1977

Estimating the Elasticity of Demand for Rail Transportation of South Dakota Wheat

Karen Ann Olson

ESTIMATING THE ELASTICITY OF DEMAND

FOR

RAIL TRANSPORTATION OF SOUTH DAKOTA WHEAT

BY

KAREN ANN OLSON

A thesis submitted
in partial fulfillment of the requirements for the
degree Master of Science, Major in
Economics, South Dakota
State University
1977

ESTIMATING THE ELASTICITY OF DEMAND

FOR

RAIL TRANSPORTATION OF SOUTH DAKOTA WHEAT

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Advisor Date

Head, Economics Department Date

ACKNOWLEDGEMENTS

The author wishes to express her appreciation to Dr. Charles E. Lamberton, Assistant Professor of Economics, for his time and advice throughout this investigation. The author also wishes to thank her fellow graduate students, Elsa Wood for typing the manuscript, David Withee for helping with the computer work, and Dale and Eileen Bertsch.

Most special thanks are extended to Dr. Oscar E. Olson, the author's father, whose encouragement and support facilitated the completion of this manuscript.

K.A.O.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The primary mode of transportation for agricultural products in the United States has historically been the railroads. They have been the least cost means of transporting most low value agricultural commodities long distances to markets where water transportation has not been available. Today, however, the use of railroads is being eclipsed by the rise of competing modes, especially trucking.

When the country was developing in the nineteenth and early twentieth centuries, railroads greatly increased the mobility of the population and opened up vast parts of the western lands for settlement. There was no comparable national system of transportation, as waterway travel was subject to physical limitations and motorized travel had not yet been developed. As early as the 1920's railroads began to experience competition from trucks and barges. Public interest in traveling by motor vehicles sparked state and federal governments to build and improve highways while improved motor vehicle technology allowed trucks to increase both capacity and speed. Where navigable rivers existed, barges became more popular because of channel improvements by the U. S. Army Corps of Engineers, development of large tow boats, and free access to waterways.[1] Minimal

[1] U. S., Congress, Senate, Committee on Agriculture and Forestry, Prelude to Legislation to Solve the Growing Crisis in Rural Transportation, Hearing, 94th Congress, 1st Sess., February 10, 1975 (Washington: Government Printing Office, 1975), p. 18.

regulation of trucks and barges gave them more leeway in their rate-making ability to compete with the regulated railroad industry.[2]

The railroads began to face financial difficulties in the 1960's when competition from trucks and barges reduced the railroad's share of the freight traffic and added to a poor profit picture. In six years out of the decade the rate of return failed to reach three percent and the average rate of return for 1960-74 was only 2.78 percent.[3]

Insufficient earnings and the inability to attract funds in the capital markets force some railroads into bankruptcy. Others were forced to abandon some of their unprofitable lines. In 1960 there were 329,704 miles of track in the U. S. By 1974 there were only an estimated 326,000 miles and an increasing number of abandonment petitions had been filed.[4]

The main problem of U. S. railroads today is the inability to obtain sufficient sums of money because of their declining market share to simultaneously continue operations, meet debt obligations, and maintain and improve facilities.[5]

---

[2]Ibid., p. 20.

[3]U. S. Congress, Senate Committee on Agriculture and Forestry. Prelude to Legislation to Solve the Growing Crisis in Rural Transportation, Hearing, 94th Congress, 1st Sess., February 10, 1975 (Washington: Government Printing Office, 1975), p. 21.

[4]Ibid., p. 20

[5]Marc A. Johnson, Community Evaluation of Railroad Branch Lines: Principles and Procedures, (East Lansing, Michigan: Michigan State University, 1975), p. 4.

Underlying this is the fact that railroads are unable to get capital for improvements and operating expenses because they are poor risks due to the number of bankruptcies of major railroad companies and they exhibit low rates of return. This has contributed to a further deterioration of service and equipment which has led to periodic shortages of railcars. The problem is aggravated by the ability of trucks and barges to engage in rate competition with the railroads for the movement of unmanufactured farm products because of less stringent regulation. For these reasons it is difficult for the railroads to regain a greater share of the market and to generate revenues.

The deterioration of railroad service is especially disturbing to many agricultural shippers. Shippers of agricultural products depend on transportation to give their products market value by getting them from places of excess supply to places where there is excess demand. Because of the nature of agricultural products--they are bulky, often must be moved a long distance, have low value per unit, and often need special services--the cost of transportation makes up a relatively large part of the final value of the product which reaches the ultimate consumer. These characteristics provide a strong incentive for shippers to seek the lowest cost mode to transport their products. They desire from this mode reliable service and flexibility in shipping to meet seasonal demands. The cost incentive is particularly important to South Dakota shippers whose distant location from markets causes transportation costs to be a larger share of total costs than for those shippers closer to markets. South Dakota farmers must meet the market price and therefore get lower net income when transportation costs are higher.

Rail has been the lowest cost means of transporation for many shippers. Recently, however, shippers have become more concerned with speed and service, perhaps because truck rates have become more competitive with rail rates than in the past. Because the railroads have been unable to replace and repair railcars and trackage due to financial difficulties, much of the railroad system is in disrepair. This can be damaging to shippers through loss of inventory due to grain spillage from cars. Unsafe trackage also forces rail traffic to travel at slower speeds. The railroads have also had difficulties enlarging the capacity of their fleets because of lack of capital to buy new and more modern cars. Therefore, there are periodic shortages of cars, especially during periods of peak demand. It also takes longer for the cars to get to the elevators to pick up the shipments and longer to get to market. This imposes additional inventory costs. The elevator operator waits for railcars when he could be receiving and shipping more grain. If the slower speed and higher risk of grain loss or railroad shipment means the shipper is unable to get his grain to market when the price is the highest, it may be advantageous for him to switch to another mode. The ability of trucks to provide fast and frequent service with less chance of grain loss, along with the abandonment of rail service in some areas where barges are not available, has induced a shift to the use of trucks in the movement of agricultural commodities.

The abandonment of trackage and the bankruptcies of Northeastern and Midwestern railroads have alarmed the government about the state of the nation's railway system. There are reasons for this concern. Railroads have certain advantages when shipping goods which are bulky and have low value such as lumber, coal, grain, and farm machinery. If railroads are not available to ship these goods, more expensive transportation alternatives may have to be used. In South Dakota, where barge travel is not available, trucking is the only mode of transport shippers can turn to. Another concern, especially in rural areas, is the capacity of roads and highways to carry additional traffic if the railroads abandon more lines. Some rural roads were not built to handle large amounts of traffic and would have to be improved. A third reason for concern is that the railroads are part of an intricate national defense system which connects the different parts of the country. If the railroads fail, this defense system could be weakened.

Important to South Dakota is the fact that if rail service is lost, in may possibly become more difficult and costly to ship the state's chief export, agricultural commodities, out of the state. Then, an alternative method of transportation would have to be found. Rural communities may also lose some services for a time, such as the shipping of certain products into and out of the community by rail.

With the problems of railroad failures and abandonments on the horizon, Congress passed the Regional Rail Reorganization Act of 1973 in which the government attempted to identify the "essential" lines in 18 states in the Midwest and Northeast. The Act also established the U. S. Railway Association (USRA) and the Consolidated Rail Corporation (Conrail). The former agency represents national rail planning and will help in restructuring railroads. The latter agency is a for-profit organization established under the laws of the states to rehabilitate, improve, and operate rail lines which are deemed "essential".

In 1976, Congress passed the Railroad Revitalization and Regulatory Reform Act. Two primary thrusts of this act were ratemaking and regulatory reform. The law affects rates in four ways:[6]

> (1) Permits railroads to raise or lower most rates as much as seven percent on 30 days notice without having to get prior ICC approval if there is found to be no market dominance which is referred to in the act as an absence of effective competition from other carriers or modes of transportation for the traffic or movement to which a rate applies.[7]

---

[6]Railroad Revitalization and Regulatory Reform Act of 1976, Section 202(a-d), 90 Stat. 150(1976), 45 U. S. C. Section 802(1976).

[7]The Railroad Revitalization and Regulatory Reform Act of 1976 states that "No rate of a carrier shall be held up to a particular level to protect the traffic of any other carrier or mode of transportation, unless the Commission finds that such rate reduces or would reduce the going concern value of the carrier charging the rate. Any rate equaling or exceeding variable cost is considered to contribute to going concern value", in the Association of American Railroads <u>Information Letter #2182</u>, December 24, 1975. However, the ICC has interpreted market dominance as follows: "A presumption of market dominance will be made when the rate in issue is more than 60 percent above the variable cost of service", from the Association of American Railroads <u>Information Letter #2213</u>, March 2, 1977. As of January 11, 1977, the ICC initial interpretation of market dominance is being challenged in court as restricting the degree of rate freedom intended in the Act, as stated in the Association of American Railroads <u>Trends</u>, January 11, 1977.

(2) Promotes the establishment of rate structures which are more sensitive to seasonal, regional, and shipper demand.

(3) Promotes separate pricing of distinct rail and rail-related services.

(4) Modernizes and clarifies the functions of rate bureaus.

One of the major causes of the railroads' problems is the inability of the railroads to alter their rates quickly enough to effectively compete with the other modes of transporation. In an attempt to make the railroads more competitive, changes in regulation were made to increase rate flexibility through the Railroad Revitalization and Regulatory Reform Act of 1976. The railroads now face the question of how to utilize this greater ratemaking flexibility to increase revenues by the greatest amount possible.

Railroads need to know the responsiveness of shippers to changes in rail rates in order to determine what these changes will do to railroad revenues. Demand elasticities are a measure of responsiveness. If rail rates are decreased and this causes an increase in revenues, or if rates are increased causing a decrease in revenues, the demand is said to be elastic. If there is an inelastic demand, a decrease in rail rates will cause a decrease in revenues just as an increase in rates will cause an increase in revenues.

OBJECTIVES

The overall objective of this study is to estimate the price elasticities of demand for rail transportation of wheat produced in

South Dakota in 1974. The specific objective of this study is to estimate the demand for rail transportation in shipping wheat and the corresponding elasticity coefficients. By accomplishing this, the impact of changes in rail rates on quantitites shipped by rail can be estimated. The degree of substitutability between rail and truck is also measured by estimating the elasticity of substitution. To accomplish the above, data on 1974 grain shipments is used to estimate demand functions from which the elasticity coefficients can be estimated. The methodology used in the calculation of the above elasticities will be discussed in following chapters.

Data on grain shipments by rail and truck collected in the parent study for this project, "A Pilot Study to Investigate Efficient Grain Transportation and Marketing Systems for South Dakota", will be used.[8] A questionnaire requesting information on amounts of grain shipped by rail and truck and destinations of shipments was sent to every elevator operator in the state. Data from the questionnaire was used to estimate demand functions for rail transportation of wheat for 1974. The method used in calculating the elasticity figures is explained in Chapter II. The elasticity of substitution between truck and rail transportation was also estimated to indicate the degree of substitution possible between the two modes as inputs in the wheat marketing process.

---

[8]"A Pilot Study to Investigate Efficient Grain Transportation and Marketing Systems for South Dakota", South Dakota State University, Report #DOT-OS-50229, Hune 1976.

CHAPTER II

A STUDY OF DEMAND ELASTICITIES

The purpose of this chapter is to provide background information about the methodology used in this study. The concept of elasticities, including formulas and explanations of the value of the elasticity coefficient are discussed in the first section of the chapter. A review of literature on the elasticity of demand for freight transportation is presented next, with five studies being discussed. The last section of the chapter is devoted to an explanation of the methodology used in this study.

The economic characteristics of the railroad and truck industries, especially the rate-making abilities, are discussed in Chapter III. In Chapter IV the models used to estimate demand elasticities and the resulting elasticity coefficients are presented. A summary and the conclusions of the study are presented in the final chapter.

ELASTICITY OF DEMAND

One of the primary objectives of estimating a demand function, $Q=f(P)$, is to be able to estimate the response in quantity demanded which can be expected from a given change in price. A measure of this response is the elasticity coefficient. The price elasticity of demand is defined as ". . .the proportional change in quantity demanded divided by the proportional change in price."[1] The formula

[1] C. E. Ferguson and J. P. Gould, <u>Microeconomic Theory</u> (Homewood, Illinois: Richard D. Irwin, Inc., 1975), p. 97.

for elasticity is:

$$\varepsilon_d = - \frac{\Delta Q/Q}{\Delta P/P} = - \frac{P}{Q}\frac{\Delta Q}{\Delta P}$$

As the change in P becomes small, ΔP and ΔQ approach zero and their ratio ΔQ/ΔP approaches the derivative dQ/dP. The formula for elasticity now becomes:

$$\varepsilon_d = - \frac{dQ/Q}{dP/P} = - \frac{P}{Q}\frac{dQ}{dP}$$

Since the purpose of the price elasticity measure is to determine the responsiveness of one variable to changes in a second variable, the sign of the coefficient is irrelevant and the absolute value ($|\varepsilon_d|$) is used.

In order to relate elasticity to revenue, the following analysis is presented Total revenue (R) equals price per unit times the number of units: R=PQ. Marginal revenue (MR) = $\frac{dR}{dQ} = \frac{d(PQ)}{dQ} = P + \frac{QdP}{dQ} =$ $P(1 + \frac{Q}{P}\frac{dP}{dQ})$. However, $\varepsilon_d = - \frac{P}{Q}\frac{dQ}{dP}$. Therefore MR = $P(1 - \frac{1}{\varepsilon})$. From this result, the following three relationships can be obtained:

(1) If $|\varepsilon_d|>1$, for a small decrease in price a more than proportional increase in Q demanded results. Marginal revenue is positive and total revenue increases as Q demanded (output) increases. Demand is said to be elastic in this case.

(2) If $|\varepsilon_d| = 1$, the small percentage decrease in price is exactly offset by an equal percentage increase in quantity demanded, marginal revenue equals zero, and total revenue remains the same. In this case, demand is of unitary

elasticity.

(3) If $|\varepsilon_d| < 1$, a small decrease in price is accompanied by a less than proportional increase in Q demanded, marginal revenue is negative, and total revenue decreases as output increases. This is called inelastic demand.

Graphically, point elasticity can be shown by using a demand function (Figure 3.1). The demand curve is FF' and the point elasticity is to be determined at Point B where price is D and quantity demanded is OE. If line ABC is constructed tangent to the demand curve at B, ABC will have the same slope at B as the demand curve has. The slope of ABC is the change in price divided by the change in quantity demanded ($\frac{\Delta P}{\Delta Q}$) which is $\frac{AD}{OE}$. The inverse of this is $\frac{\Delta Q}{\Delta P}$ or $\frac{OE}{AD}$. The price-quantity relationship is $\frac{OD}{OE}$. Therefore, the point elasticity at B is:

$$\varepsilon = \frac{\Delta Q}{\Delta P}\frac{P}{Q} = \frac{OE}{AD}\frac{OD}{OE} = \frac{OD}{AD}.$$

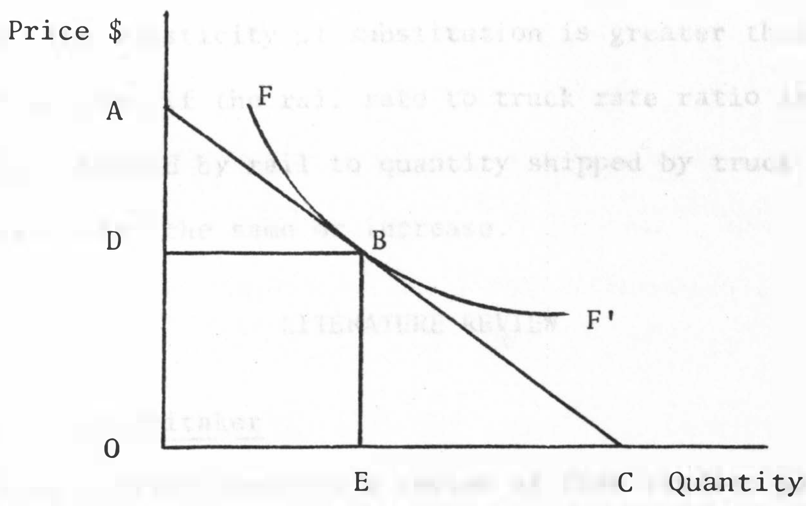


Figure 3.1: GRAPHICAL ILLUSTRATION OF POINT ELASTICITY

ELASTICITY OF SUBSTITUTION

Another important elasticity measure is the elasticity of substitution. The elasticity of substitution measures the relative responsiveness of the ratio of two productive factors to given proportional changes in the marginal rate of technical substitution between the two factors. The formula for the elasticity of substitution between rail and truck is:

$$\sigma = \frac{\Delta \frac{Q_R}{Q_T}}{\frac{Q_R}{Q_T}} \div \frac{\Delta \frac{R}{T}}{\frac{R}{T}}$$

Where: Q_R = the quantity shipped by rail
Q_T = the quantity shipped by truck
R = the rail rate
T = the truck rate

The significance of the above calculation is that according to whether the elasticity of substitution is greater than one, unity, or less than one, if the rail rate to truck rate ratio increases, the quantity shipped by rail to quantity shipped by truck ratio will decrease, stay the same or increase.

LITERATURE REVIEW

Benishay and Whitaker

This section contains a review of five studies pertaining to freight transportation demand elasticities. In a study of the common carrier freight transportation industry, Benishay and Whitaker[2] estimated demand elasticities for rail, motor, and water in an effort to compare the demand for freight transportation by mode. Transportation is a factor of production used to move goods from the point of production to the point of utilization and its demand is derived from that for the final product, and therefore a demand curve can be derived for each mode. Benishay and Whitaker estimated a demand function for each transport mode for the postwar years by using a linear time-series regression. The dependent variable used was per capita ton miles and the independent variables included were transportation prices (an aggregate mode price measure was utilized), prices deflated by the Consumer Price Index, urban concentration, and a time trend. Three sets of regressions were employed, with the first set using actual variables, the second using their logarithmic value, and the third using the first differences of the logarithms of actual values. Data used for the computations were taken from the years 1946-59 and 1961. The demand elasticities for the three modes derived from the regressions on the logs of the variables were -.269 for water, -1.150 for motor carriers, and -.766 for rail. The elasticities derived from the equation of the first differences of the logs were -.264 for water, -1.873 for motor carrier and -.842 for rail.

---

[2]Haskel Benishay and Gilbert R. Whitaker, Jr., "Demand and Supply in Freight Transportation", Journal of Industrial Economics: XIV, (1966), pp. 243-262.

Limmer

The first method used to estimate demand elasticities in the current study follows that used by Limmer in his study of the elasticity of demand for railroad transportation of fresh fruits and vegetables in Florida.[3] Limmer determined the following: (1) the degree of correlation between rail-truck rate differences and each carrier's share of the traffic; (2) the elasticity of demand for rail; and, (3) the optimum level of rail rates to the railroad. These were found for eight commodities and twelve markets. A demand function for rail service was formulated from a linear regression equation using rail percentage of total unloads at a market as the dependent variable and the excess of rail over truck rates as the independent variable. Limmer used eight regression equations--one for each of the fruits and vegetables. He estimated eight elasticity coefficients by measuring the change in the rail percentage of total unloads accompanying a one percent change in the rail rate. All eight coefficients were elastic, or greater than 1.0, indicating that given percentage changes in the railroad rates are estimated to result in greater percentage changes in the rail percentage of total unloads. To conclude his study, Limmer estimated the optimum rate which yielded the maximum amount of revenue in excess of out-of-pocket costs. For a

---

[3] Ezekial Limmer, "The Elasticity of Demand for Railroad Transportation of Florida Produce", Journal of Farm Economics, XXXVII, (1955), pp. 452-460.

commodity with an elastic demand for rail service, lower rail freight rates result in higher volumes of rail traffic and higher gross revenues. The higher volumes of traffic account for higher total variable costs for the railroad because these costs vary directly with volume. For some commodities, increases in variable costs would exceed increases in gross revenues resulting from lower lower rates. For other commodities increases in gross revenues would be greater than increases in variable costs. When comparisons were made with actual rates it was found in every case that current average charges were above the optimum rates as shown in the following table.[4]

Commodity	Actual charges	Charges maximizing income above out-of-pocket costs	Percentage decrease in actual rates to attain maximum net income.
	Dollars per 100 pounds	Dollars per 100 pounds	Percent
Beans, snap	2.12	1.95	8.0
Cabbage	1.51	1.45	4.0
Celery	1.78	1.72	3.4
Corn, green	2.01	1.99	1.0
Grapefruit	1.26	1.14	9.5
Oranges	1.16	1.09	6.0
Potatoes	1.25	1.22	2.4
Tomatoes	1.82	1.74	4.4

As far west as Chicago and St. Louis.

Table 3.1. COMPARISON OF OPTIMUM AND ACTUAL RATES IN LIMMER STUDY

[4]Ibid, p. 460.

Miklius

Miklius[5] followed Limmer's study by estimating the demand for truck and rail transportation for California lettuce. Data from a sample of lettuce shipment unloads by truck and rail at major destinations was taken and these data were combined with actual rail and truck rates. Miklius assumed that lettuce shippers had an effective choice between truck and rail to all destinations considered; thus, the shipper's choice of mode would be based on the rates. Single-equation regressions were applied, with shipments by rail and shipments by truck as the dependent variables and rail freight rate, truck freight rate, size of the market (total shipments), and a dummy variable accounting for regional differences as the independent variables. The calculations were repeated using total shipments to a specific destination. Elasticity coefficients found were: (1) rail - a range from -3.19 to -1.97; (2) truck - a range of -5.08 to -3.36. Cross-elasticity of demand was estimated at +1.00, implying relative ease in substituting the two modes. The results found by Miklius were comparable to the results found by Limmer, whose estimates ranged from -3.6 to -1.9 for rail transportation of the eight fruits and vegetables.

---

[5] Walter Miklius, "Estimating the Demand for Truck and Rail Transportation: A Case Study of California Lettuce", Agricultural Economics Research, XIX, (1967), pp. 46-50.

Perle

Another study estimating demand elasticities was done by Perle.[6] The purpose of his study was to estimate the demand for motor and rail transportation at the regional and commodity level for the years 1956-1960. Perle set up a framework for others to follow in estimating demand. He stressed that one of the central determinants of the quantity demanded of any good is its price. Therefore, prices play an important role in his model. Perle used multiple linear regression to estimate demand functions. Consumption of each transport mode expressed in quantity of a commodity shipped was used as the dependent variable and independent variables were the price of the transport mode and the price of the alternate transport mode. Perle also used a second model in his analysis. An elasticity of substitution model was introduced where the ratios of quantities consumed and prices were linked. The dependent variable was the ratio of quantities shipped by each mode and the independent variable was the ratio of the prices of each mode.

In trying to answer the question of how prices have influenced the consumption of transportation for the nation as a whole and for particular commodities, Perle analyzed the following: (1) aggregate transport demand for all commodities in the continental United States; (2) transport demand for the nation by major commodity groups;

---

[6]Perle, The Demand for Transportation. The University of Chicago. 1964.

(3) total regional transport demand (all commodities taken together); and, (4) individual region-commodity combinations. Perle used five classes of commodities and nine regions over a period of five years for his analysis. He produced many elasticity figures which helped to formulate his findings. One of his findings was that, nationally, there has been a persistent increase in motor carrier tonnage and a smaller, but obvious, decrease in railroad tonnages. Over time, motor carriers have captured larger shares of the commodity transportation markets. Perle also found that the division of market shares was fairly unresponsive to the price ratio. Therefore, he postulated that the transportation rate at which a shipper ships his product to market has not been the primary cause of the increase in motor carrier market shares.

Berger and Nelson

In another study, two North Dakota economists, Berger and Nelson,[7] developed demand elasticities for rail transportation of hard red spring wheat for all of North Dakota, seven counties in Minnesota, and 16 counties in South Dakota for 1965-67. Of primary concern was the movement of grain from country elevators to the Minneapolis-St. Paul and Duluth-Superior markets. The country elevators surveyed were those located on major highways. Thus, shippers could make an

---

[7]Donald W. Berger and David C. Nelson, An Analysis of the Elasticity of Demand for Rail Transportation of Hard Red Spring Wheat, (Fargo, North Dakota: North Dakota State University, 1970).

effective choice between rail and truck. A combination of areas was used in the analysis--the three states taken together, each one taken separately, and pair-wise combinations of states. Multiple linear regression was used to formulate 21 demand vunctions in which quantity of hard red wheat in bushels per year shipped by rail to markets was used as the dependent variable, while the independent variables were rail rates, truck rates, and the quantity of marketable hard red spring wheat in bushels per year from country elevators. After the demand functions were formulated, four price elasticity coefficients were found--point elasticity, arc elasticity, and two average arc elasticity figures. The range of the four figures was used as the pertinent elasticity. In each of the 21 cases, the elasticity was greater than 1.0, indicating that the demand for rail service was elastic. Berger and Nelson then compared the actions of truck and rail rates and quantity of marketable grain in an effort to verify their results. From this analysis they concluded, much as Perle did, that variables other than price, such as supply of rail cars and truck and service considerations also influence the choice between shipping by rail and shipping by truck.

METHODOLOGY

The scope of this study was limited to four rail lines carrying wheat from elevators in the state to out-of-state markets. The four lines and corresponding destinations are: (1) Chicago and North Western from Rapid City and leaving the state at Elkton; destinations are Minneapolis-St. Paul and Sioux City; (2) Chicago, Milwaukee, St. Paul & Pacific from Rapid City leaving the state at Canton; destinations are Minneapolis-St. Paul and Sioux City; (3) Chicago, Milwaukee, St. Paul & Pacific from Aberdeen (continued from North Dakota) to Sioux City; destinations are Minneapolis-St. Paul and Sioux City; (4) Chicago, Milwaukee, St. Paul & Pacific from White Butte (continued from North Dakota) to Big Stone City; destinations are Duluth-Superior and Minneapolis-St. Paul. Lines 1 through 3 are classified as branch lines and line 4 is a B mainline.[8] These lines were chosen because they ran close to principal through highways so that a choice between rail and truck could be made. Another criterion for choosing these lines was that they carry enough traffic so that a significant amount of data could be obtained.

Data for this study were colllected through a series of questionnaires sent out in conjunction with another study, "A Pilot Study to Investigate Efficient Grain Transportation and Marketing Systems for South Dakota".[9] A questionnaire requesting information on grain shipments for 1974 was sent to every grain elevator operator in the state. Figures requested were total quantity of grain shipped by rail and truck in bushels, destinations of shipments, and truck rates. Only questionnaires from elevators along the rail lines and highways used were considered.

Rail rates from each elevator to selected destinations were found

---

[8] A line is designated as a branchline if it handles at least one million but less than 5 million gross tons annually and is not designated as a defense-essential branchline. B mainlines are through or feeder routes which carry less than 20 million gross tons but at least

in the Minneapolis Grain Exchange Rate Book.[10] Truck rates were obtained from a rate function developed as follows: (1) truck rates to selected destinations were obtained from the questionnaires: (2) a linear regression equation was then estimated using distance as the independent variable and the rate as the dependent variable; (3) the function was then used to estimate rates from any elevator to the selected destination.

The method employed to estimate demand elasticities uses the excess of rail rates over truck rates as the independent variable and the rail percentage of total unloads at each destination as the dependent variable as Limmer did in his study. The excess of rail over truck rates was computed for every elevator which sent back a questionnaire on each of the lines to each destination. Then, the percentage of grin shipped from each of the above elevators by rail to each destination was obtained from the questionnaires. A linear regression was used to estimate a demand function from which the elasticity coefficients were found. Eight figures were estimated--the elasticity on each of the four lines to each of two destinations.

---

5 million gross tons annually. Preliminary Standards, Classification, and Designation of Lines of Class I Railroads in the United States, A Report by The Secretary of Transportation, U. S. Dept. of Transportation, August 3, 1976.

[9] "A Pilot Study to Investigate Efficient Grain Transportation and Marketing Systems for South Dakota". South Dakota State University, Report #DOT-OS-50229, June 1976.

[10] Grain Rate Book No. 11, Minneapolis Grain Exchange Traffic Department.

CHAPTER III

THE CHARACTERISTICS OF THE RAILROAD AND TRUCKING INDUSTRIES

Agricultural products in the United States generally are moved to market by one or more of three modes: rail, truck, or barge. In South Dakota competition for transporting agricultural produce, including grain, is limited to only two of these choices, rail and truck, because there is no navigable river system.

Although the service they provide to farmers is quite similar, the economic structures of the truck and rail industries are substantially dissimilar. The discussion in this chapter centers around the economic characteristics of the two industries, the regulations affecting them, and the way in which they set their rates.

THE RAILROAD INDUSTRY

The cost of transportation makes up a relatively large part of the value of a commodity if the commodity is: (1) bulky, (2) requires special services, (3) moves a considerable distance, or (4) has a low value relative to volume.[1] Grain exhibits all of these characteristics and, consequently, the cost of transporting grain is a high proportion of its market value. In order to compete in the market in delivered price terms, shippers have tried to hold their transportation costs

---

[1]Donald W. Berger and David C. Nelson, An Analysis of the Elasticity of Demand for Rail Transportation of Hard Red Spring Wheat, (Fargo, N.D.: North Dakota State University Agricultural Experiment Station, 1970), p. 1.

down. This is especially true for those producers who are distant from the market.

In the late 19th century and the first half of the 20th century, railroads were the primary means of transporting grain to market because they had the lowest rates and gave the best service. Today railroads are facing increasing competition from trucks in terms of both better service and lower rates. Part of this is because the railroad industry is a regulated industry facing heavy competition from the less regulated trucking industry in the area of rate setting. Changes in railroad rates must be approved by the Interstate Commerce Commission and the rate changing process can take a long time. Truck rates for the hauling of agricultural products are not regulated and can be adjusted to meet market changes in supply and demand more quickly than railroads.

Regulation of the railroad industry first began with the Interstate Commerce Act of 1887. This act established the Interstate Commerce Commission (ICC), the regulatory body that now oversees the railroads. Regulation of the railroad industry was deemed necessary to protect the public interest from monopolistic practices of the railroads. These practices resulted from the fact that the railroad industry is a natural monopoly. A natural monopoly occurs when "the minimum average cost of production occurs at a rate of output sufficient, almost sufficient, or more than sufficient to supply the entire market at a price covering full cost".[2] In the case of railroads, the development of natural monopolies arose from the fact that, between two points, it was profitable for only one railroad to operate because of the high initial capital outlays and fixed costs. Therefore, market forces generally dictated that only one line operate in the relevant market area. Also, greater efficiency was achieved from having one larger firm versus having a number of smaller ones. There are relatively few firms nationally in the railroad industry. Many of these are combinations of two or more railroads which were forced to merge in order to be profitable. Entry into the industry is not easy due to heavy initial capital outlays. Although private ownership of the railroads predominates, rates and services must be approved by the ICC.

RAILROAD RATE MAKING

The structure of grain transportation rates is very complex. Each commodity is charged a unique rate for different distances. Normally volume price differentials are included, such as discounts for using covered hopper cars. Seasonal variation may also change some rates.

The establishment of transportation rates and services and changes in rates and services are initiated either by the railroads or shippers.

---

[2]C. E. Ferguson and J. P. Gould, Microeconomic Theory, (Homewood, Illinois: Richard D. Irwin, Inc., 1975), p. 262.

A freight bureau recognized by the ICC reviews the rates and services or the proposed changes and makes a decision as to their implementation. Prior to 1976 all rate changes had to be approved by the ICC. With the passage of the Railroad Revitalization and Regulatory Reform Act of 1976, there is more leeway in the rate changes which are allowed. Within two years after the enactment of this law, a rate increase or decrease can be filed with the ICC if within the first and second years after January 1, 1976, the annual aggregates of increases or decreases do not exceed seven percent. These changes can be made without supervision by the ICC in an effort to expedite rate adjustments to make railroads more competitive with less-regulated modes of transportation.

THE TRUCKING INDUSTRY

The heavy inroads made by trucks into the business of hauling farm produce may be attributed to certain advantages which truck transportation has over transportation by rail. The major advantage of trucks is the ability to adapt to shipper's needs through flexibility in scheduling and choosing destinations. Trucks are able to provide direct movement of produce, can be made ready to move more quickly than rail cars, and can transport varying load sizes more easily than railroads. Service features, such as reliability, speed, and condition of trucks, also serve to make trucking more popular. Because truck service is faster, the shipper can rely on trucks to get his product to market when he want to and he won't have to worry about having his elevator tied up in inventory. Therefore there is less risk of a price change while the shipper has his inventory tied up waiting to get to market.

The agricultural trucking industry is only a part of the larger trucking industry. The Motor Carrier Act passed in 1935, was the first federal act to control motor carrier transportation. From this act two basic groups of carriers emerged--(1) the common and contract carriers, and (2) the agricultural carriers. Contract carriers are under contract to certain shippers and must have permits from the ICC. Common carriers offer to haul articles for the general public, usually on regular schedules, between certain points.[3] The common and contract carriers are regulated analogously to the regulation of railroads. These types of carriers must obtain ICC approval for route changes or extensions, rate changes to shippers, and some types of financial operations. Rate associations meet to set prices, which are then published by rate bureaus and sent to the ICC for approval.

When the Motor Carrier Act was passed in 1935, some groups were against regulation. They succeeded in having exemptions from regulation placed in the Act. The most prominent of these exemptions was the agricultural exemption. This permits agricultural carriers to haul those unprocessed farm products listed in Section 203 (b) of the Motor Carrier Act.

---

[3]Josephine E. Olson, "Price Discrimination by Regulated Motor Carriers", American Economic Review, June, 1972, p. 396.

With the exemption placed on agricultural carriers, this section of the trucking industry approaches a perfectly competitive industry. A comparison of the agricultural trucking industry with these four characteristics of perfect competition give the following analysis:[4]

(1) The products of the sellers are homogeneous.

(2) Each economic agent acts as if prices are given.

(3) Consumers, producers, and resource owners must possess perfect knowledge.

(4) All resources are perfectly mobile.

The first criterion listed above for perfect competition is that of product homogeneity. Farmer states that "...all freight transportation firms sell the same product, ton miles, and while this output can be differentiated somewhat in quality terms, such as in quality of service rendered, prompt payment of damage claims and similar factors, it is quite difficult to maintain product differentials over long periods of time".[5] The second characteristic of pure competition is that each unit acts as if prices are given. Prices in the agricultural trucking industry are set by the play of the market. Any competitor is free to enter the market and this will force an adjustment in the price. The output of a single firm in the industry represents less than

---

[4]C. E. Ferguson and J. P. Gould, Microeconomic Theory, (Homewood, Illinois: Richard D. Irwin, Inc., 1975), p. 225.

[5]R. N. Farmer, "The Case for Unregulated Truck Transportation", Journal of Farm Economics, May 1964, p. 400.

one percent of the output of most submarkets thereby insuring that no one firm's actions unduly influence the market.[6] The third criterion, that of perfect knowledge, is not completely met by the trucking industry. The market in which the industry works resembles a securities or commodity exchange with freight brokers giving general rate quotations and bringing together buyers and sellers. This arrangement facilitates transfer of knowledge of rate quotations somewhat. The last criterion--perfect mobility of resources--also applies to the agricultural trucking industry. There is easy entry into the industry because the amount of capital needed to enter is not high. Many times resources can be switched over from other uses. Also, trucks are highly mobile and therefore can be moved to meet the demand.

[6] Ibid.

CHAPTER IV

CALCULATING THE ELASTICITY OF DEMAND

A method adapted from that developed by Limmer was used in this study to calculate the elasticity of demand.[1] Information on data collection, the methodology of analysis, and the resulting estimated demand elasticities are presented in this chapter.

DATA COLLECTION

Data for this study were collected through the use of a questionnaire sent out in conjucntion with a broader project "A Pilot Study to Investigate Efficient Grain Transportation and Marketing Systems for South Dakota".[2] One questionnaire was sent to every grain elevator operating in South Dakota in 1974. Elevator names and locations were obtained from the 1974 and 1975 editions of South Dakota Grain Elevators.[3] Figures taken from the questionnaire for use in this study were total bushels of wheat shipped by rail and truck in 1974, destinations of shipments and amount shipped to each destination, and truck rate in cents per hundred pounds to each destination for each shipment. A sample questionnaire is included in Appendix A. Rail rates per

---

[1] Ezekial limmer, "The Elasticity of Demand for Railroad Transportation of Florida Produce", Journal of Farm Economics, XXXVII, (1955), pp. 452-460.

[2] "A Pilot Study to Investigate Efficient Grain Transportation and Marketing Systems for South Dakota", South Dakota State University, Report #DOT-OS-50229, June 1976.

[3] South Dakota Grain Elevators, 1975 Directory, Farmers Elevator Association of South Dakota, Aberdeen, South Dakota.

hundredweight from each elevator to selected destinations were found in the Minneapolis Grain Exchange Rate Book.[4] Data collected and used for this study are presented in Appendix B.

The scope of the study was limited to four rail lines: (1) Chicago & Northwestern from Rapid City leaving the state at Elkton; (2) Chicago, Milwaukee, St. Paul & Pacific from Rapid City leaving the state at Canton; (3) Chicago, Milwaukee, St. Paul & Pacific from Aberdeen (continued from North Dakota) leaving the state at Sioux City; (4) Chicago, Milwaukee, St. Paul & Pacific from White Butte (continued from North Dakota) leaving the state at Big Stone City.

Only questionnaires from elevators on or near these rail lines were used in estimating the elasticities. Of the 152 questionnaires sent out to elevators along these lines, 68 were returned and were usable.

LOCATION	TOTAL NUMBER OF QUESTIONNAIRES SENT	NUMBER RETURNED AND USABLE	PERCENTAGE RETURNED AND USABLE
Entire State	389	184	47.3
Line 1	38	20	52.6
Line 2	39	16	41.0
Line 3	39	20	51.3
Line 4	36	12	33.7
Total 1-4	152	68	44.7

TABLE 4.1: PERCENTAGE OF QUESTIONNAIRES RETURNED AND USABLE

[4] Minneapolis Grain Exchange Rate Book, Minneapolis Grain Exchange Traffic Department.

METHODOLOGY

The method used to estimate demand elasticities in this study was developed by Ezekial Limmer.[5] He used linear regression to formulate demand functions from which he calculated demand elasticities.

In adapting this method to the present study, the following three assumptions were made:

(1) Only rates determine quantity shipped by rail.
(2) Not only the rail rate, but the truck rate is important.
(3) The shipper has an effective choice between rail and truck.

First, it was assumed that only rates determine the quantity shipped by rail and that service is not a determining factor. With regard to the first assumption, service can be broken down into three categories: speed flexibility, and reliability. Speed refers to the time it takes the transporting mode to deliver the product to market. Speed can be an important variable in the shipment of perishables and livestock or goods whose price at market can change rapidly. Flexibility refers to the ability of the transporting mode to adjust to (1) geographic location of shippers and markets, and (2) market demand and supply. The transporting mode must have sufficient geographic mobility to be able to provide service to all potential shippers. It also must be flexible enough to handle traffic during peak periods

---

[5]Ezekial Limmer, "The Elasticity of Demand for Railroad Transportation for Florida Produce", Journal of Industrial Economics, XIV, (1966), p. 243-262.

of demand such as around harvest time. The ability of the transporting mode to provide reliable service is also important. Damage to the product or loss of the product may drive shippers away from one mode to another.

Although these variables can constitute costs to the shipper in terms of loss of income due to delay in getting the product to market or loss of the product en route to market, it is difficult to quantitatively analyze these costs. The rate for a shipment is predetermined and is a cost paid by every shipper directly to the carrier. The loss of income due to poor service cannot be determined beforehand because it is a possibility, not a sure thing. Also, even though the shipper incurs the cost, he doesn't pay anyone directly for it. The loss of income is felt in the market value of his products and the opportunity cost due to delayed income receipts.

The questionnaire sent out did not request data on the service provided to each shipper.[6] Time of grain shipments and time for which truck rates were quoted were not requested on the questionnaire. Because rates could be determined objectively and service could not it was believed that using rates as a determining factor of quantity shipped per mode rather than service would give better results. Also, because service is a difficult concept to quantify and include in mathematical modes, the previous assumption was made.

---

[6]The questionnaire did, however, provide a space for comments. Comments included sometimes mentioned railroad service.

The second assumption assumed that shippers make comparisons regarding the rates charged by different modes. Therefore, in an attempt to include that comparison in the analysis, the excess of rail rate over truck rate figure was used instead of the rail rate alone.

The third assumption noted above is merely an assertion that shippers in South Dakota do have an effetive choice between rail and truck modes. Trucking was a viable alternative to the railroads, especially over the routes selected.

ESTIMATING THE ELASTICITY OF DEMAND

In estimating the elasticity coefficients, a demand function was first formulated for each of the four rail lines by using a linear regression technique. The dependentvariable, percentage of wheat shipped by rail per elevator, was calculated from the information given on the questionnaires (see Appendix B). The excess of rail rate over truck rate was used as the independent variable and percentage of wheat shipped by rail was used as the dependent variable. This is not a regular demand function since Y is constrained between 0 and 1 and X is a price differential, not a price. The demand function can be expressed algebraically as:

$$\frac{Q_R}{Q} = a - b(R-T)$$

where: Q_R = quantity of wheat shipped by rail

Q = quantity of wheat shipped by both rail and truck

R = rail rate

T = truck rate

Because of differing distances a different rail rate is given for each town on a rail line to each destination.

Not all responding elevators supplied data on truck rates. Therefore, the corresponding truck rates were estimated using linear regression and the truck rate data which was provided on the returned questionnaires. Distance was the independent variable and truck rate was the dependent variable. One truck rate function was estimated for the entire state and applied to each of the truck shipments located on the four rail lines (see Appendix C). In this way, both a rail rate and a truck rate were found for every city on the four rail lines.

Problems were encountered in developing this truck rate function. The r^2 figure was only 0.67 indicating that distance did not explain a very large proportion of the variation in the rates. There are three reasons which could possibly account for this. First, since no time period was specified on the questionnaire, rates given were subject to seasonal variation. Those rates quoted at harvest time when demand is highest would be much higher than rates quoted from other times of the year. Second is the problem of estimating rates when there is a backhaul. A trucker may quote a lower rate to a shipper if he knows that he will also have a load to transport back. Third, there is the possibility of bad data from the questionnaires. In some cases shippers may not have been able to remember the price paid or they may have sold grain directly to the trucker and estimated a truck rate for the questionnaire. However, because only questions on truck rates and quantities were asked on the questionnaire, it was not possible to test for other relationships.

After the four demand functions were estimated, the corresponding elasticity coefficients were estimated. (See Appendix D for data used.) For each estimated demand function the elasticity of the percentage of wheat shipped by rail with respect to the rail-truck rate differential is the product of the estimated slope coefficient and the ratio of the rate differential to the percent shipped by rail. That is, for an estimated demand function:

$$Y = a+bX$$

where: Y = percentage of wheat shipped by rail;

X = rail-truck rate differential; and,

a,b = estimated intercept and slope coefficients;

the elasticity for an X is $\frac{bX}{Y}$.

Since the estimated demand functions are linear, the elasticity will vary along the demand functions. Each $\frac{X}{Y}$ ratio for a given demand function will generate a unique elasticity value. Table 4.2 shows the range of elasticity for the corresponding range of rail-truck rate differentials (X) and the average rate differential for each line.

Table 4.2 shows that the entire range of elasticities for all lines lies within +1.0 and -1.0. Thus, the percentage of wheat shipped by rail appears to respond inelastically to changes in the rate differential. This result suggests that the railroads, if left free to engage in rate competition at each location, could increase their total revenues by raising rates everywhere. Where the elasticity is negative,

TABLE 4.2: ESTIMATION OF ELASTICITY COEFFICIENTS

Line	Regression Equation	X_{max}	ε_d	X_{min}	ε_d	$\bar{X}$	ε_d	r^2	F	D.F.	Significance
1	Y=0.7764466- 3.173365(X)	.029	-.1345	.034	+.1220	.0005769	-.0024	0.050	1.2634	(1,24)	---
2	Y=0.789720 - 1.892750(X)	.050	-.1362	-.079	+.1592	-.0107142	+.0250	0.058	0.226228	(1,12)	---
3	Y=0.510407 + 6.201151(X)	.064	+.4374	-.024	-.4116	.0201538	+.1967	0.097	1.18277	(1.11)	---
4	Y=0.777743 + 1.867800(X)	.104	+.1998	-.104	-.2566	.0155789	+.0361	0.153	3.07547	(1,17)	.10

X = rail rate-truck rate differential
Y = percentage of wheat shipped by rail

$$\varepsilon_d = \frac{X}{Y}\frac{dY}{dX}$$

the higher rate differential more than offsets the traffic loss. Where the elasticity is positive, increasing the rate differential is associated with an increase in rail traffic share.

The r^2 coefficient of determination for each of the regression equations was very low indicating that the independent variable, the excess of the rail rate minust the truck rate, didn't explain much of the variance in the dependent variable, percentage of wheat shipped by rail. The correlation of the variables in three of the four equations was insignificant as shown by the F values in the table. This also indicates that the variation in Y was due to other factors and not explained by X.

The regression coefficients for lines 1 and 2 were negative as expected, indicating that an inverse relationship existed between the movement of the rate differential and percentage of wheat shipped by rail. The regression coefficients for lines 3 and 4 were positive. In studying the data it was observed that an inverse relationship between rates and quantity did not always occur. On line 3, the elevators with two the the highest rail over truck rate excesses shipped 100 percent of their grain by rail. On line 4, 13 of the 19 elevators shipped at least 85 percent of their wheat by rail. Of these 13, seven faced a rail minus truck rate differential greater than the average differential for the entire line.

A possible explanation for this is that the first assumption stated, that rates are the major determinants of percentage shipped by rail, is in error. The data suggest that factors other than price may have a greater influence on percentage shipped by rail. Poor service is one of the factors frequently cited by shippers as an explanation of the decline of the railroads' share of freight traffic.

In the three service categories previously mentioned--speed, flexibility, and reliability--trucks appear to have the edge over the rails. Improvements in highways and construction of the interstate highway system have enabled trucks to move at faster speeds while railroad speeds have been forced to decrease because of their greater flexibility. Trucks can pick up or deliver from widely scattered points and make several stops to complete a load or delivery whereas rail is limited to picking grain up only at elevators near the tracks.[7] Trucks also have more flexibility in adjusting to market demands because the fixed investment in trucks is not as high as that of railroads and the truck fleet can be expanded quickly by utilizing trucks which are being used on other tasks. Reliability is another service consideration. Shipments by truck may require less protection against damage than rail shipments because of the better condition of trucks and highways.[8]

All of these service features can help explain why shippers may choose to transport their grain by truck instead of rail even when the rail minus truck rate differential is lower. This may also explain

---

[7] U. S., Congress, Senate, Committee on Agriculture and Forestry, Prelude to Legislation to Solve the Growing Crisis in Rural Transportation, Hearing, 94th Congress, 1st Sess., February 10, 1975 (Washington: Government Printing Office, 1975), p. 54.

[8] Ibid., p. 7.

why the r^2 figures for the equations were so low. Rates alone didn't explain much of the variation in quantities shipped by rail. Other significant factors must have been involved.

FINDING ELASTICITY COEFFICIENTS ALONG THE RAIL LINE

In an effort to gain more information on the elasticity figures, another set of calculations were done with the data. By rearranging the elasticity equation, a formula for estimating elasticities at different points on the rail line was derived.

The demand equation used by Limmer and the foregoing estimates was the following:

$$\frac{Q_R}{Q} = a-b(R-T)$$

where: Q_R = quantity of wheat shipped by rail

Q = quantity of wheat shipped by rail and truck

R = rail rate

T = truck rate

This equation can be changed to read:

$$Q_R = aQ + bTQ - bRQ$$

The elasticity then becomes:

$$\frac{R}{Q_R} \frac{dQ_R}{dR} = -bQ \frac{R}{Q_R}$$

$$\varepsilon = \frac{-bRQ}{Q_R}$$

For the following set of calculations, the elasticity at each elevator along the rail line which responded to the questionnaire was found. The constant be was taken from the previously calculated regression equation. R, Q_R, and Q were the same as those used in the previous calculations (data are shown in Appendix B). The following tables show elevator number, distance to the market, and the estimated elasticity coefficients. The elasticity figures are divided into different columns for different destinations.

As can be seen in the above tables, elasticity figures vary substantially among elevators. For line 1 (figures from Table 4.3), figures from the western part of the state seem to show the highest elasticity. This may be due to the fact that line 1 originates in Rapid City and line 2 does also so there is other rail competition. I-90 also goes through Rapid City paralleling lines 1 and 2 to add truck competition. These lines run fairly close across the state to Midland where line 1 heads north. The elasticities on line 1 appear lower after Midland possibly due to the separation of lines 1 and 2 or also the separation of line 2 from I-90. In the center of the state, line 1 is less elastic except where alternative rail transportation is available. Elevator 4/35 is on line 1 and also on line 3 going north-south and the elasticity coefficient for this elevator is higher than others near it. The same is true for elevator 5/46 which is on the Bryant-Madison line (see map in Appendix F). In the eastern part of the state, the elasticity figures rise again possibly due to the fact that at this shorter distance to market,

TABLE 4.3: ESTIMATION OF ELASTICITY COEFFICIENTS ALONG LINE 1

Questionnaire Number	Destination	Distance to Destination	Elasticity Destination: Minn-St.Paul	Elasticity Destination: Sioux City
1/49	MSP	587	2.510	
1/41	MSP	565	2.523	
1/47	MSP	527	2.760	
	SC	447		2.318
1/35	MSP	476	2.225	
	SC	396		2.329
4/22	MSP	415	1.964	
	SC	335		1.759
4/4	MSP	394	1.666	
	SC	313		--*
4/7	MSP	382	2.213	
4/8	MSP	367	1.999	
	SC	287		1.460
4/9	MSP	367	1.666	
4/18	MSP	344	1.750	
4/19	MSP	344	1.797	
4/27	MSP	341	1.614	
	SC	261		1.349
4/35	MSP	314	2.112	
5/25	MSP	266	1.674	
5/46	MSP	257	4.390	
5/4	MSP	244	1.269	
5/76	MSP	232	4.025	
5/11	MSP	224	1.776	
5/12	MSP	224	2.013	
5/6	MSP	222	2.302	

*figure not possible; $Q_R = 0$

MSP = Minneapolis-St. Paul
SC = Sioux City
DS = Duluth-Superior

truck becomes more competitive. On two or three occasions, elasticity figures appear abnormally high where there is no other rail line. A possibility exists to explain this. In or near the elevator exhibiting the high coefficient there may be a particularly good trucking firm which serves as competition to the railroads. Wherever a good alternative to the railroads appears, the line should be more elastic.

On line 2 (figures in Table 4.4) the elasticity figures appear uniformly lower than on line 1 even though it parallels I-90 most of the way. However, if the final destinations of lines 1 and 2 are examined a possible explanation for this can be found.

If line 1 is followed across Minnesota after it leaves South Dakota, it can be seen that it goes directly to Minneapolis. Therefore grain shipments from Rapid City and elevators across the state can be transported directly to Minneapolis without having to change lines. However, if one follows Line 2 after it leaves South Dakota, it can be seen that the final destination is Chicago. If a grain shipment is to go to Minneapolis, it will have to switch lines and travel north from line 2 which delays the time in which the shipment reaches its final destination.

Line 3 is a north-south line which exhibits much higher elasticity figures on shipments whose destination is Minneapolis rather than Sioux City (figures in Table 4.5). Possibly this is due to the fact that in order to get to Minneapolis, the grain shipments must be transferred to an east-west line causing a delay in getting to market. Some of the

TABLE 4.4: ESTIMATION OF ELASTICITY COEFFICIENTS ALONG LINE 2

Questionnaire Number	Destination	Distance to Destination	Elasticity Destination: Minn-St.Paul	Elasticity Destination: Sioux City
1/49	MSP	626	1.495	
1/03	MSP	519	1.211	
1/4	MSP	484	1.098	
1/29	MSP	448	2.092	
	SC	262		0.785
1/50	MSP	443	1.283	
	SC	255		0.738
4/33	SC	202		1.184
5/58	MSP	365	1.111	
	SC	179		--*
5/55	MSP	354	0.994	
5/2	SC	165		0.558
5/29	MSP	333	1.551	
6/49	SC	108		2.097

*figure not possible; $Q_R = 0$

MSP = Minneapolis-St. Paul
SC = Sioux City
DS = Duluth-Superior

TABLE 4.5: ESTIMATION OF ELASTICITY COEFFICIENTS ALONG LINE 3

Questionnaire Number	Destination	Distance to Destination	Elasticity Destination: Minn-St.Paul	Elasticity Destination: Sioux City
2/34	MSP	319	3.897	
2/11	MSP	312	11.454	
2/79	MSP	300	5.298	
2/8	MSP	332	--*	
4/35	MSP	308	4.127	
5/81	MSP	318	--*	
5/48	SC	161		2.046
5/55	MSP	341	3.256	
6/20	SC	136		1.643
6/50	SC	131		1.643
6/59	SC	121		1.550
6/62	SC	71		--*
6/22	SC	27		1.209

*figure not possible; $Q_R = 0$

MSP = Minneapolis-St. Paul
SC = Sioux City
DS = Duluth-Superior

higher elasticity coefficients can be explained much as those on line 1 were. Elevator 2/11 is near line 4 and also close to U. S. 12. Elevator 2/79 is close to elevator 2/11 and faces these same alternatives. Elevator 4/35 is also on line 1 and elevator 5/55 is also on line 2. The only elasticity figure which seems high on line 3 for shipments going to Sioux City is from elevator 5/48 which is near elevator 5/55 and faces competition from line 2. Elevator 6/22 shows a rather low elasticity figure but this could be due to the fact that there is little alternative to Sioux City.

Line 4 displays fairly uniform elasticities to all destinations except from an elevator where U. S. 12 may provide competition for those shipments going to Minneapolis (figures in table 4.6). Line 4 has the second lowest elasticity figure of the four rail lines studied. This is possibly due to the fact that there is no other competing railroad or highway traveling to Minneapolis, Sioux City, and Duluth close to line 4.

ESTIMATING THE ELASTICITY OF SUBSTITUTION

Utilizing the same data used previously to estimate the elasticity of demand, an elasticity of substitution for each rail line was calculated. In order to estimate this elasticity, a linear regression technique such as that used previously was employed. In place of the demand functions formulated to find elasticity of demand, rail rate minus truck rate was replaced by a rail rate to truck rate ratio and percentage of wheat shipped by rail was replaced by the ratio of

TABLE 4.6: ESTIMATION OF ELASTICITY COEFFICIENTS ALONG LINE 4

Questionnaire Number	Destination	Distance to Destination	Elasticity Destination: Minn-St. Paul	Elasticity Destination: Sioux City	Elasticity Destination: Duluth-Superior
1/30	MSP	489	1.665		
1/55	MSP	480	1.366		
	DS	544			1.928
2/35	MSP	382	1.526		
2/49	MSP	365	1.060		
	SC	382		0.999	
2/48	MSP	316	1.023		
	SC	333		0.925	
	DS	403			1.251
2/40	MSP	271	1.254		
	SC	328		0.794	
	DS	358			1.055
3/2	MSP	360	1.395		
	DS	347			--*
3/10	MSP	350	1.677		
	DS	337			0.925
3/56	MSP	194	1.453		
3/41	MSP	171	0.681		
	DS	258			0.925

*figure not possible; $Q_r = 0$

MSP = Minneapolis-St. Paul
SC = Sioux City
DS = Duluth-Superior

quantity of wheat shipped by rail to quantity of wheat shipped by truck to yield the following equation:

$$\frac{Q_R}{Q_T} = a-b(\frac{R}{T})$$

where: Q_R = quantity shipped by rail

Q_T = quantity shipped by truck

R = rail rate

T = truck rate

These two ratios were found for every reporting elevator on each of the four rail lines and a regression equation was found for each line (data is presented in Appendix E.). Table 4.7 gives the results of these estimates.

Table 4.7 shows that the elasticity of substitution using the average X ranges from .142 to 10.673. On line 1, this elasticity is quite high with a figure of 10.673. This would indicate that when the rail rate to truck ratio increases the quantity shipped by rail to quantity shipped by truck ratio is decreasing. On line 4 this also occurs. Lines 2 exhibits an elasticity figure close to unity suggesting that when the rail rate to truck rate ratio increases the quantity shipped by rail to quantity shipped by truck ratio stays the same.

Some of the same problems discussed in connection with finding the elasticity of demand apply to finding the elasticity of substitution. The r^2 figures are all very small and none of the F figures for the

TABLE 4.7: ESTIMATION OF ELASTICITY OF SUBSTITUTION

Line	Regression Equation	X_{max}	σ	X_{min}	σ	$\overline{X}$	σ	r^2	F	D.F.	Significance
1	Y= -112.321 - 124.038(X)	1.050	7.268	.946	25.950	.99915	10.673	0.0189	0.346384	(1,18)	---
2	Y= 0.531964 - 3.33972(X)	1.103	.874	.914	1.028	1.0354285	.867	0.0032	0.0158084	(1,5)	---
3	Y= 1.26989 - 0.190940(X)	1.527	.187	.95	.125	1.1005	.142	0.0074	0.0372617	(1,5)	---
4	Y= -22.5222 - 33.1779(X)	1.180	2.354	.794	6.894	1.0220833	2.978	0.0455	0.476717	(1,10)	---

$$X = \frac{R}{T}$$

$$Y = \frac{Q_R}{Q_T}$$

$$= \frac{X}{Y} \; \frac{dY}{dX} = \frac{bX}{Y}$$

correlation in the regression equations show significance. As with the first set of regression equations, factors other than price may have the most influence on quantity of wheat shipped by rail.

CHAPTER V

SUMMARY

In summarizing the present project, the general and specific objective of this paper will be reviewed. The results and conclusions of the research will be reviewed and recommendations for further research will be given.

REVIEW OF OBJECTIVES

Referring to Chapter I, the overall objective of this study was to estimate the elasticity of demand for rail transportation of wheat produced in South Dakota in 1974. In order to accomplish this objective, demand functions were estimated for each of the four rail lines and the corresponding elasticity figures were estimated using these demand functions.

The methodology to estimate figures was adopted from that used by Ezekial Limmer in a similar study of demand elasticities.[1] The elasticity figures which were found indicated that the share of total wheat shipments moving by rail responds inelastically to changes in the rail-truck rate differential. This indicates that the railroads can raise their rates without losing traffic thus increasing total revenues. The implication of this for the Railroad Revitalization and Regulatory Reform Act of 1976 is that if the railroads can lower and raise their rates without such strict regulation, they can raise their rates on South Dakota wheat shipments and raise their total revenues

---

[1]Ezekial Limmer, "The Elasticity of Demand for Railroad Transportation of Florida Produce". Journal of Farm Economics, XXXVII, (1955), pp. 452-460.

(see discussion in Chapter II). This does not mean that the line would become profitable. Raising rates might only reduce annual losses and provide revenues sufficient to cover out-of-pocket costs but not total costs. This could prevent abandonment of the line and increase long-run losses over the alternative of early abandonment. Thus it would be rational for the railroad to avoid rate increases on such lines even if demand for rail service is inelastic.

The conclusion that demand for rail service is inelastic is questionable because of problems encountered in developing significant regression equations. Due to the small size of the sample and the nature of the individual lines, the r^2 figures were very low showing a poor correlation. The same was true in the regression equations for the elasticity of substitution figures. In Chapter IV, it was suggested that factors other than price might have more influence on quantity shipped by rail than price did.

This was also suggested by Perle,[2] Berger and Nelson,[3] and Benishay and Whitaker[4] in their studies estimating demand elasticities. These three authors, as well as Miklius and Limmer, all found that the elasticity of demand for rail transportation was above unity. The range of elasticity coefficients for Limmer's study was from 1.9 to 3.6. The

---

[2]Perle, The Demand for Transportation, The University of Chicago, 1964.

[3]Donald W. Berger and David C. Nelson, An Analysis of the Elasticity of Demand for Rail Transportation of Hard Red Spring Wheat, (Fargo, North Dakota: North Dakota State, 1970).

[4]Haskel Benishay and Gilbert R. Whitaker, Jr., "Demand and Supply in Freight Transportation", Journal of Industrial Economics, XIV, (1966), pp. 243-262.

highest elasticity figures were those found by Berger and Nelson in their study of North Dakota wheat. Their estimates were from 5.5 to 6.0.

The recommendation is thus made that while the objectives of this study were met, more research should be done on the other factors which affect quantity of wheat shipped by rail. Service qualities of rail and truck are especially important and a method of quantifying this needs to be found in order to improve elasticity estimates.

BIBLIOGRAPHY

BIBLIOGRAPHY

Benishay, Haskel, and Gilbert R. Whitaker, Jr. "Demand and Supply in Freight Transportation", Journal of Industrial Economics, XIV.(1966), pp. 243-262.

Berger, Donald W., and David C. Nelson. An Analysis of the Elasticity of Demand for Rail Transportation of Hard Red Spring Wheat. Fargo, North Dakota: North Dakota State University. 1970.

The Council of State Governments. The States and Rural Rail Preservation. Lexington, Kentucky: The Council of State Governments. 1975.

Economics and Finance Department, Association of American Railroads. Yearbook of Railroad Facts. 1975.

Farmer, R. N. "The Case for Unregulated Ruck Transportation", Journal of Farm Economics, May, 1964, pp. 398-410.

Ferguson, C. E., and J. P. Gould. Microeconomic Theory. Homewood, Illinois: Richard D. Irwin, Inc., 1975.

Grain Rate Book No. 11. Minneapolis Grain Exchange Traffic Department. 1974.

Johnson, Marc. A., Community Evaluation of Railroad Branch Lines: Principles and Procedures. East Lansing, Michigan: Michigan State University, 1975.

Limmer, Ezekial. "The Elasticity of Demand for Railroad Transportation of Florida Produce", Journal of Farm Produce, XXXVII(1955). pp.452-460.

Miklius, Walter. "Estimating the Demand for Truck and Rail Transportation: A Case Study of California Lettuce", Agricultural Economics Research, XIX(1967), pp. 46-50.

Olson, Josephine E. "Price Discrimination by Regulated Motor Carriers", American Economic Review, June, 1972, pp. 396-404.

Perle, G. S., The Demand for Transportation. The University of Chicago. 1964.

A Pilot Study to Investigate Efficient Grain Transportation and Marketing Systems for South Dakota. Report #DOT-OS-50229. Brookings, South Dakota: South Dakota State University. June, 1976.

U. S. Congress. Senate Committee on Agriculture and Forestry. Prelude to Legisltation to Solve the Growing Crisis in Rural Transportation. Hearing, 94th Cong., 1st Sess., February 10, 1975. Washington: Government Printing Office, 1975.

U. S. Congressional Record. Vo. XLV.

APPENDIX A

SAMPLE OF QUESTIONNAIRE

CONFIDENTIAL

Grain and Farm Supply Transportation Questionnaire
South Dakota State University
Economics Department
Questionnaire No. ____ ____

Please base your answers to the following questions on the calendar year 1974 (January 1, 1974 to December 31, 1974).

A. How many bushels of each of the following grains did you receive during 1974?

Wheat ______________ bu.
Corn ______________ bu.
Oats ______________ bu.
Barley ______________ bu.
Soybeans ______________ bu.
Sorghum ______________ bu.
Flax ______________ bu.

B. How many bushels were shipped from your facility during 1974?

Shipped

Wheat ______________ bu.
Corn ______________ bu.
Oats ______________ bu.
Barley ______________ bu.
Soybeans ______________ bu.
Sorghum ______________ bu.
Flax ______________ bu.

C. How was the grain SHIPPED?

1. SHIPPED BY RAIL
1/1/74 to 12/21/74

a. Total amount shipped from your elevator by rail during 1974? Please indicate bushels shipped by ordinary boxcar and by covered hopper cars.

	Ordinary Boxcar (bu.)	Covered Hopper Car (bu.)
Wheat	______	______
Corn	______	______
Oats	______	______
Barley	______	______
Soybeans	______	______
Sorghum	______	______
Flax	______	______

---

b. What was the number of rail cars loaded by quarter during 1974?

January thru March ______ cars
April thru June ______ cars
July thru September ______ cars
October thru December ______ cars

---

c. Please estimate destination and amount (bushels) of Wheat, Corn, Oats, Barley, Soybeans, Sorghum and Flax shipped by rail to OUT OF STATE DESTINATIONS during 1974.

Billing destination (city)	Wheat (bu.)	Corn (bu.)	Oats (bu.)	Barley (bu.)	Soybeans (bu.)	Sorghum (bu.)	Flax (bu.)

---

d. Please estimate destination and amount (bushels) of Wheat, Corn, Oats, Barley, Soybeans, Sorgum and Flax shipped by rail to SOUTH DAKOTA DESTINATIONS during 1974.

Billing destination (city)	Wheat (bu.)	Corn (bu.)	Oats (bu.)	Barley (bu.)	Soybeans (bu.)	Sorghum (bu.)	Flax (bu.)

2. SHIPPED BY TRUCK
1/1/74 to 12/31/74

a. Total amount shipped from your elevator by truck during 1974.

Wheat	______ bu.	Soybeans	______ bu.
Corn	______ bu.	Sorghum	______ bu.
Oats	______ bu.	Flax	______ bu.
Barley	______ bu.		

b. Please indicate bushels retailed back to farmers or feeders or used in feed sold by your firm during 1974.

Wheat	______ bu.	Soybeans	______ bu.
Corn	______ bu.	Sorghum	______ bu.
Oats	______ bu.	Flax	______ bu.
Barley	______ bu.		

c. Please estimate destination, amoutn (bushels) and most frequent transportation rate for Wheat, Corn, Oats and Barley shipped by truck OUT OF STATE during 1974.

Billing destination (city)	Wheat (bu.)	Trans. (¢/cwt)	Corn (bu.)	Trans. (¢/cwt)	Oats (bu.)	Trans. (¢/cwt)	Barley (bu.)	Trans. (¢/cwt)

d. Please estimate destination, amount (bushels) and most frequent transportation rate for Soybeans, Sorghum and Flax shipped by truck OUT OF STATE during 1974.

Billing destination	Soybeans (bu.)	Trans. (¢/cwt)	Sorghum (bu.)	Trans. (¢/cwt)	Flax (bu.)	Trans. (¢/cwt)

e. Please estimate destination, amount (bushels) and most frequent transportation rate for Wheat, Corn, Oats and Barley shipped by truck to processors and other non-farm destinations WITHIN SOUTH DAKOTA during 1974.

Billing destination (city)	Wheat (bu.)	Trans. (¢/cwt)	Corn (bu.)	Trans. (¢/cwt)	Oats (bu.)	Trans. (¢/cwt)	Barley (bu.)	Trans. (¢/cwt)

f. Please estimate destination, amount (bushels) and most frequent transportation rate for Soybeans, Sorghum, and Flax shipped by truck to processors and other non-farm destinations WITHIN SOUTH DAKOTA during 1974.

Billing destination (city)	Soybeans (bu.)	Trans. (¢/cwt)	Sorghum (bu.)	Trans. (¢/cwt)	Flax (bu.)	Trans. (¢/cwt)

D. Does your firm sell fertilizer? ________________

1. If yes, please estimate the number of railcars and truck loads of fertilizer received by quarter during 1974.

	Truck Dry	Truck Anhydrous	Truck Liquid	Boxcar	Hopper Car	Tank Car
Jan. thru March						
Apr. thru June						
July thru Sept.						
Oct. thru Dec.						

E. Was 1974 a "normal" year for your business, or was it higher or lower than "normal"? Check One:

Normal______ Higher______ Lower______ Please explain if you check "higher" or "lower". ______________________________

____

F. What is your average yearly payroll?______________________($ amt.)

G. Please estimate the following:

Annual Property tax___________________($ amt.)

Yearly amount of goods purchased locally (to operate business)

_________________($ amt.) (Such as: office supplies, cleaning and maintenance supplies, etc.)

Yearly amount of services purchased locally (to operate business)

_________________($ amt.) (Such as: telephone, electric, gas, water, legal fees, etc.)

H. How many people do you currently employ?_________________________

How many would you employ if you lose your rail service?___________

How many would you employ if rail service were up-graded to a highly acceptable service (dependable, regular, frequent, etc.)?

____

I. If there is a change in your rail service, such as stopping it altogether or improving it until it was entirely satisfactory to you, what would be the effect on your business? (Such as: "Stopped"--I would close down or move to another location at a cost of $xxx, or I would have to discontinue "such and such". If improved, I would expect to do "such and such".)_______________

____

____

____

____

J. Miscellaneous

1. If your elevator is located on a rail line, how many cars could be loaded within a 10 hour period?____________________

2. What is the maximum number of rail cars that you can place on on your loading spur at one time?__________________________

3. Are you located on a rail line that has a weight and/or speed limitation? Yes______ No_______

4. If you have a weight restriction do you receive covered hopper cars? Yes________ No________

   How full are you permitted to fill these covered hopper cars?________________%

5. Has your elevator ever used or been offered multiple car or unit train rates? Yes______ No_______

K. ADDITIONAL COMMENTS (Please feel free to make any additional comments concerning your past, present and future use of rail service. Your views will help form a better transportation system.____

APPENDIX B

DATA COLLECTED FROM QUESTIONNAIRES

DATA FOR LINE 1

CHICAGO & NORTHWESTERN FROM RAPID CITY LEAVING THE STATE AT ELKTON

Questionnaire Number	Destination of Shipment	Distance to Destination	Total Quantity of Wheat Shipped	Quantity By Rail	Rail Rate	Quantity By Truck	Truck Rate
			(bu.)	(bu.)	*	(bu.)	+
1/49	Minn.-St.Paul	587	15,538	15,538	0.790	-0-	--
1/41	Minn.-St.Paul	565	153,523	142,899	0.740	10,624	0.700
1/47	Minn.-St.Paul	527	89,300	69,300	0.675	20,000	0.700
	Sioux City	447	104,000	84,000	0.590	20,000	0.720
1/35	Minn.-St.Paul	476	271,539	242,010	0.625	29,529	0.700
	Sioux City	396	153,260	111,720	0.535	41,540	0.600
4/22	Minn.-St.Paul	415	115,000	105,000	0.565	10,000	0.640
	Sioux City	335	70,000	70,000	0.485	10,000	0.550
4/4	Minn.-St.Paul	394	131,500	63,500	0.525	-0-	--
	Sioux City	313	43,603	-0-	0.485	68,000	0.720
4/7	Minn.-St.Paul	382	232,757	132,757	0.525	43,603	--
4/8	Minn.-St.Paul	367	500,000	500,000	0.525	100,000	0.500
	Sioux City	287	100,000	100,000	0.460	-0-	--
4/9	Minn.-St.Paul	367	116,564	100,000	0.525	-0-	--
4/18	Minn.-St.Paul	344	189,189	180,448	0.505	16,564	--
4/19	Minn.-St.Paul	344	80,955	72,214	0.505	8,741	--
4/27	Minn.-St.Paul	341	225,600	224,000	0.505	1,600	0.600
	Sioux City	261	50,000	50,000	0.425	-0-	--
4/35	Minn.-St.Paul	314	20,814	14,386	0.460	6,428	--
5/26	Minn.-St.Paul	266	73,055	58,857	0.425	14,198	--
5/46	Minn.-St.Paul	257	50,000	15,000	0.415	35,000	0.420
5/4	Minn.-St.Paul	244	16,510	16,510	0.400	-0-	--
5/76	Minn.-St.Paul	232	33,450	10,022	0.380	23,428	0.400
5/11	Minn.-St.Paul	224	56,834	37,069	0.365	19,765	0.230
5/12	Minn.-St.Paul	224	22,599	13,000	0.365	9,599	--
5/6	Minn.-St.Paul	222	11,135	5,603	0.365	5,532	--

*Source: Grain Rate Rook No. 11; Mpls. Grain Exchange Traffic Dept., 1974.
+Reported on questionnaire; "--" means no truck rate was given.

DATA FOR LINE 2

CHICAGO, MILWAUKEE, ST. PAUL & PACIFIC FROM RAPID CITY LEAVING THE STATE AT CANTON

Questionnaire Number	Destination of Shipment	Distance to Destination	Total Quantity of Wheat Shipped	Quantity By Rail	Rail Rate	Quantity By Truck	Truck Rate
		(miles)	(bu.)	(bu.)	*	(bu.)	+
1/49	Minn.-St.Paul	626	15,538	15,538	0.790	-0-	--
1/03	Minn.-St.Paul	519	254,000	254,000	0.640	-0-	--
1/11	Minn.-St.Paul	484	527,806	527,806	0.580	-0-	--
1/29	Minn.-St.Paul	448	1,125,000	575,000	0.565	550,000	0.600
	Sioux City	262	200,000	200,000	0.415		
1/50	Minn.-St.Paul	443	91,384	76,198	0.565	15,186	0.530
	Sioux City	255	10,760	10,760	0.390	-0-	--
4/33	Sioux City	202	10,100	5,650	0.350	4,450	0.300
5/58	Minn.-St.Paul	365	8,736	7,810	0.525	925	0.300
	Sioux City	179	925	-0-	0.325	925	0.220
5/55	Minn.-St.Paul	354	20,000	20,000	0.525	-0-	--
5/2	Sioux City	165	2,500	2,500	0.295	-0-	--
5/29	Minn.-St.Paul	333	2,500	1,632	0.535	868	0.500
6/49	Sioux City	108	4,017	3,626	0.235	391	0.200

*Source: Grain Rate Book No. 11; Mpls. Grain Exchange Traffic Dept., 1974.
+Reported on questionnaire; "--" means no truck rate was given.

DATA FOR LINE 3

CHICAGO, MILWAUKEE, ST. PAUL & PACIFIC FROM ABERDEEN LEAVING THE STATE AT SIOUX CITY

Questionnaire Number	Destination of Shipment	Distance to Destination	Total Quantity of Wheat Shipped	Quantity By Rail	Rail Rate	Quantity By Truck	Truck Rate
		(miles)	(bu.)	(bu.)	*	(bu.)	+
2/34	Minn.-St.Paul	319	140,223	108,205	0.485	32,018	0.450
2/11	Minn.-St.Paul	312	93,428	24,531	0.485	68,897	0.420
2/79	Minn.-St.Paul	300	390,000	210,000	0.460	180,000	0.450
2/8	Minn.-St.Paul	332	69,761	-0-	0.460	69,761	--
4/35	Minn.-St.Paul	308	20,814	14,386	0.460	6,428	--
5/81	Minn.-St.Paul	318	11,242	-0-	0.505	11,242	0.500
5/48	Sioux City	161	5,463	5,463	0.330	-0-	--
5/55	Minn.-St.Paul	341	20,000	20,000	0.525	-0-	--
6/20	Sioux City	136	9,533	9,533	0.265	-0-	--
6/50	Sioux City	131	1,500	1,500	0.265	-0-	--
6/59	Sioux City	121	81,009	81,009	0.250	-0-	--
6/62	Sioux City	71	2,621	-0-	0.200	2,621	--
6/22	Sioux City	27	45,000	45,000	0.195	-0-	--

*Source: Grain Rate Book No. 11; Mpls. Grain Exchange Traffic Dept., 1974.
+Reported on questionnaire; "--" means no truck rate was given.

DATA FOR LINE 4

CHICAGO, MILWAUKEE, ST. PAUL & PACIFIC FROM WHITE BUTTE LEAVING THE STATE AT BIG STONE CITY

Questionnaire Number	Destination of Shipment	Distance to Destination	Total Quantity of Wheat Shipped	Quantity By Rail	Rail Rate	Quantity By Truck	Truck Rate
		(miles)	(bu.)	(bu.)	*	(bu.)	+
1/30	Minn.-St.Paul	489	979,117	829,117	0.755	150,000	0.600
1/55	Minn.-St.Paul	480	508,000	500,000	0.720	8,000	0.750
	Duluth-Superior	544	258,000	250,000	0.720	8,000	0.780
2/35	Minn.-St.Paul	382	180,000	130,000	0.590	50,000	0.500
2/49	Minn.-St.Paul	365	156,000	147,000	0.535	9.000	0.600
	Sioux City	382	117,600	117.600	0.535	-0-	--
2/48	Minn.-St.Paul	316	166,000	150,000	0.495	16,000	0.400
	Sioux City	333	50,000	50,000	0.495	-0-	--
	Duluth-Superior	403	100,000	100,000	0.670	-0-	--
2/40	Minn.-St.Paul	271	292,250	185,000	0.425	107,250	0.450
	Sioux City	328	50,000	50,000	0.425	-0-	--
	Duluth-Superior	358	50,000	50,000	0.565	-0-	--
3/2	Minn.-St.Paul	360	90,000	50,000	0.415	40,000	0.380
	Duluth-Superior	347	10,000	-0-	0.495	10,000	0.420
3/10	Minn.-St.Paul	350	141,537	63,061	0.400	78,476	0.400
	Duluth-Superior	337	17,200	17,200	0.495	-0-	--
3/56	Minn.-St.Paul	194	100,000	45,000	0.350	55,000	0.400
3/41	Minn.-St.Paul	171	83,400	73,200	0.320	10,200	0.410
	Duluth-Superior	258	2,100	2,100	0.495	-0-	--

*Source: Grain Rate Book No. 11; Mpls. Grain Exchange Traffic Dept., 1974.
+Reported on questionnaire; "--" means no truck rate was given.

APPENDIX C

DATA FOR TRUCK RATE FUNCTION

DATA FOR TRUCK RATE FUNCTION

(X) Distance to Destination	(Y) Truck Rate from Questionnaires
565	0.70
544	0.78
527	0.70
489	0.60
480	0.75
476	0.70
448	0.60
447	0.72
443	0.53
415	0.64
396	0.60
382	0.50
367	0.50
365	0.60
365	0.30
360	0.38
350	0.40
347	0.42
341	0.60
335	0.55
333	0.50
319	0.45
318	0.50
316	0.40
313	0.72
312	0.42
300	0.45
271	0.45
257	0.42
232	0.40
224	0.23
202	0.30
194	0.40
179	0.22
171	0.41
108	0.20

$Y = 0.099420 + 0.001157X$
$r^2 = 0.67345$
$F = 70.1189$ Significant at 0.001 level
D.F. - (1.34)

APPENDIX D

DATA FOR CALCULATION OF ELASTICITY COEFFICIENT ESTIMATES

LINE 1

(1) Questionnaire Number	(2) Percent of Total Shipments by Rail	(3) Rail Rate	(4) Regression Truck Rate	(5) Excess Rail - Truck (3) - (4)	(6) Rail Rate (increased by 1%)	(7) Excess Rail - Truck (6) - (4)
1/49	100	0.790	0.779	0.011	0.79790	0.01890
1/41	93	0.740	0.753	-0.013	0.74740	-0.00560
1/47	78	0.675	0.709	-0.034	0.68175	-0.02725
	81	0.590	0.617	-0.027	0.59590	-0.02110
1/35	89	0.625	0.650	-0.025	0.63125	-0.01875
	73	0.535	0.558	-0.023	0.54035	-0.01765
4/22	91	0.565	0.580	-0.015	0.57065	-0.00935
	88	0.485	0.487	-0.002	0.48985	0.00285
4/4	100	0.525	0.555	-0.030	0.53025	-0.02475
	0	0.485	0.462	0.023	0.48985	0.02785
4/7	75	0.525	0.541	-0.016	0.53025	-0.01075
4/8	83	0.525	0.524	0.001	0.53025	0.00625
	100	0.460	0.431	0.029	0.46460	0.03360
4/9	100	0.525	0.524	0.001	0.53025	0.00625
4/18	92	0.505	0.497	0.008	0.51005	0.01305
4/19	89	0.505	0.497	0.008	0.51005	0.01305
4/27	99	0.505	0.494	0.011	0.51005	0.01605
	100	0.425	0.401	0.024	0.42925	0.02825
4/35	69	0.460	0.463	-0.003	0.46460	0.00160
5/26	81	0.425	0.407	0.018	0.42925	0.02225
5/46	30	0.415	0.397	0.018	0.41915	0.02215
5/4	100	0.400	0.382	0.018	0.40400	0.02200
5/76	30	0.380	0.368	0.012	0.38380	0.01580
5/11	65	0.365	0.359	0.006	0.36865	0.00965
5/12	58	0.365	0.359	0.006	0.36865	0.00965
5/6	50	0.365	0.356	0.009	0.36865	0.01265
				↓ average = 0.0005769		↓ average = 0.0056403

LINE 2

(1) Questionnaire Number	(2) Percent of Total Shipments by Rail	(3) Rail Rate	(4) Regression Truck Rate	(5) Excess Rail - Truck (3) - (4)	(6) Rail Rate (increased by 1%)	(7) Excess Rail - Truck (6) - (4)
1/49	100	0.790	0.824	-0.034	0.79790	-0.02610
1/03	100	0.640	0.700	-0.060	0.64640	-0.05360
1/11	100	0.580	0.659	-0.079	0.58580	-0.07320
1/29	51	0.565	0.618	-0.053	0.57065	-0.04735
	100	0.415	0.403	0.012	0.41915	0.01615
1/50	83	0.565	0.612	-0.047	0.57065	-0.04135
	100	0.390	0.394	-0.004	0.39390	-0.00010
4/33	56	0.350	0.333	0.017	0.35350	0.0205
5/58	89	0.525	0.522	0.003	0.53025	0.00825
	0	0.320	0.307	0.013	0.32320	0.01620
5/55	100	0.525	0.509	0.016	0.53025	0.02125
5/2	100	0.295	0.290	0.005	0.29795	0.00795
5/29	65	0.535	0.485	0.050	0.54035	0.05535
6/49	90	0.235	0.224	0.011	0.23735	0.01335
				↓ average = -0.0107142		↓ average = -0.0059071

LINE 3

(1) Questionnaire Number	(2) Percent of Total Shipments by Rail	(3) Rail Rate	(4) Regression Truck Rate	(5) Excess Rail - Truck (3) - (4)	(6) Rail Rate (increased by 1%)	(7) Excess Rail - Truck (6) - (4)
2/34	77	0.485	0.469	0.016	0.48985	0.02085
2/11	26	0.485	0.460	0.025	0.48985	0.02985
2/79	54	0.460	0.447	0.013	0.46460	0.01760
2/8	0	0.460	0.484	-0.024	0.46460	-0.01940
4/35	69	0.460	0.456	0.004	0.46460	0.00860
5/81	0	0.505	0.467	0.038	0.51005	0.04305
5/48	100	0.330	0.286	0.044	0.33330	0.04730
5/55	100	0.525	0.494	0.031	0.53025	0.03625
6/20	100	0.265	0.257	0.008	0.26765	0.01065
6/50	100	0.265	0.251	0.014	0.26765	0.01665
6/59	100	0.250	0.239	0.011	0.25250	0.01350
6/62	0	0.200	0.182	0.018	0.20200	0.02000
6/22	100	0.195	0.131	0.064	0.19695	0.06595
				↓ average = 0.0201538		↓ average = 0.0239115

LINE 4

(1) Questionnaire Number	(2) Percent of Total Shipments by Rail	(3) Rail Rate	(4) Regression Truck Rate	(5) Excess Rail - Truck (3) - 4)	(6) Rail Rate (Increased by 1%)	(7) Excess Rail - Truck (6) - (4)
1/30	85	0.755	0.665	0.090	0.76255	0.09755
1/55	98	0.720	0.665	0.065	0.72720	0.07220
	97	0.720	0.729	-0.009	0.72720	-0.00180
2/35	72	0.590	0.541	0.049	0.59590	0.05490
2/49	94	0.535	0.522	0.013	0.54035	0.01835
	100	0.535	0.541	-0.006	0.54035	-0.00065
2/48	90	0.495	0.465	0.030	0.49995	0.03495
	100	0.495	0.485	0.010	0.49995	0.01495
	100	0.670	0.566	0.104	0.67670	0.11070
2/40	63	0.425	0.413	0.012	0.42925	0.01625
	100	0.425	0.479	-0.054	0.42925	-0.04975
	100	0.565	0.514	0.051	0.57065	0.05665
3/2	56	0.415	0.516	-0.101	0.41915	-0.09685
	0	0.495	0.501	-0.006	0.49995	-0.00105
3/10	45	0.400	0.504	-0.104	0.40400	-0.10000
	100	0.495	0.489	-0.006	0.49995	0.01095
3/56	45	0.350	0.324	0.026	0.35350	0.02950
3/41	88	0.320	0.297	0.023	0.32320	0.02620
	100	0.495	0.398	0.097	0.49995	0.10195
				↓ average = 0.0155789		↓ average = 0.0207894

APPENDIX E

CALCULATIONS FOR ESTIMATION OF ELASTICITY OF SUBSTITUTION

LINE 1

Elevator Number	$\frac{Q_R}{Q-Q_R}$	$\frac{R}{T}$
1/49	--	--
1/41	13.45	0.983
1/47	3.47	0.952
	4.20	0.956
1/35	8.22	0.962
	2.69	0.959
4/22	10.50	0.974
	--	--
4/4	0.93	0.946
	1.00	1.050
4/7	1.33	0.970
4/8	--	--
	--	--
4/9	6.04	1.002
4/18	20.64	1.016
4/19	8.26	1.016
4/27	140.00	1.022
	--	--
4/35	2.24	0.994
5/26	4.15	1.044
5/46	0.43	1.045
5/4	--	--
5/76	0.43	1.033
5/11	1.88	1.017
5/12	1.35	1.017
5/6	1.01	1.025
	average =	0.99915

LINE 2

Elevator Number	$\frac{Q_R}{Q-Q_R}$	$\frac{R}{T}$
1/49	--	--
1/03	--	--
1/11	--	--
1/29	1.05	0.914
	--	--
1/50	5.02	1.066
	--	--
4/33	1.27	1.051
5/58	8.44	1.006
	1.00	1.059
5/55	--	--
5/2	--	--
5/29	1.88	1.103
6/49	9.27	1.049
	average =	1.0354285

LINE 3

Elevator Number	$\frac{Q_R}{Q-Q_R}$	$\frac{R}{T}$
2/34	3.38	1.034
2/11	0.36	1.054
2/79	1.17	1.029
2/8	1.00	0.950
4/35	2.24	1.009
5/81	1.00	--
5/48	--	--
5/55	--	--
6/20	--	--
6/50	--	--
6/59	--	--
6/62	1.00	1.527
6/22	--	--

average = 1.1005

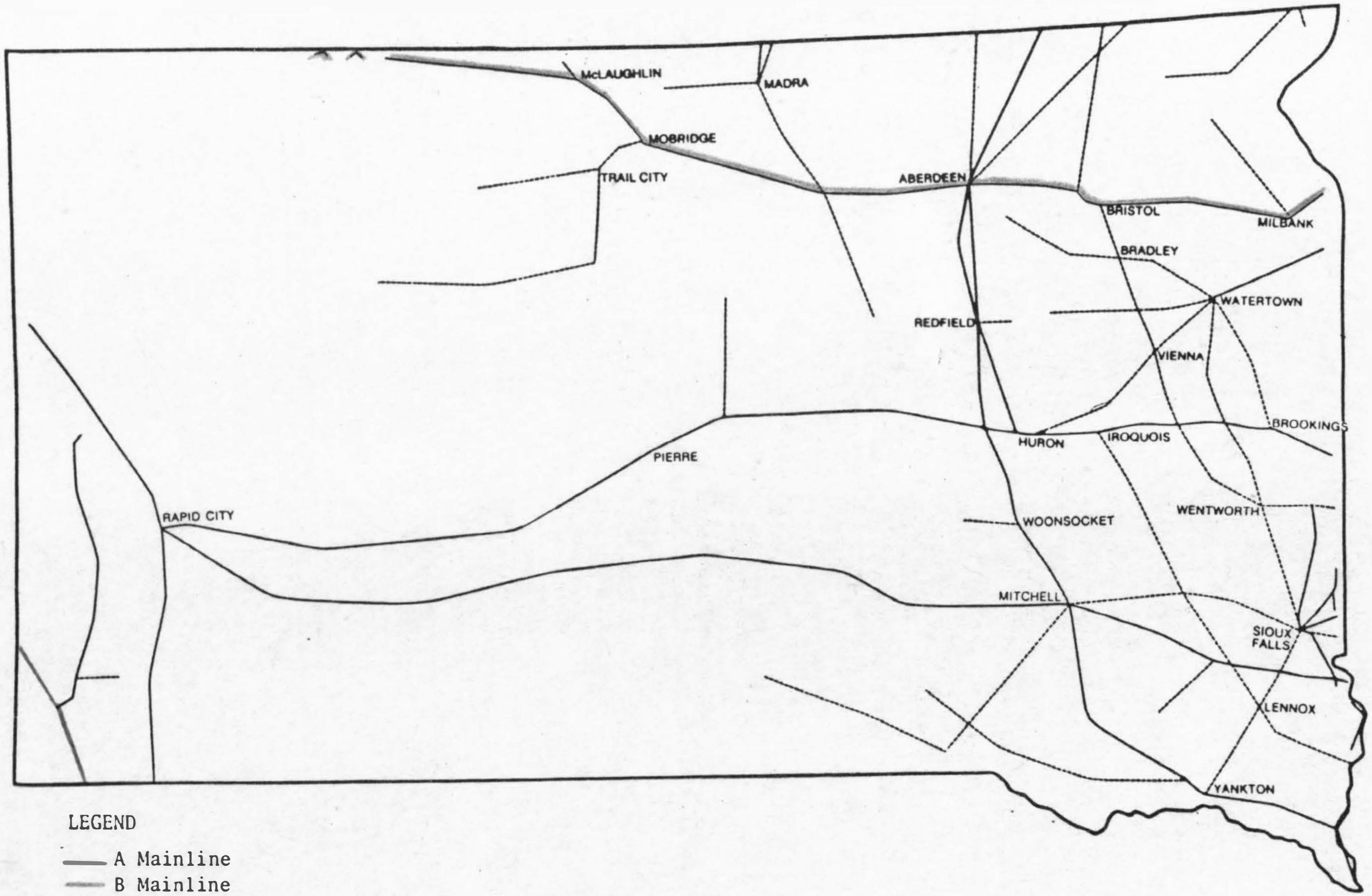
LINE 4

Elevator Number	$\frac{Q_R}{Q-Q_R}$	$\frac{R}{T}$
1/30	5.53	1.135
1/55	62.50	1.100
	31.25	0.988
2/35	2.60	1.180
2/49	16.33	1.025
	--	--
2/48	6.00	1.065
	--	--
	--	--
2/40	1.40	1.029
	--	--
	--	--
3/2	1.25	0.804
	1.00	0.988
3/10	0.80	0.794
	--	--
3/56	0.82	1.080
3/41	7.18	1.077
	--	--

average = 1.0220833

APPENDIX F

MAP OF RAIL LINE DESIGNATIONS IN SOUTH DAKOTA



LEGEND

—— A Mainline
—— B Mainline
—— A Branchline
--- Defense-Essential Branchline

Source: Preliminary Standards, Classification and Designation of Lines of Class I Railroads in the United States. U.S. Department of Transportation. August 3, 1976.