIGURE A10

SUNFLOWERS

1979 EXPORTS FROM DULUTH/SUPERIOR PORTS

TOTAL DULUTH/SUPERIOR SUNFLOWER EXPORTS:
26.7 million hundredweight

SOURCE: USDA, INSPECTION FOR EXPORTS BY COASTAL AREAS AND COUNTRY OF DESTINATION,
[Alley et. al., 1979d]
FIGURE A11
UPPER MIDWEST COUNTRY ELEVATOR RYE SHIPMENTS TO THE TWIN CITIES
(Thousand bushels)

From North Dakota
1,336
R - 68%
T - 32%

From South Dakota
2,233
R - 32%
T - 68%

TOTAL RECEIPTS
4,388
R - 46%
T - 54%

R = rail
T = truck

(Alley et. al., 1979d)
Shipments into and within Minnesota, the Twin Cities received 43%, Duluth/Superior received 31%, and other Minnesota destinations received 26%. Trucks and rail were used to the same extent in these movements. Half of the shipments into and within Minnesota were exported. Duluth/Superior shipped 54% of these exports to other countries. The rest were shipped from the Twin Cities, and most went by rail to processors in the east.
APPENDIX 5

METHODOLOGY FOR ESTIMATING COMMODITY FLOWS BETWEEN COUNTIES

1. Introduction

While data on grain flows exist (Alley et al, 1982a,b,c,d), in general no data on commodity flows on a substate, non-SMSA level are available. However, one can obtain estimates of commodity demands and supplies by county. One can then use this information in a transportation problem to determine the most efficient flows to connect supplies with demands. In this Appendix, a methodology is described to use the transportation-problem approach for estimating commodity flows on a county level.

2. Data

- $f_{ij}^h$ = flow of commodity i by mode h from state j to state k. (Source: 1977 Commodity Transportation Survey II, Census of Transportation)
- $E_{ij}$ = employment in county j of ith commodity workers. (County Business Patterns, 1970-1982)
- $S_{ij}$ = supply of commodity i in county j. (For agricultural goods, 1982 Census of Agriculture)
- $x_{hi}$ = amount of resource h used to produce one unit of commodity i. (National input-output table)
- $S_{i*}$ = supply of commodity i for the entire state of Minnesota (More data probably exist on the state level than on the local level. At this time we have not identified such sources.)
- $D_{ij}$ = demand of commodity i in county j. (No data sources found)
3. Estimating supply

If data on $S_{ij}$ exist, they should be used. If not, then the supply should be determined as shown below:

1. Estimate the supply on the state level.

   For $j = \text{Minnesota}$, set
   
   $$ S_{ij} = f_{j}^{*}. $$

   Alternatives to this estimation would be (a) to use data on $S_{ij}$ if they exist or (b) to use the County Business Patterns and the labor input-output coefficient. In alternative (b), where $h = \text{labor}$, set
   
   $$ S_{ij} = \frac{E_{ij}^{*}}{\sum_{i} S_{ij}} \cdot (\text{hours in time period}) $$

   For both alternatives (a) and (b), one must adjust the procedure used to determine inter- and intracounty flows from the data.

2. Estimate the supply on the county level.

   Use County Business Patterns. Set
   
   $$ S_{ij} = \frac{E_{ij}}{\sum_{i} S_{ij}} \cdot (\text{hours in time period}) $$

3. Adjust county supplies so that they add up to state supplies.

   Set
   
   $$ S_{ij} = S_{ij} \cdot \frac{S_{i}^{*}}{\sum_{j} S_{ij}}. $$

4. Make adjustments to account for different years of data sources.

   Ascertain that different units and amounts from data sources are accounted for.
4. Estimating demand

If data on $D_{ij}$ exist, they should be used. However, if the data do not exist, then they should be estimated as follows:

1. Estimate consumption demands by one of the following approaches:

   (a) For national or preferably state level, determine the demand for each good $i$ by a typical consumer. Multiply this demand by the number of consumers in the county. (The source for these data is not known at this time, but probably exists or the data can at least be estimated.)

   (b) Regress the demand for each good $i$ against personal income. Use the regression equations, and data on personal income in the 1980 Census of Population to estimate the demands in each county.

2. Determine industrial demands in each county by using county supplies and input-output coefficients, by setting

   \[ D_{ij} = \sum_{i} s_{ij} x_{hi} \]

3. Estimate governmental demand. The Census of Governments will provide information on employment and other data to help make these estimates.

4. Add consumption, industrial, and government demands together.

   \[ D_{ij} = C_{ij} + I_{ij} + G_{ij} \]

5. Estimating commodity flows between counties

   This methodology will estimate flows between Minnesota counties and regions outside of Minnesota. The outside regions must add up to be all of the U.S. except Minnesota, and each state must be wholly within one region. Note, that for operational purposes of this methodology, counties will not be regarded as regions.
In this methodology, all counties in the Minneapolis/St. Paul production
center, as defined by the Commodity Transportation Survey, will be treated as
one region. The regions will be indexed \(-1, 2, \ldots, n\); where \(n\) is the number of
regions. The demand for each region will be set as:

\[
D_{ik} = f_{k}^{*} - f_{kk}^{*} - \frac{1}{h} f_{kk}^{*}
\]

\(h\) in other regions

The supply for each region will be set as:

\[
S_{ik} = f_{k}^{*} - f_{kk}^{*} - \frac{1}{h} f_{kk}^{*}
\]

\(h\) in other regions

For each region, the cost of transporting from that region to itself will
be set prohibitively high since the intraregional flows are already known. The
remaining steps to estimate the flows of commodity \(i\) are:

1. Estimate the transportation costs of shipping commodity \(i\) from
county \(j\) to county (or region) \(k\).

2. Solve the transportation problem specified by the supplies,
demands, and transportation costs.

The solution to the transportation problem will specify the estimated
commodity flows between counties and the regions for commodity \(i\). To obtain
estimates for all commodities, \(m\) transportation problems must be solved where \(m\)
is the number of commodities.
APPENDIX 6
GLOSSARY

Control systems (closed loop) are physical, biological, organizational and other entities, in which the controlled variable, i.e., the quantity that must be maintained at a prescribed value, has an effect upon the input quantity in such a manner as to maintain that prescribed value.

Control systems (open loop) are entities in which the controlled variable has no effect upon the input quantity to the entity.

Disaggregate data (refering to travel) are data on the trip characteristics of individual trip makers.

Elasticity of Y with respect to X is the percentage change in Y (e.g., income) for a 1% change in X (e.g., transport cost).

Final demand is demand for goods and services that are ready for consumption, investment, or spending; e.g., gasoline is a final good but crude oil is an intermediate good.

Input-output (I/O) coefficients indicate the dollar amount of a particular input that is required to produce a dollar of a certain output.

Interregional flow data are data describing the amount of a particular commodity that is transported from a given region to another.

Regional production cost is the cost to produce a particular commodity in a given region.

Regional Purchase Coefficient (RPC) is the portion of the local demand for a certain commodity that is purchased from local supplies.

Transactions represent an exchange of money for a good or service.
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