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Transportation and Economic Development:

Simulation of Highway Investment Impacts on the Forestry Sector in Northeast Minnesota

Final Report: Appendix VII

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

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

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

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

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16. Abstract (Limit: 200 words)

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.

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TRANSPORTATION AND ECONOMIC DEVELOPMENT:

SIMULATION OF HIGHWAY INVESTMENT IMPACTS ON THE FORESTRY SECTOR IN NORTHEAST MINNESOTA

Final Report - Appendix VII

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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.

SIMULATION OF HIGHWAY INVESTMENT IMPACTS ON THE FORESTRY SECTOR IN NORTHEAST MINNESOTA

1. INTRODUCTION

In this section, we use an indirect analytical method to assess the economic effects of a transportation policy in a Minnesota region. Because the State is pursuing enhancement of the economy of the Northeast, Northeast Minnesota has been selected (in consultation with the Minnesota DOT) for the analysis. The specific policy to be analyzed deals with highway investment. In particular, we assess the possible economic effects of increasing all spring load restrictions in Northeast Minnesota to ten tons per year. To accomplish this, we use the Input-Output SIMLAB economic simulation model.

Since the mining industry is in decline (and relies heavily on railroads and Great Lakes shipping), we have identified the Wood Products Industry for this analysis. Wood Products, along with tourism, is the major industry in the area and relies heavily upon highway transportation.

An impetus for this study was a contact made with the Cloquet branch of Potlatch, Inc. While Cloquet lies within five miles of Interstate 35, the road connecting Cloquet to the Interstate is restricted for two spring months to 9 tons. As a result the truck shipments leaving Potlatch load to 9 tons rather than 10 tons for the entire trip length, which is on average about 1000 miles. It seemed economically inefficient for a five-mile segment of road to cause a reduction from 10 to 9 tons, not only for that five-mile segment but also for the remaining 995 miles of 10-ton road.

While the SIMLAB methodology does not determine whether such a spring load restriction is economically efficient, it does determine all the effects - both primary and the multiplier effects - of the spring load restrictions. A benefit

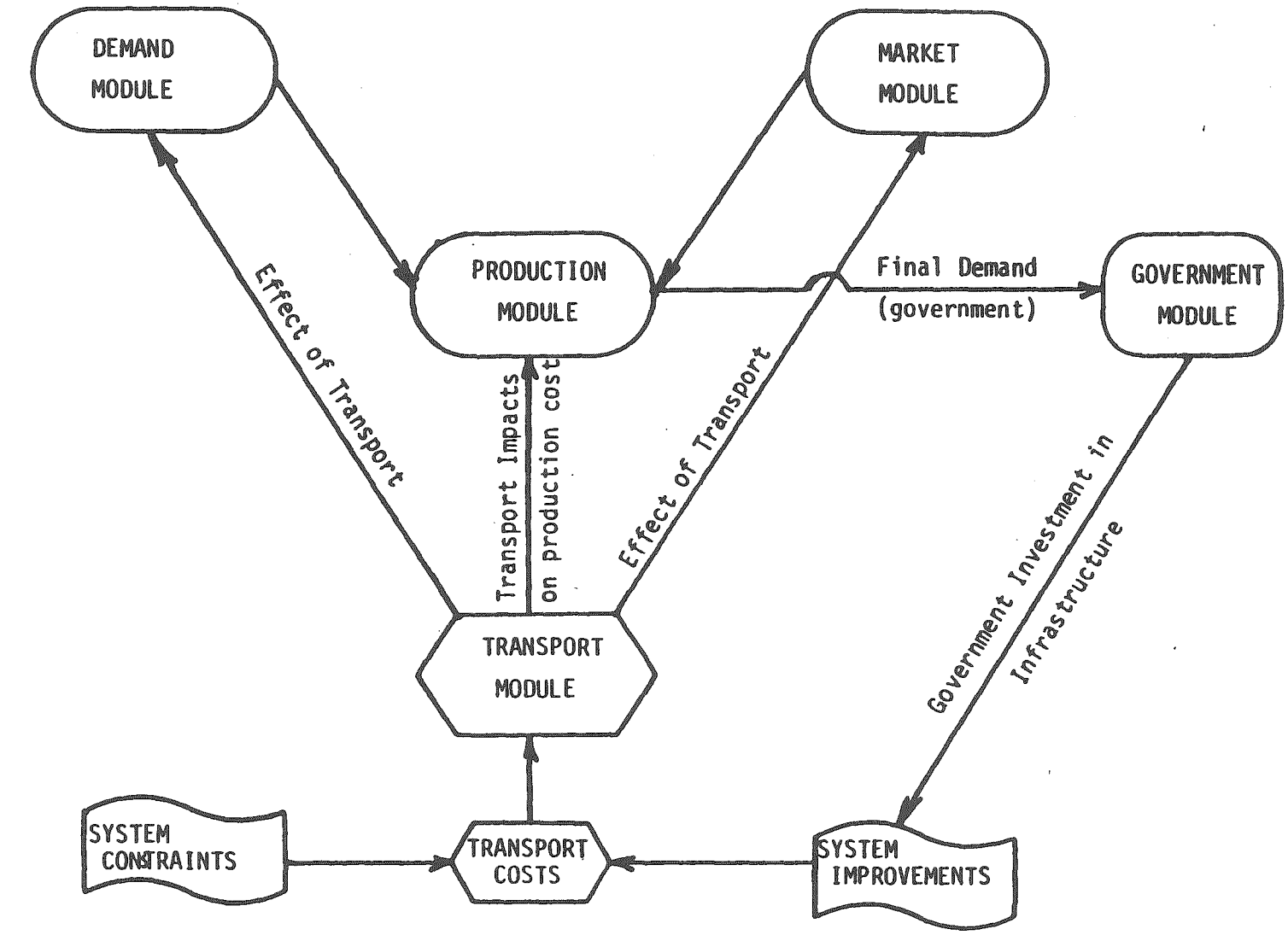
- cost analysis can then be performed based on this information. A general method for such an analysis (with application in the forest sector of Northeast Minnesota) is developed in Appendix VI of this report.

2. METHODOLOGY

2.1 SIMLAB background

The major relationships between the various modules of SIMLAB are summarized in Figure 1. As can be seen from the figure, specified transportation system improvements determine the new transportation cost of exporting industries in the region. In this analysis, we assume that demand absorbs the marginal increase in production brought about by transport cost savings, and thus the market share of the region increases. This, in turn, drives the production module and results in increased earnings, from which the government module then draws taxes. If these taxes exceed the cost to improve the transport system, then the benefit/cost ratio is greater than 1 and the project is beneficial to the region from the government point of view. In our case, we address the question, whether the economic return to the State and Local governments generated by improved transport efficiency, i.e., the capability to carry heavier loads, is sufficient to pay for the cost of the road improvements. While the government could decide to implement the improvements in any case, the analysis can still identify the cases in which project participation by the private parties that stand to benefit most is warranted.

The SIMLAB methodology uses an input-output table represented by a matrix A, the size of which is 75 sectors by 75 sectors. Each element a_{ij} of the matrix represents the dollars of input from sector i used to produce one unit of output of sector j. The following explains how we update a_{ij} to reflect changes in the spring load restrictions to 10 tons year-round.



PRIMARY INTERACTION OF TRANSPORT MODULE WITH OTHER SIMLAB MODULES

Figure 1

2.2 Timber industry sectors and highway weight restrictions

The sectors considered in this study include:

WOOD PRODUCTS INDUSTRIES CONSIDERED	SIMLAB SECTOR
Logging	24
Sawmills	25
Particle Board	26
Other Wood Products	27
Pulp and Paper	29

A typical regional multiplier for these sectors is 1.7. This implies that, for every dollar increase in production in each of these sectors, a 1.7 dollar increase will occur in the local economy in general. This multiplier is less than the ones corresponding to other typical economic activities, such as for the non-natural resource sectors.

For our base runs we use the Status Quo in 1977. At that time some roads were restricted to 7 tons for part of the year and most allowed 10-ton loads except during the spring breakup when they were restricted to 9 tons. In order to determine the effect of changing these limitations on timber-related industries, 6 major companies that produce pulp, paper or wood products were asked to identify roadways which limited their shipments. While specific inmformation on names, location and shipments cannot be disclosed, the following summarizes the data we collected and the assumed present and future weight limitations of roadways serving these companies.

TABLE 1. CLASSIFICATION OF FORESTRY TRUCKLOADS BY LOAD RESTRICTIONS

NUMBER OF TRUCKLOADS	1977 LIMITS	1986 LIMITS
10,064	10T/10mo. 9T/ 2mo.	10T/12mo.
6,171	10T/10mo. 9T/ 2mo.	10T/10mo. 9T/ 2mo.
909	10T/ 3mo. 9T/ 9mo.	10T/10mo. 9T/ 2mo.
768	9T /10mo. 7T / 2mo.	10T/10mo. 9T/ 2mo.

The increase in weight carrying capacity will enable most of the companies to increase their truckload shipments while maintaining the same transport cost, since they presently must ship a given number of truckloads at a higher cost (since the shipments are weight limited.) In the SIMLAB simulations, we assume the base line is at the 1977 limits and the spring load restriction is increased to 10 tons year round. Because specific data on transportation costs are not available for each of the shipments identified above, we determine the costs indirectly by determining the new coefficients a_{ij}.

2.3 Development of transport cost and market share estimates

2.3.1 Determining new truckloads per year from old truckloads per year

In each year the ith location will have q_i/j trucks, where j is the number of tons allowed to be shipped. Thus, using the definitions in the Appendix,

$$T_i = \sum_{j \text{ in } R} \frac{m_{ij}}{12} \frac{q_i}{j}$$

Since q_i is constant, the ratio of the new truckloads to the old truckloads is:

$$\frac{T^*_i}{T_i} = \frac{\sum_{j \text{ in } R} m^*_{ij}/j \quad q_i/12}{\sum m_{ij}/j \quad q_i/12}.$$

Therefore,

$$(2) \quad T^*_i = T_i \frac{\sum_{j \text{ in } R} m^*_{ij}/j}{\sum_{j \text{ in } R} m_{ij}/j}$$

The computation for the new truck loads is shown in Table 2.

Table 2. Computation of new number of truckloads per year

Location	T_i	$\sum_{j \text{ in } R} m_{ij}/j$	$\sum_{j \text{ in } R} m^*_{ij}/j$	T_i^*/T_i	T^*
1	10064	1.222222	1.2	.981818	9881.0
2	6171	1.222222	1.2	.981818	6058.8
3	909	1.3	1.2	.923077	839.1
4	768	1.296825	1.2	.859091	659.8
total	17912				17438.7

2.3.2 Computation of new Input-Output coefficients

The coefficient of highway transportation for each of the timber-related industries is updated as described below. We begin by defining the total transportation cost, C, over all locations:

$$C = c \left(\sum_{i \text{ in } L} T_i \right)$$

Therefore, the direct requirement coefficients of transportation for this industry (i.e., the percent contribution of each sector needed for transportation) before and after the change in transportation are, respectively:

$$a = \frac{C}{Q}, \text{ and } a^* = \frac{C^*}{Q},$$

since Q, total production, is assumed constant (If Q did increase then C* should increase proportionately under fixed coefficients so that no loss of generality occurs by assuming Q constant).

The ratio of the new coefficient to the old coefficient is:

$$\frac{a^*}{a} = \frac{C^*}{C} = \frac{c\left(\sum_{i \text{ in } L} T^*_i\right)}{c\left(\sum_{i \text{ in } L} T_i\right)}$$

Therefore,

$$(1) \qquad a^* = a \frac{\sum_{i \text{ in } L} T^*_i}{\sum_{i \text{ in } L} T_i}$$

From equation (1), we find that a* = 17438.7/17912 a = 0.9735763 a. The new coefficients for the timber-related sectors are presented in Table 3.

Table 3. Computation of new coefficient

Sector	old coefficient a_{ij}	multiplier	new coefficient a^*_{ij}
24 Loggin	.0023710248	0.9735763	0.0023083736
25 Sawmill	.0013696455	0.9735763	0.0013334544
26 Particle Board	.0077668823	0.9735763	0.0075616525
27 Other Wood	.0033639186	0.9735763	0.0033371468
29 Pulp & Paper	.0036820949	0.9735763	0.0036527908

It is assumed that all the cost savings are passed onto the purchaser in the form of a lower price. Thus, the value added is not assumed to change, although the other direct requirement coefficients must change to balance out the decrease in highway transportation cost. We accomplish this by making the following adjustment for i=1,2,...75:

$$\bar{a}_{ij} = a^*_{ij} \sum_{k=1}^{75} a_{kj} \Big/ \sum_{k=1}^{75} a^*_{kj}$$

2.3.3 Estimate of REXPORT (Regional Exports) and REGMKSR (Rate of Change in Regional Market Share)

We assume that all the cost savings from the transportation change are passed onto the purchaser. Thus, the change of price will equal the change in transportation cost. If E is the elasticity of demand with respect to price,

NEW MARKET SHARE = OLD MARKET SHARE/(1 - E(a-a*))

Using this expression, the changes in market share for E = 1 are summarized for the five sectors in Table 4 below. Later calculations also present the results for E=10.

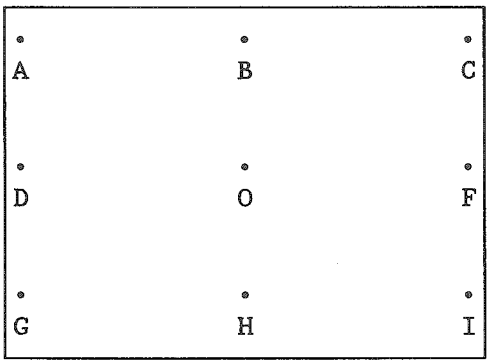
Table 4. Computation of new Regional Export Market Share

Sector	Baseline REXPORT	New REXPORT	Baseline REGMKSR	New REGMKSR
24 LOGGING	7507.261	7507.400	.000022	.000031
25 SAWMILL	1684.413	1684.431	-.003229	-.003224
26 PART. BD.	1697.795	1697.898	-.003170	-.003140
27 OTHER WOOD	37086.547	37087.540	-.018399	-.018386
29 PULP & PAP.	417446.733	417458.967	-.049965	-.049951

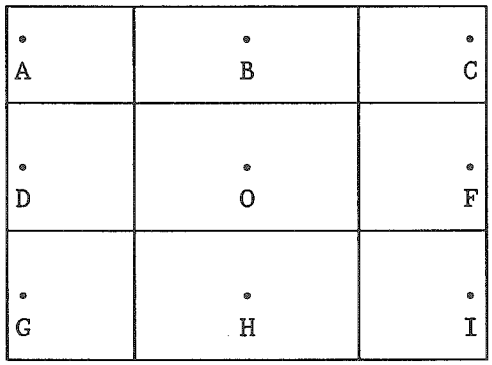
NOTE: The assumed rate of change in regional market share is applied for a period of two years, after which the baseline rate of change is assumed again. Negative market share indicates imports.

2.3.4 Elasticity

Most of the changes in the economy occur because of the way the use of SIMLAB affects market share. As explained earlier, market share is directly related to the elasticity (sensitivity) of demand, E. In this subsection, we look at a simple theory as to what the elasticity should be. In particular, assume a grid of producers as shown below:

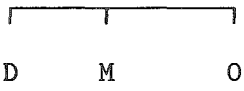


Also, assume that the demand of the product lies uniformly over the area of the above rectangle. Assume that the cost/mile of transporting the good is the same for each producer, and that each producer sells his/her product at the same price before transportation costs. If each purchaser bought the product from where it was least expensive after transportation costs, then the rectangle would be divided as shown below:



Now, let us assume that the cost of shipping from point O drops by 1%, but that the shipping costs from all other points remain the same and that each purchaser purchases the same total quantity as before. Then the area of point O's market will increase as determined below.

Take, for example, the border of the markets for points D and O.



We seek a point M where the cost of shipping from D to M is the same as the cost from point O to M. Let c_D and c_O be the cost/mile of shipping from D and O, respectively. Where d(AB) is the distance between two points A and B, point M is defined as $d(DM)c_D = d(OM)c_O$. When $c_D = c_O$, d(DM) = d(OM) = .5d(DO). When $c_O = .99c_D$, then d(DM) = .99d(OM), or d(OM) = [1/1.99]d(DO), which is a .5% change in the distance from O to its market border. However, all four of point O's market borders will increase by .5%. Thus, since the area of its market boarder is base x height = 1.005b* x1.005h* where b* and h* are the original base and height lengths, the area of point O's market will increase by 1%. Therefore, a 1% decrease in point O's costs (and only point O's costs) would result in a 1% increase in the demand for its product, i.e. an elasticity of one.

The above discussion makes it clear that an elasticity of one to changes in transportation costs is a reasonable assumption. Note that the discussion assumed that customers in point O's market would not increase their demand. However, because some of these customers would experience lower cost of buying the product, some additional increase in demand may be expected. Thus, an

elasticity greater than one may occur. Nevertheless, since factors other than cost may also influence choice, we do not expect the elasticity to be substantially greater than one.

3. RESULTS

In this section, three simulations are performed:

(a) BASELINE SIMULATION: Uses the old 1977 I/O coefficients.

(b) UNITARY ELASTICITY SIMULATION: Assumes a change from the 1977 state of highways to one where all highways are at 10 tons/12 months. We assume an elasticity of one for this simulation.

(c) TEN ELASTICITY SIMULATION: The same as (b) except we assume an elasticity of ten. We realize that an elasticity of ten is high but we use it as an upper limit to indicate the greatest possible expected impacts of the highway improvements.

3.1 Baseline simulation

The SIMLAB model is run from the year 1977, for which the Input-Output Table has been generated and for which the database has been established, through the year 1986 without modification. This is the "baseline" run against which a comparison with changes in transportation costs will be made. The baseline forecasts indicate a sharply reduced labor force and a gradual decline in employment and gross output over the time period suggesting the need for state assistance to this region.

3.2 Comparison with increased market share simulations

Market Share is first assumed to change by 1%, and then by 10%. For the first scenario, the rate of change in market share from Table 4 is applied for the 2-year period 1977-1979, after which the original values are used. For the second scenario, a rate of change in market share that yields a 10% increase in

market share after two years is assumed.

For the regional economy as a whole, the unit-elasticity scenario results in no measurable changes. Assuming that a 10% change in market share occurs with a 1% change in transportation costs, it is predicted that gross output increases 0.018% per year from 1979 onwards; earnings are estimated to increase by 0.022%. If the individual sectors are examined, somewhat larger increases can be expected. In particular, the increases are 0.17% for the Particle Board sector and 0.10% for the primary forest sector. These changes are illustrated in Table 5 below.

TABLE 5. REGIONAL OUTPUT

Sector	BASIC RUN	Unit Elastic (chg)	10 Elasticity (chg)
24	556209.0000	556386.0000 (0.032%)	556809.0000 (0.108%)
25	183270.0000	183311.0000 (0.022%)	183404.0000 (0.073%)
26	27658.0000	27664.0000 (0.022%)	27705.0000 (0.170%)
27	541807.0000	541853.0000 (0.008%)	542199.0000 (0.072%)
29	3241604.0000	3241961.0000 (0.011%)	3244940.0000 (0.103%)

In terms of actual predicted dollar value of the Regional Output, the following are obtained:

Scenario	Regional Output (000)	Difference from Baseline
Baseline	$ 5,059,597.1	--
Unit Elasticity	5,059,666.1	$ 69,000
10% Elasticity	5,060,343.3	746,200

Thus, based upon the simplified assumptions above, the total increase in Regional Output with upgraded weight limits and an assumed increase in market share equal to the relative drop in transportation costs is only $69,000, while with an assumed 10% increase in market share for the timber-related sectors, the increased output would be $746,200.

4. COST-EFFECTIVENESS ANALYSIS

4.1 Estimated New Taxes from Improvements

While the analysis here is oversimplified, it appears safe to assume that the total of State and Local taxes generated by the additional output would not be more than 10%, or $6,900 for the unit elasticity and $74,600 for the higher elasticity. It is likely that the actual figure would lie somewhere in between these two.

4.2 Estimated Roadway Improvement Costs

Estimate of annual costs per mile allocated to truck traffic on Minnesota roadways is $1,200 (John Sem, former staff, MnDOT Planning). This takes into account the marginal costs assigned to trucks over and above those which would be required in any case to provide a roadway to carry normal automobile traffic. This is also based upon a 30-year lifetime, and hence represents the continuous annualized cost required to build and maintain a 10-ton roadway.

4.3 Cost-Effectiveness Results

While exact mileages needed to be upgraded are not available for the six companies at the present time, these can only be estimated. Some of the plants are located close to major highways, and hence require only a few miles of upgrading. Several are located a long distance from 10-ton roads, and hence require a longer distance. Since the purpose of this paper is to evaluate the usefulness of the model concept, and the companies would like the data kept confidential, an exact analysis is not possible. However, some general conclusions can be drawn here.

The estimated distance which is in need of upgrading is estimated to be between 100 and 200 miles, thus costing the State $120,000 to $240,000 annually. It can be seen that, even when a 10% elasticity in market share is assumed, tax revenues are estimated to be $75,000. This would provide for the upgrading of 63 miles of roadway which may not be too unrealistic, if the longer distance (and hence more remote company) were eliminated from

consideration. However, if the unit elasticity were more likely, this would mean that only six miles of roadway could be upgraded without costing the taxpayers of the State additional monies.

4.4 Limitations to Northeast Minnesota

This exercise is based upon a very small sample of firms (six), which are, however, the important components of the timber-related sectors considered. However, a number of smaller companies doing business in the region were not contacted. Thus, the impact of roadway improvements in the region is likely to be somewhat higher than estimated here.

Another factor not considered here is the time value of the product being shipped. While timber products have some inventory value if not shipped during the weight-restricted season, products such as grain not only have inventory value but can have significant price fluctuations. If grain needed to be shipped during the weight-limited season, the entire annual harvest may have to be shipped inefficiently. Upgrading the roadway would in this case be much more significant than for timber-related products in Northeast Minnesota.

APPENDIX

DEFINITIONS

a_{ij} is the old coefficient representing the direct requirements for the transportation input i into industry j

a^*_{ij} is the new coefficient a_{ij} after the transportation change takes place

T_i is the truckloads per year from location i

T_i^* is the new truckloads per year from location i

c is the cost per truckload

q_i is the output per year at location i (assumed constant)

m_{ij} is the number of months that the road in class i was j tons

m_{ij}^* is the number of months that the road in class i is j tons after transportation change

C is the total transportation cost

L is the set of locations

Q is the total value of output per year from all locations

R is the list of ton restrictions on road i

market share is positive when indicating exports, negative when indicating imports