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ECONOMIC IMPACT OF ALTERNATIVE GRAIN TRANSPORTATION SYSTEMS
A Northwest Missouri Case Study

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Daniel Salomone, David E. Moser and Joseph C. Headley*

CHAPTER I

INTRODUCTION

Corn and soybeans are products of major and increasing importance in America's domestic and international trade. During the period from 1962-63 to 1975-76, U.S. corn and soybean production increased by nearly 70 percent, from 4.3 billion bushels to 7.3 billion bushels. During the same time period, corn and soybean exports more than quadrupled, increasing from 538 million bushels to 2.27 billion bushels.

America's grain handling and transportation system has been criticized as being unresponsive to the needs of the grain industry and lagging in its adjustment to changes in technology and the economic environment. The marked increase in grain production and export has contributed to problems in storage and transportation. During several recent years when large quantities of grain have moved to export markets, shippers have been hard pressed to obtain the transportation equipment needed to meet their commitments to both domestic and foreign buyers. The heavy exports have taxed the capacity of the handling system. Lack of storage and put-through capacity at the deepwater ports has resulted in frequent, severe rail and barge traffic congestion. The congestion means longer turnaround times at the ports, which in turn have caused difficulty in scheduling rail and barge shipments from grain producing regions.

Other significant changes have occurred in the physical distribution system for grain. Harvesting innovations have made it possible for producers to move very large quantities of grain directly to the elevator at the time of harvest. This development, coupled with the persistent temporary shortages of transportation equipment, has forced the storage of large quantities of grain on the ground for lack of elevator capacity to meet the surge demand for storage.

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Among the innovations in the transportation system affecting the marketing of grain, one of the most significant is the introduction by the railroads of a multiple car rate structure offering substantial savings to shippers who are in a position to ship in 50-car, 75-car, or 116-car lots. For such volume shippers, savings may be on the order of 40 percent and more.

Railroads are also encouraging the use of larger rail cars for grain transport. Jumbo covered hopper cars, capable of hauling up to 3,500 bushels of grain, are rapidly replacing the 2,000 bushel capacity, 40-foot box car, which had long been the standard grain hauling unit. The number of 40-foot box cars in the U. S. railroad car fleet declined from 563,470 in 1960 to 212,000 in 1973. During the same period, the number of covered hopper cars increased from 64,255 to 186,219 cars.

For the short run, these innovations have created additional problems in grain transportation. Many miles of rail line built for an earlier technology will require renovation and upgrading. The diminishing availability of 40-foot box cars and the trend toward incentive rates which encourage multiple car shipments have placed many elevators located on limited capacity branch rail lines at a considerable disadvantage.

It is generally contended among railroaders that, under today's conditions, many branch lines cannot pay their way and will ultimately have to be abandoned. There is less agreement on the question of which segments and how many must be discontinued.

The question of how to deal with this problem of adjustment is a difficult one since the various stages which make up the physical distribution system for grain are highly interdependent, with major capital investment decisions hanging in the balance.

Questions are raised about rail abandonment from the standpoint of public interest and investment. The closing of a rail line may impose certain social costs that should be weighed against the benefits of the abandonment. Such costs could come from several sources. The heavier traffic and the use of heavier equipment for transporting grain diverted from abandoned rail lines may require upgrading and increased maintenance costs for public roads and bridges. Traffic buildup may also detract from the safety and convenience of highway travel for other users. Finally, increased truck usage, relative to rail, may result in greater energy consumption in the movement of grain.

Among the problems and uncertainties created by recent innovations and changes in grain production, processing, storage and transportation, questions such as the following surface as especially troublesome to decision makers: Where should grain handling facilities be located and how large should they be? What rail branch lines should be abandoned? What are the advantages of the various alternative grain distribution systems? The present study is addressed to such questions as these.

The general objective of this research was to determine a grain distribution system which would yield the highest net return to producers and marketers within a given region. More specifically, the research objectives were to:

1. Describe the grain marketing system of the selected region in terms of:
   a. The location and quantities of grains produced, by variety, timing of harvest, quantities consumed on farms, and off-farm marketings.
   b. The number, location, capacity and handling characteristics of storage and conditioning facilities in the region.
   c. A description of transportation capabilities at these storage points, such as truck unloading and loading capacity, track and siding capacity, and ability to load box cars and/or covered hoppers.
   d. Destination of grain marketed off the farm, including export terminals and transit points.
   e. The transportation network serving the region, including rail, water and highways, in terms of shipper access points, terminal locations, lines and routes, and amount and type of grains carried in each vehicle type as well as mode.

2. Develop the costs for storing, conditioning and transporting grain, for farms, country elevators and subterminals, in terms of investment costs and operation and maintenance costs.

3. Identify transportation rates and costs for each mode of transport.

4. Develop projections to 1985 of grain production, off-farm consumption, and on-farm consumption within the region as a basis for identifying grain to be marketed outside the region.

5. Generate and analyze a series of rail-based transportation/storage alternatives that are feasible in terms of economic, technical and financial criteria.

6. Select the transportation/storage alternative that minimizes the cost of distributing the region's grain output, including farmer, elevator, rail, barge and trucking costs, as a basis for investment decisions in transportation, storage and handling facilities. The selection should be subject, but not limited, to the following considerations and constraints:
   a. The magnitude of the investments required.
   b. The financial viability and general profitability of the production, storage and transportation components in the distribution system selected.
   c. The flexibility of the system with respect to change in destination and customer service requirements, quantities of grain produced, and sensitivity to variations in grain prices or transportation costs.

7. Discuss the implications of the findings for farmers, communities, transporters, and public policy.

CHAPTER II

METHOD OF ANALYSIS

The Analytical Model

The analytical logic used in this study may be described as a location and transhipment model. The specific framework used here is sometimes referred to as the Stollsteimer model after its developer, John F. Stollsteimer (12). This model simultaneously identifies number, size and location of grain storage and handling plants (elevators) that will be necessary to minimize the combined transportation, assembly and handling costs of moving a given amount of grain from farm to market.

Through the use of a set of computerized algorithms developed at Iowa State University, the grain to be marketed from the 358 designated farm origins is routed through the country elevators and/or subterminal elevators to a final market destination by the various transport modes such as rail, truck, rail-barge or truck-barge. The revenue, net of transportation and handling costs, is computed for all combinations of these routings. The elevators, final destinations and transport modes are identified that will maximize net revenue for the region. This is the basic procedure.

The procedure was performed for four different rail options representing different patterns of rail service in the region. The options varied from the present system to one where all rail lines in the area were upgraded to allow the use of jumbo hopper cars. In addition, the analysis was performed for each quarter of the marketing year to show shifts in patterns during the year.

The present discussion will not cover all of the mathematical details of the model. A detailed account of the basic model is available from Stollsteimer (12). An explanation of application of the model to grain marketing by Ladd et al is found in an earlier Iowa State University study (7). Theoretical discussions of the broad economic framework that encompasses economic location models can be found in Lefeber (8) and Isard (6).

Data Requirements and the General Nature of Results

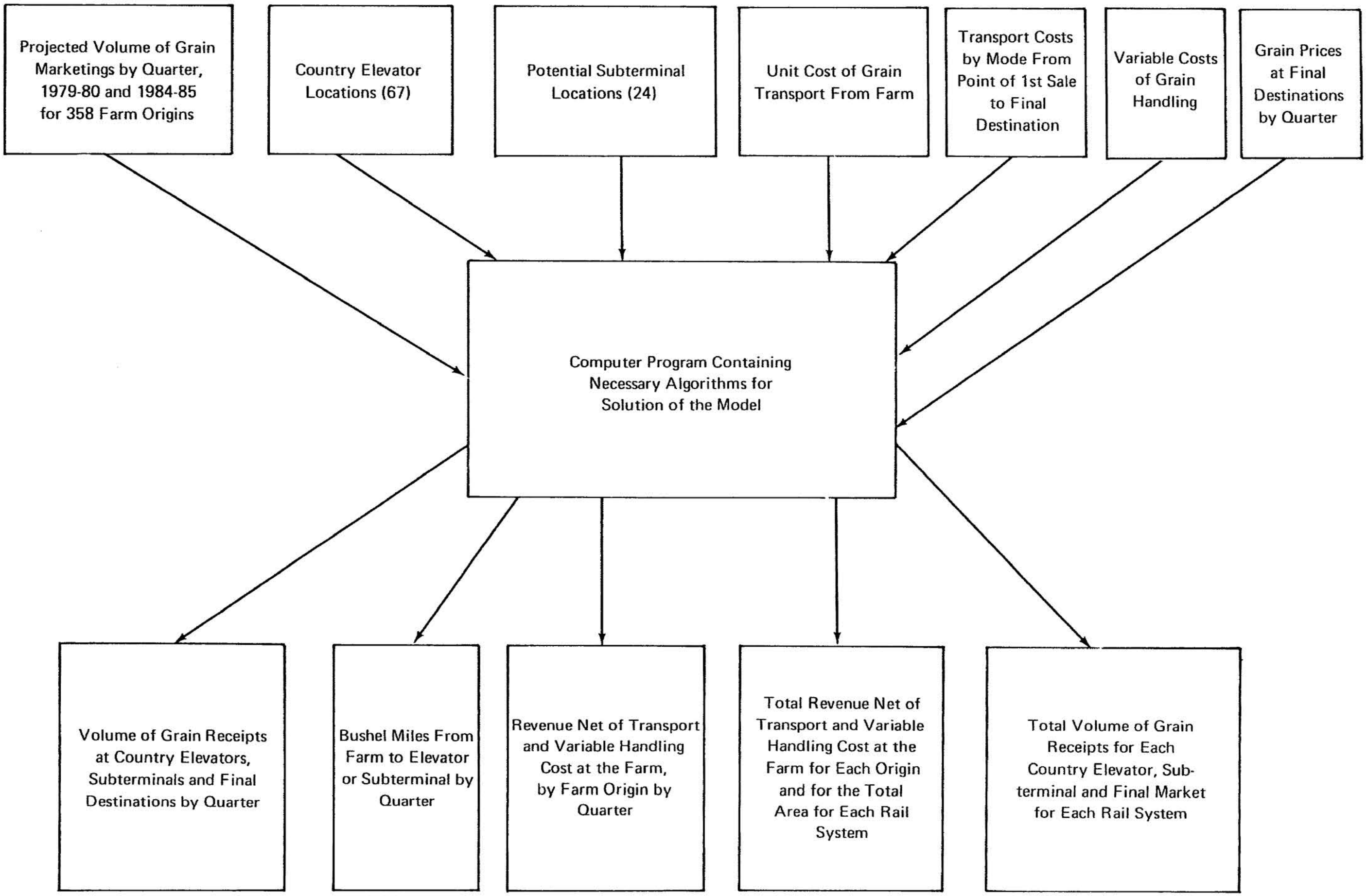
A schematic representation of the specific data requirements of the model and the type of results generated by the model is given in Figure 1. The data input consists of five basic kinds of information: (1) quarterly quantities of grain projected to be marketed from each farm origin for 1980 and 1985, (2) list and location of country elevators and subterminals, (3) transportation costs (a) from farm to point of first sale and (b) from elevator and/or subterminal to final market destination by various modes, (4) elevator and subterminal handling costs, and (5) list, location and quarterly grain prices for final destination markets.

When all of these data have been processed through the computer algorithms, there are five types of information that comprise the results for each assumed rail system in the study area: (1) volume of grain receipts at country elevators, subterminals and final markets by quarter, (2) bushel miles from farm to elevator or subterminal by quarter, (3) revenue net of transport and variable handling cost at the farm by farm origin, by quarter, (4) total revenue net of transport and variable handling cost at the farm for each origin and for the total area for each rail system, and (5) total volume of grain receipts for each country elevator, subterminal and final market for each rail system.

The results given by the model provide a basis for an evaluation of the relative economic efficiency of alternative rail systems, locations of country elevators and locations of subterminals in the study area, measured in revenue return to the area less transport and handling cost. Given the assumptions of the model, the solutions generated suggest shifts in volumes for elevators as certain rail lines are removed from service, shifts in volume of grain moving by various modes, implications for the need to upgrade highways and bridges, and the possible relative financial impact on farmers of alternative grain transportation systems.

It should be recognized that the final return in revenue, less transport and variable handling costs, does not represent what would actually accrue to farmers. Each solution involving subterminals requires that new elevator capacity be built to handle the optimal pattern of grain receipts. Certain rail system options involved upgrading of rail lines, as well as upgrading and maintenance of highways and bridges, when transport was shifted from rail to truck. Therefore, the net revenue given in the solution must represent a return to any added capital investment in new elevator

Figure 1. Data Input and Solution Output for Grain Location—Transhipment Model, Northwest Missouri, 1980 and 1985



capacity, a return to any added capital investment in rail lines and a return to any public investment in highways, as well as a net price to the farmer.

CHAPTER III

THE STUDY AREA

The area to which this study is applied is limited to 16 counties in Northwest Missouri (see Figure 2).

A list of grain elevators in the study area was developed and a mail survey questionnaire was sent to each. A copy of the questionnaire is found in Appendix F. From the results of the questionnaire, 101 "grain hauling" elevators were identified which were involved in moving grain from the 16 county area to final market. These elevators are found at 66 distinct geographical locations. Because of its proximity to the area and its importance in the area's grain traffic, a 67th location, St. Joseph, Missouri, was added to the list and treated as an elevator of subterminal capacity. Where two or more elevators were found at one named location, their various capacities were combined and the location was treated as having one elevator. The list of elevators, by county, is found in Appendix C. Table 1 shows the list of 67 locations and their map reference numbers.

Farm Origins

The 16 county area was divided into squares, each square representing an area five miles by five miles. These are defined as farm origins. Although ideally these farm origins should be defined to be smaller, the five mile by five mile size was chosen as a compromise between realism and manageability. For example, using a size of three miles square gives well over 900 origins while the five mile size gives 358.

Mileage from each of the 358 farm origins to each elevator location is calculated by computer, using mileage coordinates with reference to a predetermined zero-zero point in the region. For example, the mileage from the origin to the elevator shown below would be 11 miles. While this overstates the straight line distance, it may not be a bad approximation when one considers the actual path by which grain is transported from farm to elevator.

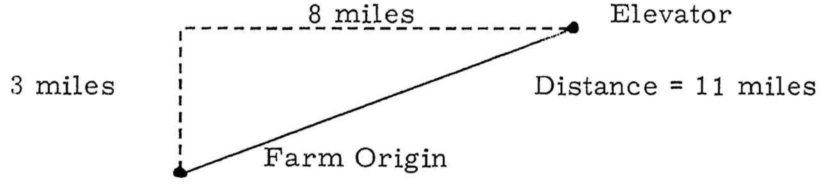


Figure 2. Sixteen County Study Area Location in Northwest Missouri

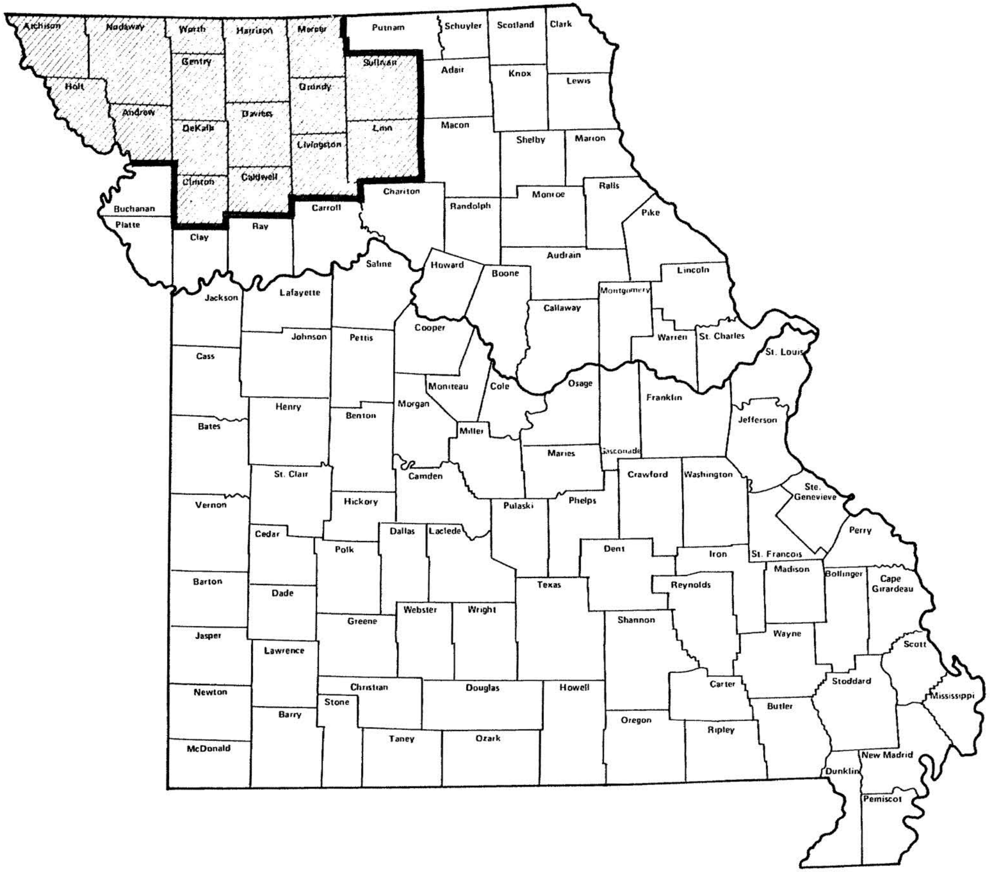


Table 1

Elevator Locations and Map Reference Numbers

No.	Location	No.	Location
1	Watson	34	New Hampton
2	Phelps City	35	Pattonsburg
3	Langdon	36	Winston
4	Tarkio	37	Polo
5	Fairfax	38	Cowgill
6	Corning	39	Hamilton
7	Craig	40	Gallatin
8	Bigelow	41	Bethany
9	Mound City	42	Blythdale
10	Fortescue	43	Ridgeway
11	Forest City	44	Gilman City
12	Maitland	45	Jamesport
13	Skidmore	46	Lock Springs
14	Elmo	47	Breckenridge
15	Maryville	48	Braymer
16	Barnard	49	Chillicothe
17	Rea	50	Chula
18	Savannah	51	Laredo
19	Ravenwood	52	Trenton
20	Conception Junction	53	Spickard
21	Sheridan	54	Princeton
22	Stanberry	55	Newton
23	King City	56	Wheeling
24	Union Star	57	Meadville
25	Gower	58	Laclede
26	Plattsburg	59	Linneus
27	Lathrop	60	Browning
28	Turney	61	Milan
29	Cameron	62	Green City
30	Osborn	63	Winnigan
31	Maysville	64	Brookfield
32	Albany	65	Bucklin
33	Grant City	66	Marceline
		67	St. Joseph

Figure 3 shows the study area with the farm origins and elevator locations.

Rail Options

In addition to supply origins and transhipment points, the spatial pattern of grain marketing is determined by the pattern of rail lines (Figure 4) and highways (Figure 5). This study uses four different rail options. A rail option is defined as a network of tracks and a set of train sizes. For each rail option the complete analysis is performed to determine the optimal number and location of subterminals, the optimal routing of the grain, and the total revenue net of handling and transportation variable cost. The option which yields the highest net revenue is selected as the final solution.

The four options selected are described below:

Option I: The Present Network

Option I assumes the present network of both light and heavy rail lines. Light line is defined as rail line of less than 263, 000 pounds capacity (i. e., rail line that cannot handle fully loaded jumbo hopper cars). It is assumed that elevators located on light lines ship out only single, 40-foot, 65-ton box car shipments, while elevators on heavy lines ship out only single 100-ton jumbo hoppers. If an elevator is designated as a subterminal, it ships via single jumbo hopper to all markets except the Texas and Louisiana export markets. To these markets it ships via 50 car shipments of jumbo hoppers. By assumption, only elevators located on heavy line can be considered as potential subterminals.

In Option I, seven elevator locations are without rail service. Elevators without rail service are assumed to ship by truck or truck-barge only. Figure 4 shows the Option I rail lines and elevator locations.

Option II: Complete Abandonment of Light Lines

Option II assumes that all light lines are abandoned. While this is an extreme case, it may be of interest as the trend to abandonment of light lines continues. Further, in many cases, while a line is officially in operation its condition and frequency of use are such that for all practical purposes the line might be considered abandoned. The shift from Option I to Option II places an additional 25 elevator locations off rail lines, for a total of 32 locations without rail service.

The assumptions on train sizes and types remain the same as in Option I. Figure 6 shows the Option II rail lines and elevator locations.

Figure 3. Study Area Farm Origins and Elevator Locations, 1975

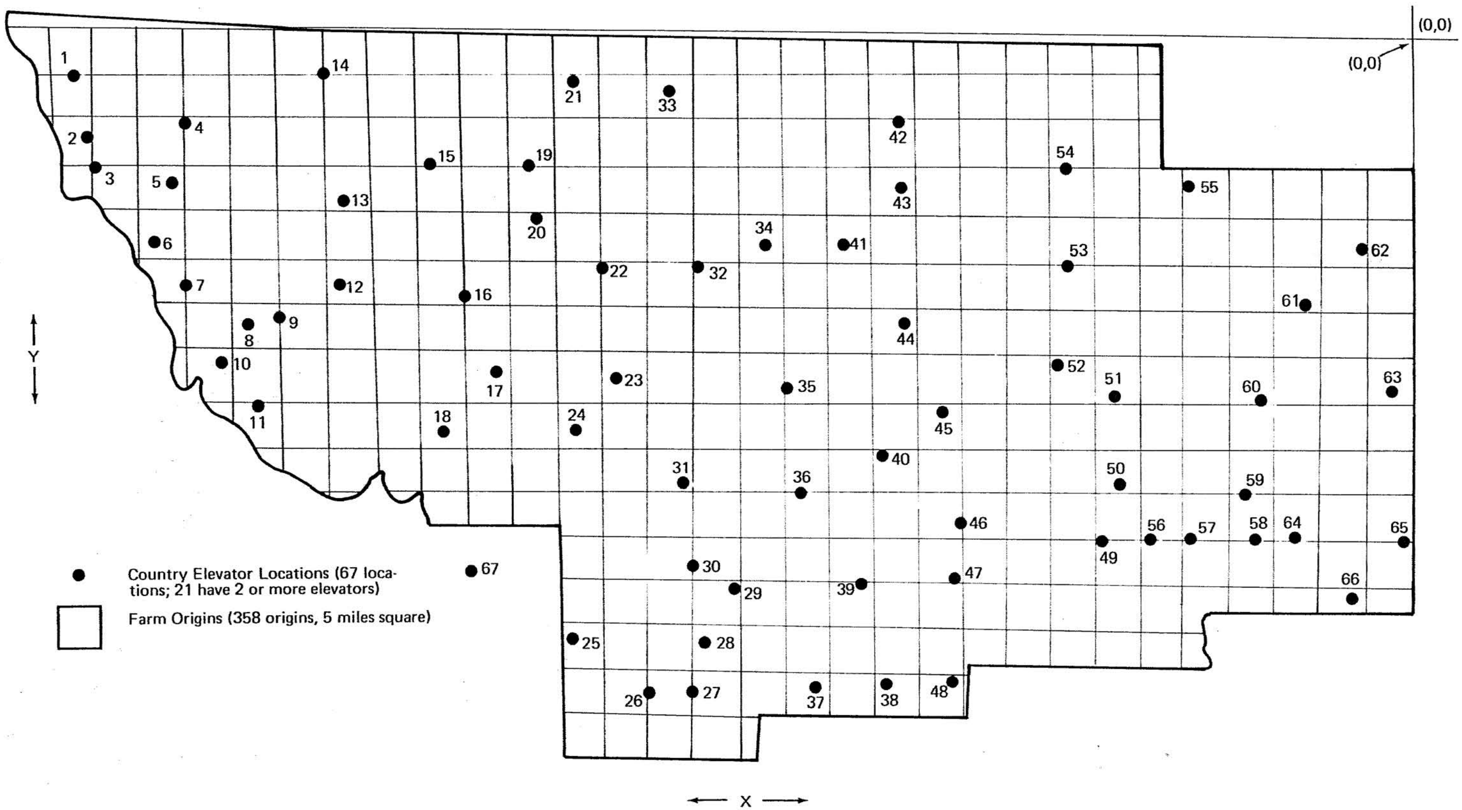
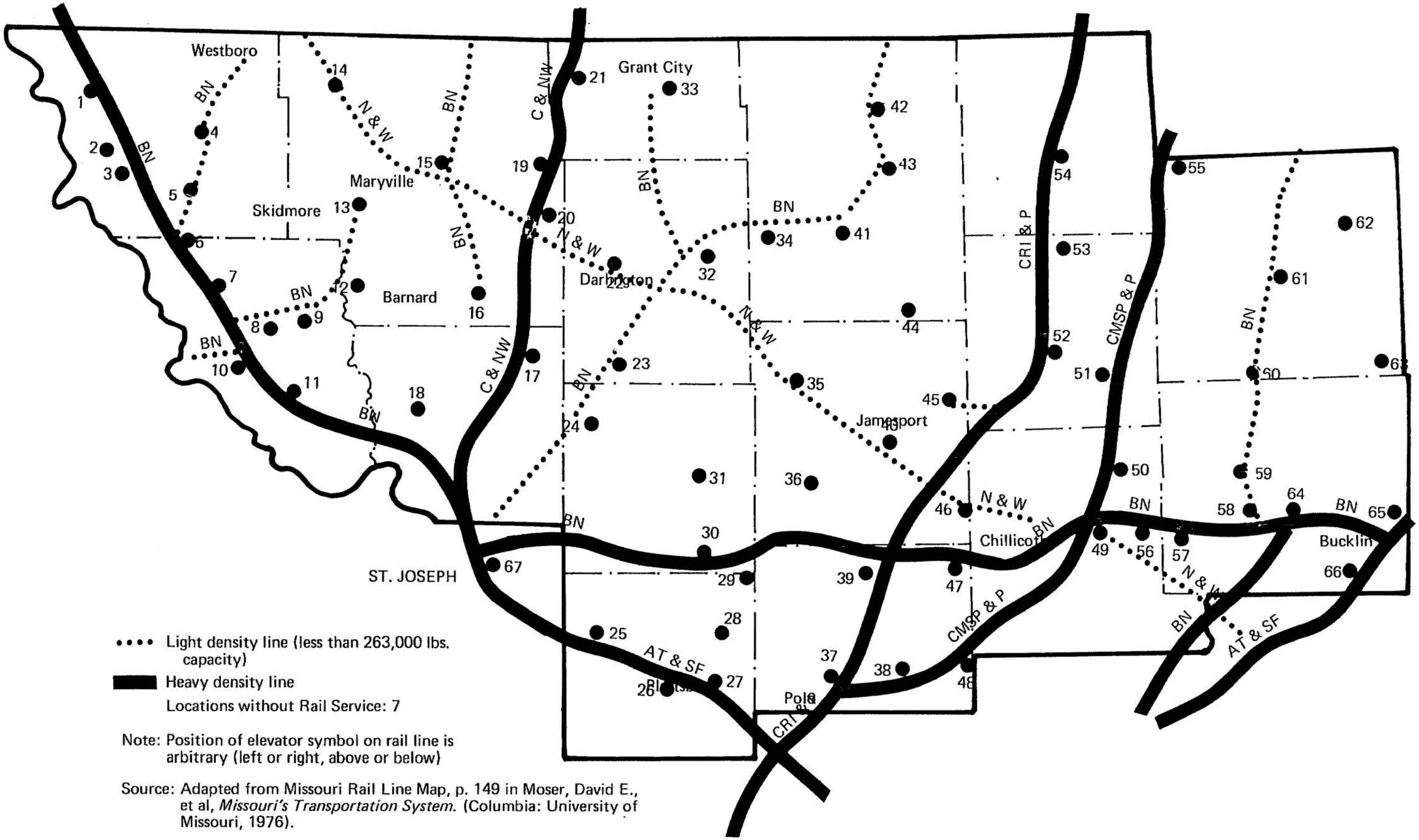


Figure 4. Rail Line System and Elevator Locations in 16 County Study Area (Rail Option I)



•••• Light density line (less than 263,000 lbs. capacity)

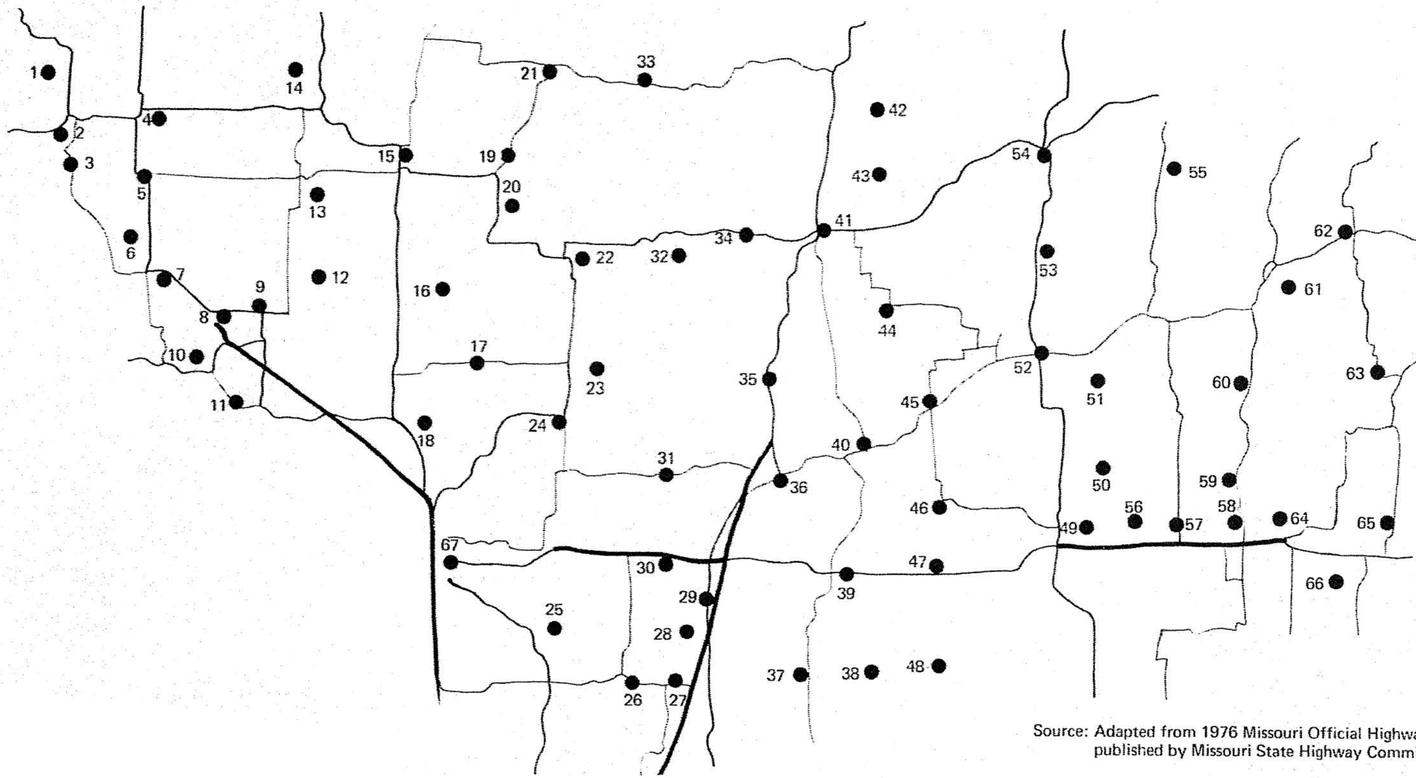
▬ Heavy density line

Locations without Rail Service: 7

Note: Position of elevator symbol on rail line is arbitrary (left or right, above or below)

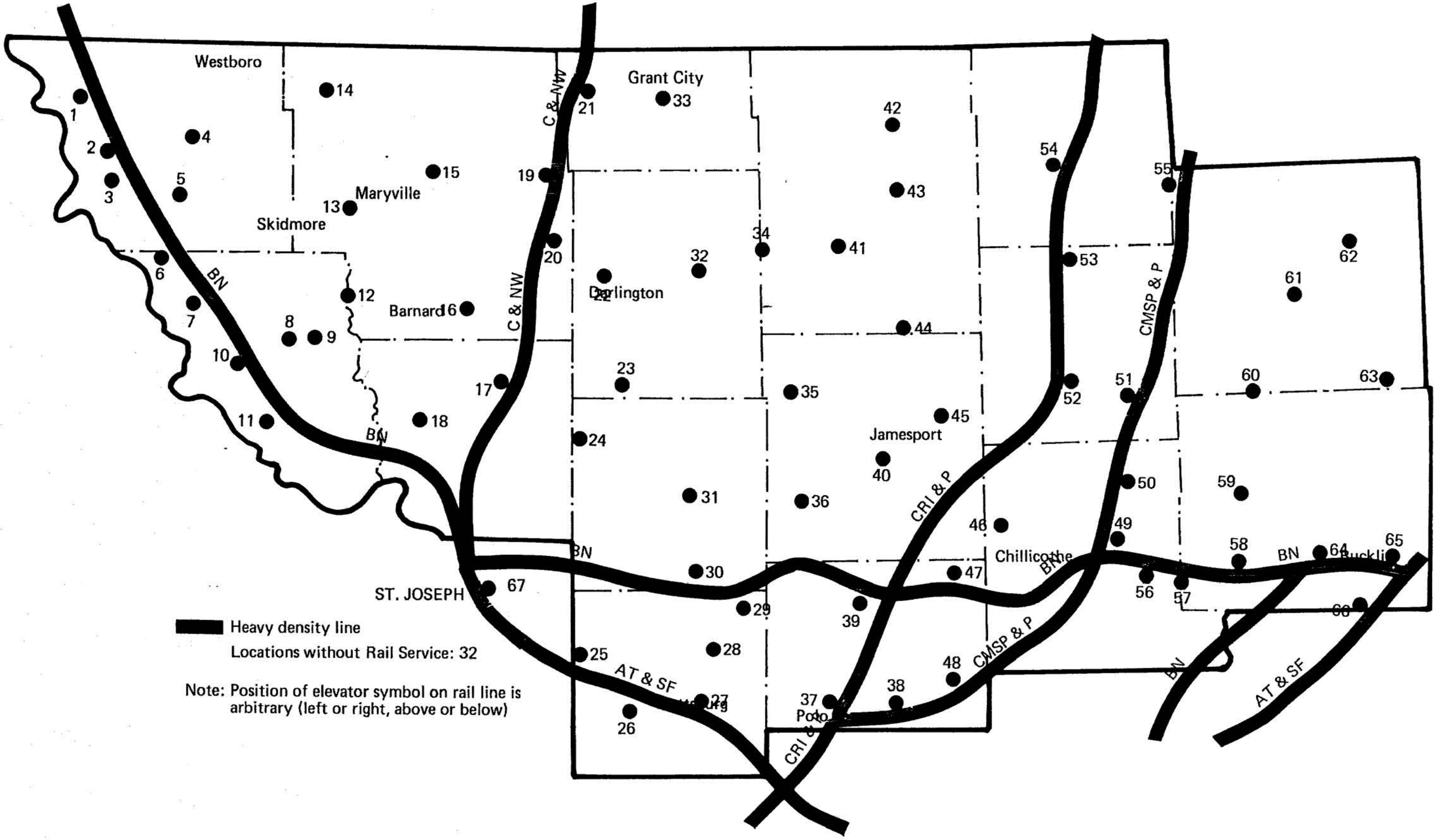
Source: Adapted from Missouri Rail Line Map, p. 149 in Moser, David E., et al, *Missouri's Transportation System.* (Columbia: University of Missouri, 1976).

Figure 5. State and U.S. Highway System and Elevator Locations in 16 County Study Area



Source: Adapted from 1976 Missouri Official Highway Map published by Missouri State Highway Commission

Figure 6. Rail Option II: All Existing Light Capacity Lines Abandoned



Option III: Selective Abandonment

Option III assumes that all existing heavy line is retained and that the following light line is upgraded to handle jumbo hopper cars:

Lines Upgraded

1. Norfolk and Western line from Elmo through Chillicothe.
2. Burlington Northern line from Togo, Iowa, through Bethany and Albany, Missouri, to St. Joseph.
3. Burlington Northern line from LaClede to Milan.

All remaining light line is abandoned. This option involves upgrading approximately 275 miles of track.

Assumptions on train size and type remain the same as those of Options I and II.

In this option, there would be 16 elevator locations without rail service. Figure 7 shows the rail network and elevator locations of Option III.

Option IV: Complete Upgrading

Option IV assumes that all existing light line is upgraded. Hence, all elevators now with rail service would be located on heavy line and could ship via jumbo hopper cars (Figure 8). To achieve this network, some 395 miles of track would need to be upgraded. Like Option II, this is an extreme case, one not likely to be achieved, yet it may serve as a useful guideline in matters of rail line abandonment. As in the case of Option I, seven elevator locations would remain without rail service.

In addition to the four options described above, a single-car alternative was calculated for each option. The single-car alternative allows no subterminals and requires single-car (1 to 10 car) shipments to all markets, including the Texas and Louisiana export points, rather than the 50 car shipments. In other words, each option was run with and without multiple car shipments to the export points.

Table 2 shows the rail service status of each elevator location under the assumptions of various rail options.

Figure 7. Rail Option III: Selective Abandonment and Upgrading

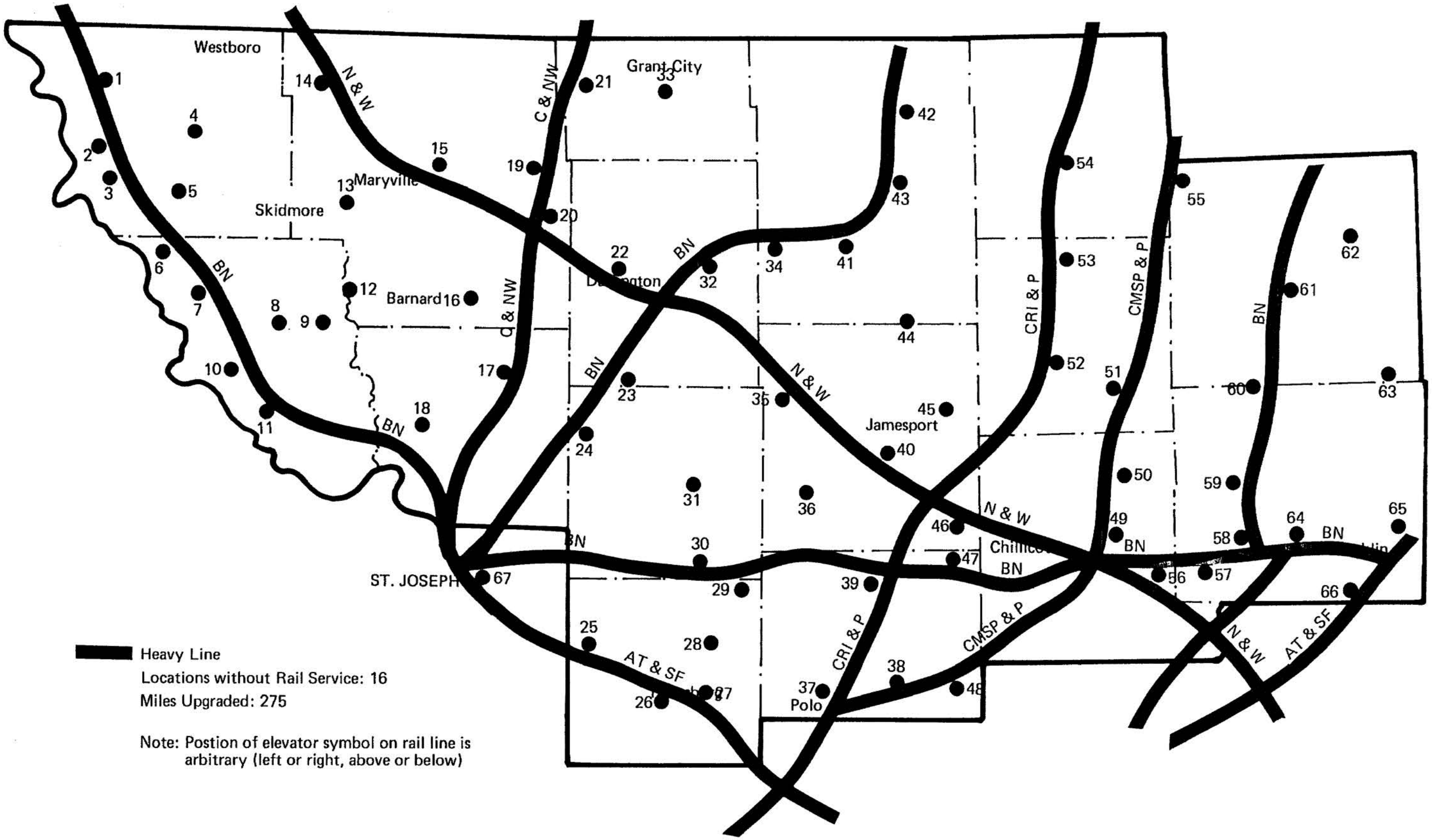


Figure 8. Rail Option IV: Complete Upgrading

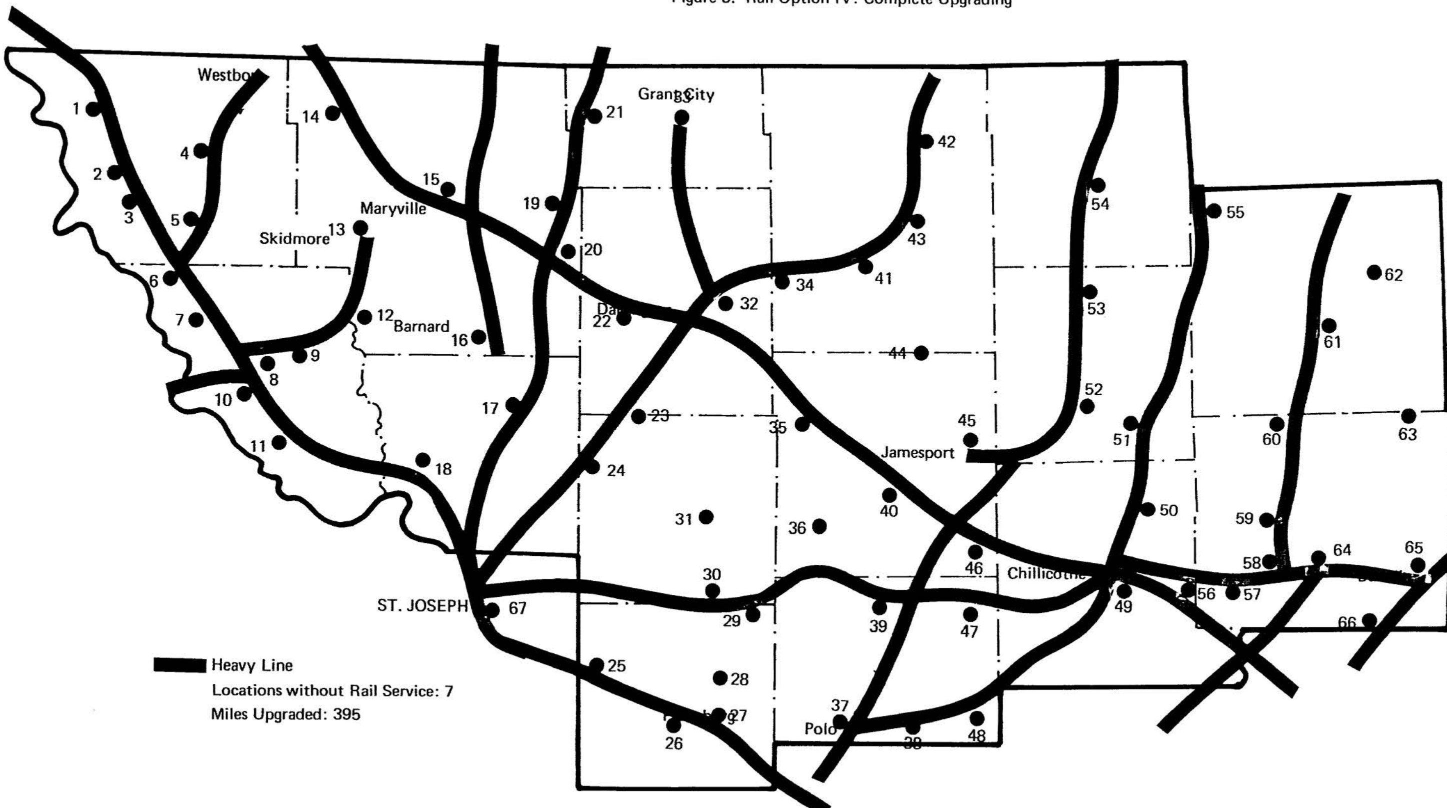


Table 2

RAIL SERVICE STATUS OF ELEVATOR LOCATIONS
IN VARIOUS RAIL OPTIONS

Elevator Location Number*	OPTION I		OPTION II		OPTION III		OPTION IV	
	Light Line	Heavy Line	Light Line	Heavy Line	Light Line	Heavy Line	Light Line	Heavy Line
1		X		X		X		X
2		X		X		X		X
3		X		X		X		X
4	X		No Rail		No Rail			X
5	X		No Rail		No Rail			X
6		X		X		X		X
7		X		X		X		X
8	X		No Rail		No Rail			X
9	X		No Rail		No Rail			X
10		X		X		X		X
11		X		X		X		X
12	X		No Rail		No Rail			X
13	X		No Rail		No Rail			X
14	X		No Rail			X		X
15	X		No Rail			X		X
16	X		No Rail		No Rail			X
17		X		X		X		X
18	No Rail		No Rail		No Rail		No Rail	
19		X		X		X		X
20		X		X		X		X
21		X		X		X		X

Table 2 (Continued)

Elevator Location Number*	OPTION I		OPTION II		OPTION III		OPTION IV	
	Light Line	Heavy Line	Light Line	Heavy Line	Light Line	Heavy Line	Light Line	Heavy Line
22	X		No Rail			X		X
23	X		No Rail			X		X
24	X		No Rail			X		X
25		X		X		X		X
26		X		X		X		X
27		X		X		X		X
28	No Rail		No Rail		No Rail		No Rail	
29		X		X		X		X
30		X		X		X		X
31	No Rail		No Rail		No Rail		No Rail	
32	X		No Rail			X		X
33	X		No Rail		No Rail			X
34	X		No Rail			X		X
35	X		No Rail			X		X
36	No Rail		No Rail		No Rail		No Rail	
37		X		X		X		X
38		X		X		X		X
39		X		X		X		X
40	X		No Rail			X		X
41	X		No Rail			X		X
42	X		No Rail			X		X
43	X		No Rail			X		X
44	No Rail		No Rail		No Rail		No Rail	

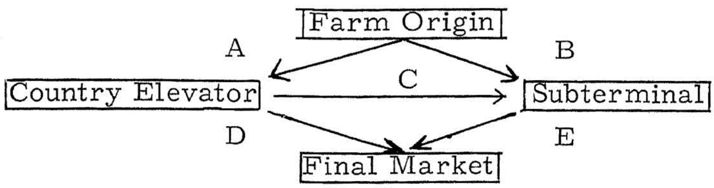
Table 2 (Continued)

Elevator Location Number*	OPTION I		OPTION II		OPTION III		OPTION IV	
	Light Line	Heavy Line	Light Line	Heavy Line	Light Line	Heavy Line	Light Line	Heavy Line
45	X		No Rail		No Rail			X
46	X		No Rail			X		X
47		X		X		X		X
48		X		X		X		X
49		X		X		X		X
50		X		X		X		X
51		X		X		X		X
52		X		X		X		X
53		X		X		X		X
54		X		X		X		X
55		X		X		X		X
56		X		X		X		X
57		X		X		X		X
58		X		X		X		X
59	X		No Rail			X		X
60	X		No Rail			X		X
61	X		No Rail			X		X
62	No Rail		No Rail		No Rail		No Rail	
63	No Rail		No Rail		No Rail		No Rail	
64		X		X		X		X
65		X		X		X		X
66		X		X		X		X
67		X		X		X		X

*See Table 1 and Figure 2 for identification of elevator locations.

Assumptions on Shipping Alternatives

The movement of grain from farm origin to market may or may not pass through a subterminal. If it goes to a subterminal, the movement may be direct from farm to subterminal or indirect from farm to elevator to subterminal. Similarly, grain movements from elevator to market may or may not pass through a subterminal. The diagram below shows routing possibilities for each stage of grain marketing.



Shipments of grain from origin directly to market are negligible and are here ignored. The shipping alternatives assumed for each link are described below.

Links A and B. All farm-to-elevator or farm-to-subterminal movement is by truck or wagon. A recent survey of farmers in the study area has shown that 300 bushel and 450-500 bushel trucks, as well as tractor-wagon units are involved in this first link of grain marketing.* Appendix A sets out the derivation of the total costs per bushel per mile for the two truck sizes and the tractor-wagon units. These were estimated to be:

Grain Hauling Costs

Wagon:	$.0046/bu./mile
300 bu. truck:	$.0036/bu./mile
450-500 bu. truck:	$.0029/bu./mile

Since all three types of equipment are used in grain hauling, the following predetermined split was used based on the survey mentioned above:

Wagon:	37.5%
300 bu. truck:	12.5%
450-500 bu. truck:	50.0%

Hence, every bushel of farm grain hauled to an elevator or subterminal is assumed to cost $.003885 per bushel per mile, the weighted sum of the hauling costs above.

*University of Missouri Farm Truck Survey, 1975. See Appendix D for details.

Link C. All elevator-to-subterminal movements of grain are assumed to be by truck. No data on such trucking in Missouri were collected; however, the Iowa experience indicates that movement is by both 450-500 bushel trucks and 810 bushel tractor-trailer trucks, with weighting factors of 3/4 and 1/4 respectively.*

Appendix A also contains the derivation of the cost estimates for the 810 bushel truck costs. These are $.00092 per bushel per mile. Hence, every bushel of elevator-to-elevator grain is assumed to be hauled at a cost of $.00239 per bushel per mile, which is the weighted sum of 450-500 bushel and 810 bushel truck costs.

Link D. The rail alternatives of a non-subterminal elevator depend on the capacity of the rail line on which it is located. If the line is low-capacity the rail alternative is single car shipments utilizing the standard 40-foot box car. If the line is high-capacity (263,000 pounds or more), the elevator is assumed to ship single jumbo hopper cars.

In addition, link D includes the possibility of truck movements and both truck-barge and rail-barge movements. On link D all truck movements are assumed to be 810 bushel tractor-trailer movements.

Barge movements apply only to grain destined for New Orleans, with truck barge transfers occurring at an arbitrarily predetermined loading point. The assumed loading points are Brownsville, NE; White Cloud, KS; St. Joseph, MO; and Miami, MO. The loading points were selected in such a way that major segments of the Missouri River are represented. All rail-barge movements involve single-car rail shipment to either Kansas City or St. Louis and barge beyond.

Thus, shipping alternatives on link D depend on which market is being served.

Link E. Subterminal-to-market movements are assumed to be identical with those of link D, except that because subterminals are located on heavy line they are assumed to ship single hoppers instead of single box cars. Also, where the Gulf markets are concerned, it is assumed that all rail movement is by multiple car trains of 50 cars (except rail-barge which is single hopper to Kansas City or St. Louis). All other alternatives are identical to those of link D.

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*Based on suggestions of researchers at Iowa State University, Department of Economics.

Rail Costs

Appendix B contains the assumptions and derivations of rail cost coefficients for both single car shipments and shipments of 50 cars. Since, for example, the cost of moving a single car from Kansas City, MO, to Houston, TX, in a one-car train would not serve as a guide to single car rate determination, the cost coefficients for movement of a 10-car train are used for single car shipments. Table 3 shows some derived cost coefficients for various trip lengths.

Barge Costs

The shipping season on the Missouri River runs from approximately April 1 to December 1. The present study allows for the possibility of both truck-barge and rail-barge shipments to New Orleans export points.

Since barge hauling of bulk agricultural commodities is not rate-regulated, barge rates fluctuate in response to supply and demand for services. Generally, barge rates fluctuate around the established base rates throughout the crop season, being above the base rates at the peak of harvest and below the base rates when shipping demand slackens.

For purposes of this study, the published rate for bulk grain was used in calculating the cost of transporting grain to the Gulf. The rates used were in effect as of March 1, 1975.

For the truck-barge combination, each elevator location in the 16-county study area was assigned to the closest of four river loading points. Table 4 shows the assignment of elevator locations to the river loading points. The published rates on corn and soybeans from each of these points to New Orleans were:

From	Cents Per Bushel to New Orleans	
	Corn	Soybeans
Brownsville, NE	22.29	23.88
White Cloud, KS	22.29	23.88
St. Joseph, MO	20.10	21.54
Miami, MO	18.14	19.44

Source: Waterways Freight Bureau Tariff No. 7.

Table 3

VARIABLE COST PER BUSHEL
(Cents per Bushel)

One-Way Mileage	Soybeans Single Box	Soybeans Single Hopper	Soybeans 50 Hoppers	Corn Single Box	Corn Single Hopper	Corn 50 Hoppers
100	8.69	6.13	5.25	8.11	5.73	4.90
200	12.31	8.83	6.88	11.49	8.24	6.42
300	15.92	11.53	8.51	14.86	10.76	7.95
400	19.53	14.23	10.14	18.23	13.28	9.47
500	23.15	16.92	11.77	21.61	15.80	10.99
600	26.76	19.62	13.40	24.98	18.31	12.51
700	30.38	22.32	15.03	28.35	20.83	14.03
800	33.99	25.01	16.66	31.73	23.35	15.55
900	37.61	27.71	18.29	35.10	25.86	17.07
1000	41.22	30.41	19.92	38.48	28.38	18.59

Source: Adjusted ICC cost coefficients based on ICC <u>Rail Carload Cost Scales</u> for 1972. (See Appendix B.)

Table 4

LIST OF ELEVATOR LOCATIONS AND ASSIGNED RIVER LOADING POINTS

Loading at
Brownsville, Nebraska

Watson
Phelps City
Langdon
Tarkio
Fairfax
Corning
Elmo

Loading at
St. Joseph, Missouri

Barnard
Rea
Savannah
Ravenwood
Conception Junction
Sheridan
Stanberry
King City
Union Star
Gower
Plattsburg
Lathrop
Turney
Cameron
Osborn
Maysville
Albany
Grant City
New Hampton
Pattonsburg
Winston
Hamilton
Gallatin
Bethany
Blythedale
Ridgeway
Gilman City
Jamesport
Lock Springs
St. Joseph

Loading at
White Cloud, Kansas

Craig
Bigelow
Mound City
Fortescue
Forest City
Maitland
Skidmore
Maryville

Loading at
Miami, Missouri

Polo
Cowgill
Breckenridge
Braymer
Chillicothe
Chula
Laredo
Trenton
Spickard
Princeton
Newton
Wheeling
Meadville
Laclede
Linneus
Browning
Milan
Green City
Winnigan
Brookfield
Bucklin
Marceline

For rail-barge combinations, only Kansas City and St. Louis were used. In other words, an elevator, in order to barge grain to the Gulf, could truck grain to its designated truck-barge point (one of the four above) or it could ship by single rail car to Kansas City or St. Louis for a rail-barge movement.

The published barge rates on corn and soybeans from Kansas City and St. Louis were:

From	Cents Per Bushel to New Orleans	
	Corn	Soybeans
Kansas City	18.14	19.44
St. Louis	11.17	11.97

Source: Waterways Freight Bureau Tariff No. 7.

Markets and Prices

An important part of determining the optimal configuration of rail lines and subterminals is to have a clear indication of the ultimate destination of the grain from the study area. This information was obtained in two steps. First, individual interviews were arranged with a sample of grain haulers from the 16-county area to determine the markets to which they hauled grain. These interviews revealed that grain from the study area went to markets in Kansas, Arkansas and Southwest Missouri as well as to St. Joseph and Kansas City. Since it was likely that much of the grain going to St. Joseph and Kansas City moved out to other markets, it was necessary to examine the movement of grain from St. Joseph and Kansas City.

Through the use of data gathered for a study under way at Kansas State University under the direction of Orlo Sorenson, it was possible to determine the dominant movements of grain out of the Kansas City area. It was assumed that St. Joseph grain moved to the same markets. Based on these investigations, the following list of markets for the 16-county area was established:

Markets for Corn
from the 16-County Area

Export

Houston-Galveston, Texas
New Orleans, Louisiana

Domestic

Des Moines, Iowa
Fort Smith, Arkansas
Fort Worth, Texas

Kansas City, Missouri
Quincy, Illinois
St. Louis, Missouri

Markets for Soybeans
from the 16-County Area

Export
Houston-Galveston, Texas
New Orleans, Louisiana

Domestic
Des Moines, Iowa
Fort Worth, Texas
Fredonia, Kansas
Kansas City, Missouri
Lincoln, Kansas
Mexico, Missouri
Quincy, Illinois
St. Louis, Missouri

A total of eleven markets were designated. (Note: For purposes of calculating revenue at the origins, there were actually 25 markets--11 by rail, 11 by truck, truck-barge to New Orleans and two rail-barge alternatives to New Orleans.)

Prices

The model requires a set of delivered prices for each grain for each period at each destination. Hence, a set of destination prices for each of the quarters was developed.

Since prices in the model are used to determine the spatial routing of grain, it is the relative prices rather than absolute price levels that are important. Therefore, in selecting the optimal rail network and elevator pattern all that is needed is a set of spatial price relationships. These relationships are then assumed to hold in 1980 and in 1985.

The prices used in the model were obtained by contacting grain buyers and sellers familiar with grain sales at each destination. For each quarter of the 1974-75 crop year beginning in October, the 15th day of the middle month (i.e., November, February, May and August) was selected for recording. Table 5 shows the prices used in the study. In all but a few cases, these prices are rail bids. In the cases where no rail bid was available, the price used is a truck bid.*

In the case of truck-barge and rail-barge movements

*A rail bid is a bid for grain delivered on the rail siding at the final destination. A truck bid is a bid for grain delivered by truck.

Table 5

DELIVERED GRAIN PRICES FOR SELECTED DESTINATIONS
(Cents per Bushel)

	Oct-Nov-Dec	Jan-Feb-Mar	Apr-May-June	July-Aug-Sept
		Corn		
Texas Export	364	338	278	302
La. Export	364	338	278	302
Ft. Smith	360	303	270	321
Des Moines	337	283	257	288
Kansas City	350	294	261	299
St. Louis	347	303	268	286
Quincy	343	296	266	290
Ft. Worth	344	320	263	335
		Soybeans		
Texas Export	768	667	562	555
La. Export	768	667	562	555
Des Moines	737	615	532	525
Kansas City	741	628	534	526
St. Louis	747	641	553	548
Mexico	735	630	540	526
Quincy	734	636	547	540
Fredonia	748	632	540	542
Ft. Worth	726	631	532	525
Lincoln	730	600	527	521

to New Orleans, it was necessary to define the river loading point as the market. For example, the price used for a truck-barge movement using White Cloud, KS as a loading point was calculated as the Gulf price less barging costs from White Cloud and less handling costs at the loading point. Handling costs at the loading point were assumed to be $\frac{1}{2}$ of 1% of the Gulf price. For example, the price used for truck-barge soybeans using White Cloud would be:

Gulf Price (quarter I)	\$7.6800
Barge--White Cloud to New Orleans	-.2388
Handling Costs	-.0384
Delivered Price at White Cloud	\$7.4028

Grain Handling Facilities

The optimal routing of grain may require that some elevators be expanded to subterminal capacity. Therefore it is necessary to know the capacities of the existing elevators so that the amount of expansion required may be calculated.

Information on the existing elevators in the 16-county study area was obtained from mail questionnaires which were sent to all elevator managers in the area. The survey produced 50 usable responses from which information on existing elevators was calculated. Appendix F contains a sample of the elevator survey.

Elevator size was measured in four capacities:

1. Receiving Capacity
2. Drying Capacity
3. Storage Capacity
4. Load Out Capacity

Receiving capacity was measured as the amount of grain that could be received in bushels per hour. It was found that the average receiving capacity for corn was 2802 bushels per hour. For soybeans the average was 2615 bushels per hour. The average receiving capacity for corn and soybeans received together was 3545 bushels per hour. Receiving capacities for corn ranged from 400 to 8500 bushels per hour, for soybeans from 500 to 10, 000 bushels per hour and for both, from 400 to 14, 000 bushels per hour.

Drying capacity was defined as the rated dryer capacity at 5 percent moisture removal in bushels per hour. The average capacity was 678 bushels per hour.

Storage capacity was defined as the sum of both flat and upright storage space. Storage capacity for the 50 respondent elevators averaged 190, 787 bushels.

Load out capacity was measured as the number of bushels of grain that could be loaded in an eight hour day. The survey yielded the following information:

9 elevators without rail service
38 elevators with rail service

20 could load out jumbo hoppers
18 could not load out jumbo hoppers

For those elevators with rail service, it was found that rail sidings could hold an average of nine box cars or seven jumbo hoppers. It was also found that an average of 10, 699 bushels of grain could be loaded into box cars in an eight hour day, while 14, 156 bushels could be loaded into jumbo hoppers in eight hours.

Table 6 summarizes the survey results of elevator capacities.

Handling and Expansion Costs

Since the model used in this study involves the maximization of net revenue at the farm origin, all transportation and handling costs must be deducted from revenue.

Elevator handling costs are divided into receiving, storing, and loadout cost. Iowa State University has furnished figures for grain handling costs based on a recent USDA publication.* These figures include the cost of receiving grain by truck and loading it out by rail. Since storage costs are assumed to be the same at all facilities, they do not affect the routing of grain or the location or number of subterminals. Hence storage costs are ignored in the computer calculations. The handling costs used in this study are:

Variable Handling Costs
(Cents per Bushel)

	Corn	Soybeans
At Elevators	4.8	5.8
At Subterminal	3.8	4.8

Source: Iowa State University, USDA, Feed Situation, FDS-252, February 1974.

These figures include an allowance for shrink of $\frac{1}{2}$ of 1 percent of the current grain price.

It should be pointed out that since the study deals with existing elevators, all fixed costs of handling are treated as sunk costs and only the variable handling costs are used. Only in the case where an elevator is expanded to subterminal size is it necessary to deduct fixed costs.

When an elevator location is selected as the site for a subterminal, it will usually involve some expansion of capacities. This study assumes that the minimum capacities needed for an elevator to serve as a subterminal are:

Receiving	10,000 bushels per hour
Drying	1,500 bushels per hour
Load Out	20,000 bushels per day

* "Costs of Storing and Handling Grain in Commercial Elevators, Projections for 1974-75," Allen Schienbein, Commodity Economics Division, USDA, Feed Situation FDS-252, February 1974.

Table 6

EXISTING CAPACITIES AT SURVEYED ELEVATORS, NORTHWEST MISSOURI, 1975

	Receiving		Drying	Storing	Load Out	
	Corn	Soybeans			Box	Hopper
	(bu/hr)		(bu/hr)	(bu)	(bu/day)	
Total	131,700	112,450	25,070	8,967,000	373,400	453,000
Average	2,744	2,615	678	190,789	10,669	14,156
Standard Deviation	2,071	2,154	503	268,960	6,880	7,910
Respondents	48	43	37	47	35	32

Source: University of Missouri, Northwest Missouri Grain Elevator Survey.

If an elevator's capacities are less than these it must be expanded to these minimum levels before it can be considered a subterminal.

The costs of expanding to these limits are calculated using estimating equations recently developed at Iowa State University. These equations are:

Receiving

Installed Cost	=	$99,400	+	8.303 (X)
Annual Cost	=	18,004	+	1.521 (X)

Drying

Installed Cost	=	$20,325	+	38.506 (X)
Annual Cost	=	4,081	+	7.780 (X)

Load Out

Installed Cost	=	$16,150	+	19.019 (X)
Annual Cost	=	3,932	+	2.972 (X)

where
X represents the difference between existing capacity and minimum requirements given above.

In addition, a constant of $36,834, which represents an estimate of the fixed cost of storage expansion, was included in all expansion calculations.

An example of how all this is used would be helpful here. Calculate the revenue net of transportation and handling costs with 3 subterminals as $480,000. Then, consider adding a fourth subterminal at a specified location. It will be worthwhile only if the change in net revenue is greater than the annualized expansion cost. For example, suppose the prospective subterminal has existing capacities of:

Receiving	8,000 bu./hr.
Drying	700 bu./hr.
Load Out	16,000 bu./day

To expand this elevator to subterminal size would require an annual outlay calculated as follows:

Receiving

$18,004 + 1.521 (10,000 - 8,000) = $21,046

Drying

$4,081 + 7.780 (1,500 - 700) = $10,305

Load Out

$3,932 + 2.972 (20,000 - 16,000) = $15,820

Fixed Cost of Storage Expansion	=	$36,834
Total Annual Expansion Cost	=	$84,005

If the addition of this subterminal raises annual net revenue by more than $84,005 it will be justified; if not, it remains as a country elevator. In short, a subterminal is established if the resulting change in annual net revenue is greater than the annual expansion cost.

CHAPTER IV

RESULTS

Alternative rail options were evaluated by comparing the revenue net of variable cost which would accrue to the entire 16-county area using both 1979-80 and 1984-85 grain marketing forecasts.

As stated above, all four rail options were analyzed twice, once with a single-car assumption, which allowed no subterminals or multiple-car shipments, and once with the possibility of subterminals and multiple-car shipments. Table 7 shows the results for all four options for both single and multiple car assumptions. A word of caution on the nature of these numbers is in order. The numbers in Table 7 are all based on prices, transportation rates and costs of 1972-1974. Therefore, the level of revenue net of variable cost is not realistic. In effect, the numbers in the table serve only as dummy variables or indices. For example, we can say that Option IV yields more revenue than Options I, II, or III, but we cannot say that actual revenue net of variable cost for origins in the 16-county area is exactly $289,753,000. To make them realistic, the numbers of Table 7 would have to be adjusted to reflect 1980 and 1985 prices, rates and costs.

These adjustments, however, would not affect the relative size of the numbers so long as the spatial relationship of grain prices and rail and barge charges remain unchanged. It is assumed that these relationships would continue to be valid in 1980 and 1985.

Table 7 shows that, without exception, multiple car solutions yield more net revenue than single car solutions. The existence of subterminals, with 50 car shipments to the Gulf, increases net revenue by an average of 2.4 million dollars in 1980 over the single car solution and by 2.6 million dollars in 1985.

Before allowing for rail and highway upgrading costs or elevator expansion costs, we find from Table 7 that Option IV gives the highest net revenue of all the options. The difference in net revenue between Option IV and the other options, however, is relatively small. Therefore, it is not unlikely that the optimal solution after adjustment for upgrading and expansion costs could shift from Option IV to some other option. Since the figures are so close, one must be careful to reserve conclusions until the costs of upgrading and expansion have been considered.

Table 7

REVENUE NET OF VARIABLE COST*: RESULTS OF OPTIMAL SOLUTIONS FOR RAIL OPTIONS I-IV, NORTHWEST MISSOURI
(Thousands of Dollars)

	Single Car			Multiple Car		
Option	Corn	Soybeans	Total	Corn	Soybeans	Total
			1980			
I	73,253	190,373	263,626	73,884	192,134	266,018
II	73,213	190,362	263,575	73,869	192,129	265,998
III	73,350	190,428	263,778	73,993	192,128	266,121
IV	73,405	190,458	263,863	74,012	192,133	266,145
			1985			
I	76,133	210,894	287,027	76,788	212,839	289,627
II	76,093	210,882	286,975	76,772	212,834	289,606
III	76,231	210,956	287,187	76,900	212,829	289,729
IV	76,288	210,987	287,275	76,919	212,834	289,753

*These figures do not include allowance for rail and highway upgrading costs and of investment cost of new subterminals.

Multiple Car Solutions

Since it seems that all multiple-car solutions are superior to corresponding single-car solutions, the multiple-car solutions will be discussed in greater detail. In the process of computer analysis of the data, a set of 15 potential subterminal sites located in the relatively heavy production areas were hand-picked as the set from which the optimal number would be selected. From the 15 sites, the optimal ones were determined by a process of trial and error. This was done for each of the four rail options.

The optimal number of subterminals for each of the four options is nine. Table 8 shows the optimal subterminal locations for each rail option. The optimal set of elevators is the same for the first and second options and also for the third and fourth. Since Option IV appears to be the best option from the standpoint of maximizing joint net revenue (upgrading and expansion costs aside), a detailed look at the results for Option IV follows.

Option IV--Markets

It will be recalled that Option IV involved a complete upgrading of all existing low-capacity rail line. Since this involved upgrading 395 miles of track, one must consider the superiority of this option as being tentative until upgrading charges are known. All elevators that have rail service in this option are shipping via jumbo hopper cars. If the elevator is located at one of the nine subterminal sites listed above, it also ships via 50-car trains to the Gulf export markets of Galveston and New Orleans.

Option IV optimal grain routing is broken down by quarters of the crop year beginning with October. There is considerable variation in routing from quarter to quarter due to the changing price relationships in each quarter. In Quarter I (October, November, and December), the markets to which corn was sold were Galveston, Fort Smith, Arkansas, and Kansas City. The mode selected for all three markets was rail only. All markets served are shown by commodity, by year, and by quarter, in Table 9. Since transport rates and costs used do not vary by quarters, the shifting of markets is a result of the changing spatial price relationship from quarter to quarter. Table 10 shows the annual receipts of grain by market for the optimal solution.

Table 8

OPTIMAL SUBTERMINAL LOCATIONS TO HANDLE CORN AND SOYBEANS FOR EACH RAIL OPTION, NORTHWEST MISSOURI

Option I	Option II	Option III	Option IV
Chillicothe	Chillicothe	Albany	Albany
Craig	Craig	Chillicothe	Chillicothe
Hamilton	Hamilton	Craig	Craig
Lathrop	Lathrop	Hamilton	Hamilton
Phelps City	Phelps City	Lathrop	Lathrop
Princeton	Princeton	Phelps City	Phelps City
Ravenwood	Ravenwood	Princeton	Princeton
St. Joseph	St. Joseph	St. Joseph	St. Joseph
Trenton	Trenton	Trenton	Trenton

Table 9

OPTIMAL MARKETS FROM NORTHWEST MISSOURI FOR CORN AND SOYBEANS, BY QUARTER*
(MARKET YEARS 1979-80 AND 1984-85 COMBINED)

1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Corn			
Rail to Galveston	Rail to Galveston	Rail to Galveston	Rail to Fort Worth
Rail to Fort Smith	Truck-Barge to New Orleans	Rail to Quincy	
Rail to Kansas City	Rail-Barge to New Orleans		
Soybeans			
Rail to Galveston	Rail to Galveston	Rail to Galveston	Rail to Galveston
Truck-Barge to New Orleans	Truck-Barge to New Orleans	Rail to St. Louis	Rail to St. Louis

*First quarter includes the months of October, November and December; 4th quarter includes July, August and September.

Table 10

ANNUAL RECEIPTS OF GRAIN FROM NORTHWEST MISSOURI BY MARKETS SELECTED IN THE OPTIMAL SOLUTION[1]

(Bushels)

Corn	1980	1985
Rail to Galveston	14,116,611	14,706,592
Rail to Fort Smith	5,459,360	5,644,798
Rail to Kansas City	14,633	--
Truck-Barge to New Orleans[2]	9,637	7,934
Rail-Barge to New Orleans[2]	15,656	12,890
Rail to Quincy	839,272	884,268
Rail to Fort Worth	2,838,996	2,950,235
Soybeans	**1980**	**1985**
Rail to Galveston	24,945,568	27,576,576
Truck-Barge to New Orleans	618,049	708,610
Rail to St. Louis	2,044,690	2,301,090

[1] The results of the model do not lend themselves to statistical testing. Numbers of relatively small magnitude may be statistically insignificant.

[2] Rail-Barge transloads at Kansas City.
Truck-Barge transloads at four Missouri River points.

Option IV--Routing

There are several ways in which grain can move from origin to market. Where subterminals exist, grain can move from the farm to a country elevator and then to a subterminal before going to market. This study allows grain to go to either or both in pursuit of maximum net revenue, but direct farm-to-market movements are not allowed.

Table 11 shows, for each quarter, the number of country elevator locations from the list of 58 (67 minus 9 subterminal locations), which are completely bypassed--that is, which receive no grain in those periods. For example, the 1980 routing of corn in the first quarter leaves 23 country elevator locations without corn receipts. Fifteen locations receive no corn during the entire crop year.

The projected receipts of elevators and subterminals are shown in Tables 12 and 13.

Table 11

NUMBER OF COUNTRY ELEVATOR LOCATIONS NOT RECEIVING A PARTICULAR COMMODITY, UNDER OPTIMAL ROUTING, NORTHWEST MISSOURI, BY QUARTER AND MARKETING YEAR, 1979-80 AND 1984-85*

	CORN								SOYBEANS							
	1979-80				1984-85				1979-80				1984-85			
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
Locations Without Receipts	23	55	28	15	25	52	29	19	48	48	12	7	48	48	12	7
Locations Without Receipts, Entire Year			15				16				6				6	

*For purposes of this study, the 1979-80 and 1984-85 marketing years for corn and soybeans begin with the last quarter of calendar years 1979 and 1984. Thus, marketing year 1979-80 extends from October, 1979 through September, 1980, with Quarter I corresponding roughly with the harvest season.

Table 12

PROJECTED OPTIMAL ANNUAL COUNTRY ELEVATOR RECEIPTS IN BUSHELS, RAIL OPTION IV, MULTIPLE CAR SOLUTIONS, NORTHWEST MISSOURI

	Corn		Soybeans	
	1980	1985	1980	1985
Barnard	0	0	95,425	110,941
Bethany	132,748	142,323	21,226	22,902
Bigelow	141,072	145,327	4,812	5,710
Blythedale	258,371	273,336	52,796	57,742
Braymer	571,299	717,418	70,296	80,810
Breckenridge	50,284	48,926	29,377	34,858
Brookfield	0	0	27,694	30,164
Browning	46,903	38,618	25,156	26,812
Bucklin	0	0	18,463	20,109
Cameron	268,593	272,777	24,460	31,007
Chula	69,346	105,100	39,219	44,981
Conception Junction	89,564	96,673	39,229	45,030
Corning	62,463	61,915	10,955	13,864
Cowgill	292,112	310,583	9,466	10,858
Elmo	47,667	47,171	193,760	226,252
Fairfax	72,576	71,943	15,650	19,805
Forest City	1,007,652	1,028,423	71,030	83,819
Fortescue	447,867	461,396	19,660	13,049
Gallatin	269,599	298,879	60,681	67,423
Gilman City	0	0	0	0
Gower	564,870	557,975	17,944	15,596
Grant City	64,333	68,933	25,234	27,704
Green City	2,402	1,976	13,890	14,612
Jamesport	189,490	190,436	36,625	40,849
King City	235,632	254,286	88,214	97,129
Laclede	0	0	10,770	11,730
Langdon	13,469	13,335	0	0
Laredo	144,615	168,686	36,691	40,983
Linneus	0	0	9,231	10,054
Lock Springs	84,981	111,950	19,168	22,049
Maitland	0	0	38,984	45,334
Marceline	0	0	130,215	141,827
Maryville	0	0	345,477	401,690
Maysville	0	0	0	0
Meadville	16,449	31,156	17,159	19,080
Milan	123,342	101,548	85,261	89,407
Mound City	613,474	632,021	32,995	7,358
New Hampton	82,760	88,527	15,412	16,629

Table 12 (cont'd)

	Corn		Soybeans	
	1980	1985	1980	1985
Newtown	43,542	28,136	113,150	133,848
Osborn	11,688	9,711	44,777	49,710
Pattonsburg	207,148	181,777	58,389	64,868
Plattsburg	375,521	370,911	12,281	10,001
Polo	651,888	693,100	22,735	26,067
Ravenwood	0	0	262,875	305,417
Rea	85,012	49,171	35,789	40,963
Ridgeway	75,118	78,711	20,253	26,043
Savannah	22,246	0	46,779	53,413
Sheridan	0	0	235,830	268,953
Skidmore	0	0	25,225	39,321
Spickard	58,353	59,682	103,159	115,233
Stanberry	232,449	250,989	22,510	26,949
Tarkio	336,346	333,010	51,681	65,416
Turney	0	0	0	0
Union Star	17,326	10,150	75,366	83,809
Watson	53,990	60,061	9,390	11,881
Wheeling	29,594	56,088	35,142	47,774
Winnigan	7,235	5,958	0	0
Winston	0	0	0	0

Table 13

PROJECTED OPTIMAL ANNUAL SUBTERMINAL RECEIPTS, RAIL OPTION IV, MULTIPLE CAR SOLUTIONS, NORTHWEST MISSOURI
(Bushels)

Subterminal Location	1980	1985
Corn		
Albany	1,251,638	1,336,193
Chillicothe	590,535	1,065,569
Craig	3,572,313	3,659,116
Hamilton	2,823,570	2,957,445
Lathrop	3,058,723	3,071,928
Phelps City	1,337,902	1,374,099
Princeton	602,612	328,794
St. Joseph	508,660	484,542
Trenton	1,287,171	1,469,058
Soybeans		
Albany	2,585,945	2,896,890
Chillicothe	2,875,874	3,320,740
Craig	3,523,937	2,934,304
Hamilton	2,205,211	2,632,070
Lathrop	1,353,165	1,268,114
Phelps City	2,701,330	3,368,999
Princeton	5,382,320	6,301,375
St. Joseph	2,423,957	2,754,113
Trenton	1,643,242	1,817,090

Option IV--Use of Modes

The movement of grain from farm origin to elevator or subterminal is always by truck. Since Option IV involves upgrading of all low-capacity track, more elevators would be offering the benefits of jumbo hopper shipments. One would therefore expect less farm-to-elevator mileage, because the closest elevator is likely to be located on a heavy rail line. The results seem to bear this out. Table 14 shows the aggregate amount of farm-to-elevator trucking of corn and beans. Since the annual amount of marketings is the same for each option, a higher bushel-mile figure means more road mileage.

Table 14

ANNUAL FARM-TO-ELEVATOR TRUCKING OF CORN AND SOYBEANS FOR ALL OPTIONS, NORTHWEST MISSOURI
(Bushel-Miles)

	Corn		Soybeans	
Option	1980	1985	1980	1985
I	240,067,280	247,792,260	402,669,570	450,621,700
II	249,527,200	257,362,500	406,108,670	454,464,510
III	224,883,660	232,185,330	400,291,330	447,922,940
IV	212,844,850	219,947,840	398,149,890	445,668,610

*All figures assume multiple-car options.

The movement of grain out of the elevators to the markets is accomplished by selecting the mode which leads to maximum net revenue to the farmers, i. e., the low-cost mode. If grain moves directly from the country elevator to market (that is, does not go to a subterminal), it moves by either single-car shipments of jumbo hopper cars, by 810 bu. trucks, or by truck-barge using 810 bu. trucks, to a designated loading point. Table 15 shows how all non-subterminal grain moves to market.

Shipments of grain out of subterminals by mode are shown in Table 16.

Table 15

MODES BY WHICH NON-SUBTERMINAL GRAIN MOVES TO MARKET, OPTION IV
(Bushels)

	Corn		Soybeans	
	1980	1985	1980	1985
Single Car, Jumbo Hopper	8,145,884	8,439,264	2,295,993	2,490,560
Truck	--	--	--	--
Truck-Barge	9,637	7,934	618,049	708,610
Rail-Barge	15,656	12,890		

Table 16

MODES BY WHICH GRAIN MOVES OUT OF SUBTERMINALS, OPTION IV
(Bushels)

	Corn		Soybeans	
	1980	1985	1980	1985
Rail, 50 Car Jumbo Hopper	14,116,611	14,706,592	24,375,533	27,022,531
Rail, Single Car Jumbo Hopper	1,006,377	1,040,037	319,448	271,164
Truck	--	--	--	--
Truck-Barge	--	--	--	--
Rail-Barge	--	--	--	--

Limitations of the Study

The mechanics of this study are based on a modified form of the Stollsteimer location-transhipment model. As such, the results are not subject to statistical hypothesis testing. Hence, the size of some of the numbers may not be statistically significant. The model is merely a method of determining the routings of grain supplies which maximize joint net revenue. Obviously, the results of the model are only as good as the data used as input.

The model assumes a given supply of grain which is to be distributed to a set of markets in any way which will maximize net revenue subject to some restrictions such as the type of trains used, the location of river loading points, etc. The annual and quarterly supplies of grain are separately predetermined and fixed. It is just the routing and market selection that is to be determined.

Furthermore, the model implicitly assumes that the demand for grain at all markets is perfectly elastic at all times: that is, that any market could absorb any amount of grain sent to it at the prices used in the study. This is an important shortcoming and one to which further research efforts ought to be directed. By pre-selecting those markets from which the computer selects the optimal set, one can reduce the possibility that irrelevant markets are selected or that markets may be oversold. The possibility of overselling at a given market cannot, however, be eliminated.

The model also assumes that all net savings due to volume shipments and other economies are fully passed on to the farmer.

Adjustment for Investment Cost of Building Subterminals

As mentioned above, revenue net of variable cost needs to be adjusted to reflect the annualized combined cost of rail and highway upgrading and the cost of expanding some existing elevators to subterminal capacity. Rail and highway upgrading costs are not presented here. However, the annualized cost of upgrading the nine elevator locations to subterminal capacity has been estimated.

Using the equations presented above for calculating expansion costs of elevators and using the inventory of existing capacities, the annualized cost of expansion for each subterminal location has been calculated. It was assumed that St. Joseph elevators required no upgrading. The cost of expanding the other elevators was calculated and aggregated to avoid disclosure problems. The total annualized cost of expanding elevators at subterminal locations to subterminal capacity is presented in Table 17.

Deducting these expansion costs from revenue net of variable cost gives the figures in Table 18. These figures reflect returns from marketings of corn and soybeans, under multiple car options, net of variable costs for handling and transportation and costs for elevator expansion to subterminal capacity, but without adjustment for any necessary rail and/or highway upgrading costs.

Table 17

ESTIMATED ANNUALIZED COST OF EXPANDING NINE COUNTRY ELEVATOR LOCATIONS TO SUBTERMINAL CAPACITY, NORTHWEST MISSOURI
(Multiple Car Options Only)

Option I	--	$1,099,138	Option III	--	$1,083,332
Option II	--	$1,099,138	Option IV	--	$1,083,332

Source: Iowa State University equations and Missouri Elevator Survey.

Table 18

GRAIN REVENUE NET OF VARIABLE HANDLING AND TRANSPORTATION COSTS AND ELEVATOR EXPANSION COSTS, NORTHWEST MISSOURI
(Multiple Car Options Only)

(Thousands of Dollars)

	1980	1985
Option I	$264,919	$288,528
Option II	$264,899	$288,507
Option III	$265,038	$288,646
Option IV	$265,062	$288,670

Source: Table 7 and Table 17.

CHAPTER V

SUMMARY AND CONCLUSIONS

This study has attempted to provide information necessary to determine the most economically efficient transportation system for handling the projected corn and soybeans produced in a 16-county area of northwest Missouri and marketed outside of the area in 1980 and 1985. A computerized location-transhipment model was used to select a pattern of rail lines, train sizes and intermodel service combinations, and numbers and locations of country elevators and subterminals, which would maximize farmer revenue from grain sales net of transportation and handling costs. Four different rail options were evaluated, including the present system, for projected marketings.

The results of the analysis produced the following conclusions:

1. Multiple car solutions including subterminals produced higher net revenues than single car solutions with no subterminals for corn and soybeans for both years.
2. The optimal number of subterminals for each rail option would be nine.
3. Option IV, which involves converting all existing track to heavy line to carry 100-ton jumbo hopper cars, is the maximum net revenue option before considering rail and highway upgrading costs and subterminal investment.
4. Under Option IV, the Galveston rail market gets the bulk of both corn and soybeans from the area in both years.
5. Corn is marketed in more locations than soybeans.
6. Several country elevators would be without receipts for marketing outside the study area under the optimal pattern during the various quarters of the marketing year. The largest number bypassed would occur during the harvest quarter (Oct-Dec) and the one immediately following.
7. The optimal rail pattern with multiple car solutions and subterminals reduces the amount of truck mileage by farmers to get grain to the elevators which give access to the best markets.
8. After deducting the annualized cost of converting country elevators to subterminals, Option IV with multiple car rates gives the maximum net revenue, but is only a few thousand dollars better than the

other options. It is not likely that the difference would pay the cost of upgrading rail lines and highways necessary to implement Option IV.

It is appropriate to seek the general or overall conclusion and value from this study. The study suggests that whether there is all heavy rail line or the existing system is not crucial for the study area as it affects the revenue of grain farmers. The market options or transportation costs were not that different for the alternate rail options. What was more important was the existence of subterminals on heavy line and the use of multiple-car rates. This could provide as much as 2.4 to 2.6 million dollars per year in farmer net revenue before considering elevator, rail line and highway upgrading costs.

The study does suggest that not all 67 country elevator locations are necessary to provide for an efficient system for the marketing and transporting of corn and soybeans outside of the production area. As is usually the case, the study asks more questions than it answers, but it does support the idea of many that transportation and facilities problems must be worked out together to provide for economically efficient marketing of grain.

REFERENCES

1. Agricultural Statistics (issues 1966 through 1974), USDA, U.S. Government Printing Office, Washington, 1974.

2. "American Agriculture, Its Capacity to Produce," USDA-ERS #544, February 1974.

3. Arrow Transportation Company, Guide to Published Barge Rates on Bulk Grain, Schedule No. 8, October 1972.

4. Baumel, C.P., Thomas P. Drinka, Dennis R. Lifferth and John Miller, An Economic Analysis of Alternative Grain Transportation Systems: A Case Study, Iowa State University, Prepared for Federal Railway Administration, PB-224819, November 1973.

5. Baumel, C. Phillip, Robert N. Wisner, Thomas E. Fenton, Dennis R. Lifferth, John J. Miller, Projected Quantities of Grain and Fertilizer to be Transported by Counties, Iowa,1979-80 and 1984-85, Center for Agricultural and Rural Development, Iowa State University, Ames, Iowa, CARD Report 52, November 1972.

6. Isard, Walter, Location and Space Economy (New York: John Wiley and Sons, 1956).

7. Ladd, George W. and Dennis R. Lifferth, "An Analysis of Alternative Grain Distribution Systems." American Journal of Agricultural Economics, 57:420-430, August 1975.

8. Lefeber, L., Allocation in Space: Production Transport and Industrial Location, (Amsterdam: North Holland Publishing Company, 1958).

9. Missouri Farm Facts, (issues 1960-1974), Missouri Department of Agriculture.

10. Rand McNally and Co., Handy Railroad Atlas of the United States, New York, 1973.

11. Schienbein, Allen, "Costs of Storing and Handling Grain in Commercial Elevators, Projections for 1974-75," USDA, Feed Situation, FDS-252, February 1974.

12. Stollsteimer, John F. "A Working Model for Plant Numbers and Location," Journal of Farm Economics, 45:631-645, August 1963.

REFERENCES Cont'd.

13. U.S. Interstate Commerce Commission, Explanation of Rail Cost Finding Procedures and Principles Relating to the Use of Costs, Statement No. 7-63, Washington, D.C., November 1963.

14. U.S. Interstate Commerce Commission, Rail Carload Costs Scales 1972, Statement No. 1C1-72, Washington, D.C., October 1974.

15. U.S. Interstate Commerce Commission, Waterways Freight Bureau, Supplement 76 to Tariff 7, ICC 10, Washington, D.C., August 30, 1974.

16 "U.S. Soybean Economy in the 1980's," USDA-ERS #518, April 1973.

APPENDIX A

TRUCK AND TRACTOR-WAGON COSTS

The movement of bulk agricultural commodities by truck is unregulated. Hence the use of truck costs serves as a good proxy for price. In this study engineering-type truck and tractor-wagon costs were developed.

In the model, trucking of grain can appear in several ways. Virtually all hauling from the farm origin to the elevator or subterminal is by truck or tractor-wagon. To determine the relative importance of each mode in the farm-to-elevator movement of grain, a survey of 80 farmers was taken. This revealed that approximately 50% of farm-to-elevator grain movements went by 300 bu. trucks, while 12.5% went by 450 bu. trucks and 37.5% went by wagon. The calculation of costs for each type of vehicle follows. The equation below was used to calculate the cost of farm-to-elevator movement of grain.

$$X = (.0046)\frac{3}{8}M + (.00288)\frac{1}{8}M + (.0036)\frac{4}{8}M$$

$$\text{or } X = .003885\ M$$

where
X is cost in cents per bushel
M is mileage to the elevator
Number in parentheses are cost coefficients whose derivation follows.

Besides farm-to-elevator trucking, there is the possibility of elevator-to-subterminal trucking and also of elevator- or subterminal-to-market trucking. In the case of elevator-to-subterminal movements the following equation was used.

$$X = (.00288)\frac{3}{4}M + (.00092)\frac{1}{4}M$$

$$\text{or } X = .00239\ M$$

Here it is assumed that only 450-500 bu. trucks and 810 bu. tractor-trailer trucks will be used in a 3/4 : 1/4 split. This split is based on information obtained from an Iowa State University study.

Truck movements from elevator or subterminal to market are assumed to involve only 810 bu. tractor-trailer trucks.

The development of the cost coefficients for 300 bu., 450-500 bu., wagon, and 810 bu. trucks follows.

Truck Costs (300 Bushel Farm Truck)

Methodology*

Operating costs are separated into three categories: variable cost which varies directly with mileage, fixed costs which do not depend on mileage, and transfer costs which vary directly with the number of trips per year.

Fixed costs include:

(1) Depreciation
(2) Interest
(3) License fees
(4) Insurance

Variable costs include expenses for:

(1) Fuel
(2) Oil
(3) Tires
(4) Wages
(5) Maintenance and Repairs

Transfer costs include the costs of loading and unloading. These are represented by the wage-cost of loading and unloading time.

Assumptions

(1) The truck under consideration is a 300 bu., gasoline engine, single axle grain truck having a 16 ft. bed with hoist.
(2) The truck will travel a total of 2,000 miles per year, 673 of which will be for purposes of hauling grain.
(3) Average speed will be 28 m.p.h.
(4) Average fuel consumption will be 7 m.p.g.
(5) Average one-way trip distance will be 8 miles.
(6) During the course of the year, the truck will make 42 trips to the elevator.

These assumptions are consistent with the results of a survey of Northwest Missouri grain farmers.

*The methodology used in the estimation of operating costs of farm trucks basically parallels that used by Iowa State University with the exception that fixed costs of truck operation are apportioned to grain use in accordance with the percentage of total mileage due to grain hauling.

I. Fixed Costs

(1) Depreciation and Interest

Based on prices obtained from five new truck dealers, the purchase price of a new grain truck as described was estimated to be approximately $10,000.

Assume a 10 year life and a salvage value of $6,400. (Past experience has shown that used truck prices move with new truck prices in such a way that in ten years the dollar value of the truck declines approximately 36%. For example, according to the dealer, a 1965 truck which sold new for $5,000 in 1965 was worth about $3,200 in 1975. The same rate of non-deflated depreciation is used above.)

Both the depreciation charge and the interest charge can be calculated together by using the formula for "annual equivalent cost" shown below. Basically, this involves the application of the capital recovery factor to the difference between the purchase price and the discounted salvage value. The "annual equivalent cost" (A. E. C.) is given by the formula:

$$\text{A.E.C.} = P\frac{i(1+i)^n}{(1+i)^n - 1} - P_s\frac{i}{(1+i)^n - 1}$$

where P = Purchase Price
P_s = Salvage Value (not discounted)
i = Interest Rate
n = Life of the Asset

using a 10% interest rate with the figures above yields:

$$\text{A.E.C.} = \$10,000\left(\frac{.1(1.1)^{10}}{(1.1)^{10} - 1}\right) - \$6,400\left(\frac{.1}{(1.1)^{10} - 1}\right)$$

$$\text{A.E.C.} = \$1,225.72/\text{yr.}$$

Therefore, together, interest and depreciation charges amount to $1,225.72 annually.

(2) License Fees

The truck in this study has a gross vehicle weight of 30,000 pounds.

The Missouri Department of Revenue license fee for a truck of gross vehicle weight between 24,001 and 30,000 is $45.50 annually. This fee applies to local plates only. This plate restricts non-farmers to a municipality plus 25 miles therefrom. Farmers, however, are unrestricted in hauling their own products.

Adding the fee for the required annual inspection gives:

$45.50	License plate
3.50	Annual inspection
$49.00	Annual license cost

(3) Insurance

Naturally, insurance costs vary with type of coverage, insurance company, age of vehicle, and locality. Estimates from several insurance companies yielded premiums from $85 per year to $273 per year. This study assumes an annual premium of $150.

II. Variable Costs

(1) Fuel and Oil

Using a gasoline price of 40¢ per gallon, fuel costs per mile can be calculated as:

$$\text{Price per gallon/miles per gallon} = \frac{\$.40}{7} = \$.0571$$

According to dealer estimates, oil should be changed every 3 months (500 miles) with a new filter once a year.

One oil change without filter requires four quarts of oil.

Using a price of $.55 per quart, one oil change is $2.20. This annual oil cost is:

$$\$2.20 \times 4 = \$8.80$$

Once a year a new filter is added at $2.50. When a filter is changed, an additional quart of oil is required. So, once a year there is additional cost of $3.05:

$2.50	Filter
.55	Quart of oil
$3.05	

Therefore, the cost of oil per mile becomes:

$$(\$8.80 + \$3.05)/2,000 = \$.0059$$

(2) Tires

Tire prices were obtained from three major tire companies. For a 900-20 10-ply tire, prices average $100 and $120, front and rear, respectively. On farm trucks the life depends on road surfaces and weather perhaps as much as it does on mileage. It is assumed that tires will last 28,000 miles.

Tire expenses per mile = Tire cost/tire life

= (200 + 480)/28,000 = \$.0243 per mile

(3) Wages

It is assumed that farm truck drivers are non-union drivers and are general farm laborers. The Missouri State Employment Service figures on wages paid to laborers in the field of Farm, Fishery and Forestry show an average of \$2.40 per hour.*

Assuming the farm truck driver is paid \$2.40 per hour, the wage cost per mile is calculated as:

$$\frac{\text{Wage Cost}}{\text{Per Mile}} = \frac{\text{Hourly Wage}}{\text{Miles Per Hour}} = \frac{\$2.40}{28} = \$.0857/\text{mi.}$$

(4) Maintenance and Repairs

The farm truck survey produced an average annual figure of \$276.36 for general maintenance and repairs on 300 bu. trucks. Using this figure gives maintenance and repair per mile of:

$$\frac{\$276.36}{2,000} = \$.13818 \text{ per mile}$$

III. Loading and Unloading Costs

No loading time is charged in this analysis since trucks are usually loaded in the field and such costs are chargeable to grain production.

It is assumed that the truck will make 42 trips per year (673/16). The truck survey indicated that an average unloading time (waiting and dumping) was:

68 minutes -- at harvest
10 minutes -- otherwise

Using a harvest period of 2 months (October and November) and assigning weights of 2 and 10 to the harvest and non-harvest times respectively, the overall average waiting time is calculated as:

$$\frac{68(2) + 10(10)}{12} = 20 \text{ minutes}$$

hence,

$$42 \text{ trips} \times \frac{20}{60}(\$2.40) = \$33.60 \text{ total unloading cost per year.}$$

*Based on Missouri State Employment Service job orders.

Summarizing

Total Operating Costs

Fixed Costs

Depreciation and Interest	$1,225.72/yr.
License Fees	49.00/yr.
Insurance	150.00/yr.
Total Fixed Costs	$1,424.72/yr.

Variable Costs

Gas	$.0571/mi.
Oil	.0059/mi.
Tires	.0243/mi.
Wages	.0857/mi.
Maintenance and Repairs	.1382/mi.
Total Variable Cost/Mile	$.3112/mi.

Transfer Costs $33.60/yr.

As noted above, only part of the total fixed cost is chargeable to grain movement. Grain miles constitute 34% of total annual mileage. Thus only 34% of fixed costs will be included in the costs of hauling grain.

$$\text{Total Fixed Costs} \times \frac{\text{Grain Miles}}{\text{Total Miles}} = \text{Fixed costs chargeable to grain}$$

$1,424.72 x .34 = $484.40

Adding the transfer costs of $33.60 to the grain fixed costs gives:

$484.40	fixed costs chargeable to grain
33.60	transfer costs
$518.00	annual costs which do not vary with mileage

Spreading this cost over the 673 grain miles gives a fixed cost per mile of:

$518.00/673 = $.770

Therefore, we have:

$ .770	FC/mi.
.311	VC/mi.
$1.081	TC/mi. (grain only)

Costs Per Bu. Per Mile

$$\frac{\$1.081}{300} = \$.0036 \text{ per bu. per mile } (.36 \text{ cents})$$

Breakdown of All Costs per Mile

		Cost/Mi.	% of TC/Mi.
A. E. C.	($1224.74 x .34) ÷ 673 =	$ .619	57
License	($49.00 x .34) ÷ 673 =	.025	2
Insurance	($150.00 x .34) ÷ 673 =	.076	7
Transfer	$33.60 ÷ 673 =	.050	5
Gas		.0571	5
Oil		.0059	1
Tires		.0243	2
Wages		.0857	8
Maintenance and Repairs		.1382	13
TC/mi.		$1.0812	100

Note: a 10¢ change in gasoline prices increases the TC/mi. by about 1½¢.

Truck Costs (450 Bushel Farm Truck)

Assumptions

(1) A 450 gasoline engine, single axle grain truck with an 18 foot bed, with hoist.
(2) The truck travels a total of 2,000 miles per year, 673 of which are for the purpose of grain hauling.
(3) Speeds average 28 mph.
(4) Gasoline consumption averages 6 mpg.
(5) Average one-way distance to the grain elevator is 8 miles.
(6) The truck makes 42 trips per year.

I. Fixed Costs

Purchase Price	$13,500
Salvage Value	$8,600
Life	10 years
Interest Rate	10%

(1) Depreciation and Interest: Annual Equivalent Cost

$$AEC = \$13,500\left(\frac{.1(1.1)^{10}}{(1.1)^{10} - 1}\right) - \$8,600\left(\frac{1}{(1.1)^{10} - 1}\right)$$

$$AEC = \$13,500\ (.1627) - \$8,600\ (.0627)$$

$$AEC = \$1,657.23/\text{year}$$

(2) License Fees: Assuming a gross vehicle weight of between 36,000 and 42,000 pounds, the Missouri license fee (local plates) is $100.50 annually. Adding the $3.50 annual inspection fee gives license fees of $104.00 per year.

(3) Insurance: Assume an annual premium of $150.

II. Variable Costs

(1) Fuel and Oil: 6 miles per gallon @ 40¢ per gallon gives $.40/6 = $.0667/mi.
Oil cost remains at .0059 (see 300 bu. estimate).
Total = $.0667 + $.0059 = $.0726

(2) Tires: Tire expenses per mile = $.0243 (see 300 bu. estimate).

(3) Wages: wage cost per mile = $.0857 (see 300 bu. figure).

(4) Maintenance and Repairs: using annual maintenance costs of $197.14 (see farm truck survey), maintenance costs per mile are

$197.14/2000 = $.09857/mile

III. Loading and Unloading Costs

No loading costs included.
Unloading costs per year = $33.60 (see 300 bu.).

Summarizing

Fixed Costs	
Depreciation and Interest	$1,657.23
License Fees	104.00
Insurance	150.00
Total Fixed Costs	$1,911.23/yr.

Variable Costs	
Fuel and Oil	$.0726
Tires	.0243
Wages	.0857
Maintenance and Repairs	.0986
Total Variable Costs	$.2812/mi.

Transfer Costs	$33.60/yr.

Allocating fixed costs to grain handling:
$1,911.23 x .34 = $649.82 (see 300 bu. estimate)

Plus annual transfer costs gives:
$649.82 + $33.60 = $683.42

Fixed costs per mile are $683.42/673 = $1.015/mile

Total costs per mile are $1.015 + .281 = $1.296/mile

Total costs per bushel per mile are $1.296/450 = $.00288/bu./mile.

Tractor-Wagon Hauling Costs

Assumptions

(1) An 80-90 horsepower farm tractor with cab and air conditioning (single wheel).
(2) A 250 bu. side dump wagon with 10 ton running gear without brakes.
(3) Tractor-wagon speeds of 10 mph.
(4) Total annual miles of grain hauling is 500.
(5) Average one-way distance to the elevator is 5 miles.
(6) Tractor fixed costs are not allocated to grain hauling.

I. Fixed Costs

Wagon Purchase Price	$1000 ($500 box, $500 running gear)
Salvage Value	0
Life	12 years
Interest Rate	10%

(1) Depreciation and Interest

AEC = $146.76

(2) License Fees: none.

(3) Insurance: none.

Tractor fixed costs not charged to grain hauling.

II. Variable Costs

Wagon

(1) Tires: Assume replaced every 7 years (ordinary auto tires).

$$\text{Tire cost/year} = \frac{\$25 \times 4}{7} = \$14.28$$

$$\text{Tire cost/mile} = \frac{\$14.28}{500} = \$.0286/\text{mile}$$

(2) Maintenance and Repairs: negligible, therefore ignored.

Tractor

(1) Fuel and oil: Assume fuel consumption is 7 gallons per hour; at 10 mph this gives .7 miles per gallon.

Using bulk price of diesel fuel (tax not included) of \$.34 per gallon, fuel costs are

$$\frac{\$.34}{.7} = \$.4857 \text{ per mile.}$$

Assuming one oil change every 100 hour s with new filter gives:

9 quarts @ \$.55 = \$4.95
1 filter @ \$2.50 = \$2.50

Cost of oil change = \$7.45

Since only 50 hours of tractor time are chargeable to grain hauling (500 miles @ 10 mph), one half of the \$7.50 is charged to grain hauling. Hence

$$\text{Oil cost per mile} = \frac{(\$7.45)/2}{500} = \$.0075/\text{mile}$$

(2) Driver's wages: using \$2.40 per hour gives

$$\text{Wage per mile} = \frac{\$2.40/\text{hr}}{10 \text{ mph}} = \$.24$$

(3) Tires: Assume a 5 year life.

Tire Costs:

Front Pair (11-L-16)	Rear Pair (16-9-34)	Total	Total Per Year
\$100	\$400	\$500	\$100

Allocated to grain hauling (assume 12% of total wear) \$100 (.12)/500 = \$.024

(4) Maintenance and Repairs: ignored.

III. Transfer Costs

50 trips per year : $50 \times \frac{20}{60}(\$2.40) = \$40/\text{yr}$ (see 300 bu. truck estimate).

$$\text{Transfer costs per mile} = \frac{\$40}{500} = \$.08/\text{mile}$$

Summarizing

Fixed Costs (wagon only)

Depreciation and Interest \$146.76/yr \$.294/mi.

Variable Costs	
Wagon	
Tires	$.0286/mi.
Tractor	
Fuel and oil	$.4932/mi.
Wages	.2400/mi.
Tires	.0240/mi.
Transfer Costs	.0800/mi.
Total Costs per Mile	$1.1598
Total Costs per Bu. Mile	$ .0046

Tractor-Trailer Truck Costs

Assumptions

(1) An 810 bu. tractor-trailer truck with GVW of 73,280 lbs., 48,000 lbs. net.
(2) Truck travels an average of 80,000 miles per year.
(3) Average speed of 50 mph.
(4) Fuel consumption averages 5 mpg.

I. Fixed Costs

(1) Depreciation and Interest

Tractor Price	$25,000	
Trailer Price	$9,500	(flat aluminum)
Salvage Value		
Life	5 years	
Interest Rate	10%	

AEC = $6,365.91/year

(2) License Fees

Missouri beyond local rate for 72,000 lbs.:

$1,050.00	license plate
$25.00	PSC fee for all Missouri carriers
$1,075.00	/ year per truck

(3) Insurance

Tractor and Trailer	$2,500/ year
Cargo	100/ year
Total	$2,600/ year

(4) Road Use Taxes: (Federal Form 2290)

$220/year

II. Variable Costs

(1) Fuel and Oil: Using a price of $.46 per gallon, fuel cost per mile:

$$\frac{\$.46}{5 \text{ mpg.}} = \$.092$$

Assuming an oil change every 4,000 miles at a cost of $7.80 gives

$$\text{Oil cost per mile} = \frac{\$7.80}{4,000} = \$.002$$

(2) Tires: Using an average price of $150 per tire and tire life of 70,000 miles on steering axle tires and 120,000 miles on others gives

$$\frac{(\$150) \times 2}{70{,}000} + \frac{(\$150) \times 16}{120{,}000} = \$.02428/\text{mile}$$

(3) Wages:

$$\frac{\$5.00/\text{hr}}{50 \text{ mph}} = \$.10/\text{mile}$$ (using $5.00/hr obtained from interviews)

(4) Maintenance and Repairs

Interviews yield an average of $3,200 /year

Thus, $\frac{\$3{,}200}{80{,}000} = \$.03995/\text{mile}$

III. Transfer Costs

From interviews:

average loading time:	1 hour
average unloading time:	2 hours
total	3 hours

3 x $5.00/hr. = $15.00/trip

Summarizing

Fixed Costs

Depreciation and Interest	$6,365.91/yr.
License Fees	1,075.00/yr.
Insurance	2,600.00/yr.
Road Use Taxes	220.00/yr.
	$10,260.91/yr.
	$.128/mi.

Variable Costs

Fuel and Oil	$.094/mi.
Tires	.024/mi.
Wages	.100/mi.
Maintenance and Repairs	.400/mi.
Transfer Costs	$15.00/trip
Total Costs per Mile (excluding Transfer Costs)	.746/mi.
Total Costs per Bushel per Mile	.00092

APPENDIX B

RAIL COSTS

Rail costs were estimated by adjusting figures from the ICC Publication, Rail Carload Cost Scales, 1972. This publication shall be referred to as The Scale. The publication provides cost scales based upon the 1972 operations of all class I line-haul railways (those with revenues of $5,000,000 or more). The costs are developed from computer processed Rail Form A. The data in the publication are presented for seven rail territories. Region V, the "Western district, excluding Mountain Pacific and Trans-Territory" was selected for the analysis of rail costs. A detailed explanation of the procedures used by the ICC in calculating the costs which appear in The Scale can be found in Statement No. 7-63, Explanation of Rail Cost Finding Procedures and Principles Relating to the Use of Costs published by the ICC's Bureau of Accounts.

The figures reported for Region V reflect the overall average of all operations in that region. Since the movement of grain is of interest here, several adjustments have been made to reflect the specifics of grain hauling. A total of five adjustments were made. These are:

1. Inclusion of loss and damage payments
2. Adjustment of average loads
3. Adjustment of tare weights
4. Adjustment of train type
5. Adjustment of the origin and destination portion of freight train car costs.

Each adjustment is made according to the procedures outlined in The Scale. All adjustments were made to Table 3 of The Scale from which Tables 1 and 2 of the scale are derived. The information on which the adjustments are based was obtained through consultation with railroads in the territory, principally the Milwaukee Road and the Rock Island Line. A description of each adjustment follows.

Inclusion of Loss and Damage Payments

Table 3 of The Scale does not include payments for loss and damages. Appendix A on page 180 of The Scale shows average United States claim payments per hundred-weight originated, by commodity classes.

Line 3 of Appendix A shows average grain payments of .299¢ per cwt. originated. Hence, .299¢ is added to the terminal costs per cwt. shown in column (7) of Table 3.

Column (7) of Table 3 becomes .035 + .299 = .334¢ (hopper assumed to be one-fourth of this).

Since there are no figures to show how length of haul affects loss and damage payments, the same figure is used for all hauls.

Adjustment of Average Loads

Average loads for each car are assumed to be

Box	62.5 tons
Hopper	97.5 tons

instead of those used on page 150 of The Scale. These numbers are used to calculate trailing weights.

Adjustment of Tare Weights

Tare weights are assumed to be

Box	25 tons
Hopper	32.5 tons

instead of the figures shown on page 154 of The Scale. These too are used in calculation of trailing weights. (See Type of Train Adjustment.)

Type of Train Adjustment

Table 3 of The Scale is based on specific trailing weight, number of locomotives and wages. Appendix E on pages 203-205 of The Scale show how these three items are used in the calculation of costs per hundredweight mile. This final figure becomes Column (5) of Table 3. What follows is the format for recalculating costs per hundredweight mile based on the relevant trailing weight, number of locomotives, and wages.

Note: In adjusting Appendix E, no distinction or classification of average, way, or through train was used.

As an example of the type of train adjustment, the table below shows the calculations for a train of 10 box cars (40 ft. general).

Appendix E (of The Scale) Region V

1.	Expense per gross ton-mile	$0.00106	
2.	Weight of train (trailing tons)	[875.0]	
3.	Total gross ton-mile expense	$0.92750	line 1 x line 2
4.	Locomotive unit-mile expense	$0.55844	
5.	Locomotive units per train	[1.0]	
6.	Locomotive costs per train-mile	$0.55844	line 4 x line 5
7.	Other expense per train-mile	$0.62360	
8.	Wages per train-mile	[2.0]	
9.	Total expenses per train-mile	$4.10954	lines (3+6+7+8)
10.	Cost per revenue plus non-revenue gross ton-mile	.46966¢	line 9 ÷ (line 2 ÷ 100)
11.	Ratio of revenue gross ton-miles to total gross ton-miles	.98431	
12.	Cost per revenue gross ton-mile	.47715¢	line 10 ÷ line 11
13.	Cost per hundredweight-mile	.02376¢	line 12 ÷ 20 cwt.

The boxes are filled as follows:

Line 2--Weight of Trains: 10 box cars @ 87.5 (tare + load) tons each = 875 tons.

Line 5--Locomotive Units Per Train: This example assumes one 1,500 hp., 4 axle unit. In this study only two train sizes were used: ten-car hopper or ten-car box, and 50-car hopper. All ten-car trains are assumed to require only one locomotive unit while the fifty-car train is assumed to require two, 3,000 hp. 6 axle units.

Line 8--Wages Per Train Mile: Since it is difficult to find a simple relationship between train size and wages per train mile, this study used the following constants:

10 car train	$2.00
50 car train	$2.50

Line 13 of the table above becomes column (5) of Table 3 of The Scale.

Changes in train type also necessitate changing column (4) of Table 3. This is accomplished in the following format:

original line 12 of Appendix E	.23585¢
less new line 12	- .47715¢
equals	- .23561¢
Times Box Car Tare Weight	x 25
equals	-5.89025¢
Times 1 plus empty return ratio	x 1.63
equals car mile adjustment	-9.60111¢

Therefore,

Column 4, Table 3	24.62396¢
less car mile adjustment	-(-9.60111)¢
equals new column 4, Table 3	34.22507¢

Origin and Destination Portion of Freight Train Car Cost Adjustments

Table 3 of the Scale includes ownership costs per car, including maintenance, depreciation and allowance for cost of capital. These are shown separately and can be deducted. The adjustment here consists of deducting these costs, recalculating them using the capital recovery formulation, and adding them back into Table 3. The following were assumed:

Car Prices
Box: \$21,500 Hopper: \$26,500

Life
Box: 25 years Hopper: 25 years

Salvage Value
Box: \$2000 Hopper: \$2500

Tax
Box: \$200 Hopper: \$250

Interest Rate: 10%

Serviceable Car Days Per Year: 341

Using the capital recovery based "annual equivalent cost" (AEC) formula, where

$$AEC = P \frac{i(1+i)^n}{(1+i)^n - 1} - P_s \frac{i}{(1+i)^n - 1}$$

where P = purchase price = \$21,500 (box car)
n = life of car = 25 years
i = interest rate = 10% (assumed)
P_s = salvage value = \$2,000

then AEC = \$2348.27

thus AEC + Annual Tax = \$2348.27 + \$200.00 = \$2548.27

then Per Diem AEC = $\frac{\$2548.27}{(341)}$ = \$7.4729

This figure is used to determine adjusted ownership costs as follows: Assume a trip involves 7 days turn around time. Then

7 x \$7.4729 = \$52.3103

represents the ownership costs for the haul. In Table 3, Column 6 of <u>The Scale,</u> subtract off the ICC calculated ownership cost and add back that calculated above. This would appear as:

Column 6	ICC ownership cost	
9,187.34¢	-3,232.286¢	= 5,955.054¢

then adjusted Column 6 reads

5,955.054¢ + 5,231.03¢ = 11,186.084¢

Since the number of days for turn around depends on length of haul, this number varies for different trips. This study assumed the following relationship between turn around time and mileage

$$T = 5 + J/600$$

where T is turn around time in days
J is mileage

With these adjustments, Table 1 and Table 2 of <u>The Scale</u> can be generated for various trip lengths according to the format represented in <u>The Scale.</u>

The results of these adjustments for the two train sizes appear below. Since the estimates for single car movements were very high relative to known single car rates and since single car rates are not ordinarily based on the costing of the movement of one car in isolation, the 10-car cost coefficients are used as a basis for single car costs. That is, it is assumed that the 1-10 car rates would be based on 10-car cost coefficients.

10 Car Cost Coefficients Variable Cost
Per Bushel (Cents Per Bushel)

	Box		Hopper	
Miles	Soybeans	Corn	Soybeans	Corn
100	8.69	8.11	6.13	5.73
200	12.31	11.49	8.83	8.24
300	15.92	14.86	11.53	10.76
400	19.53	18.23	14.23	13.28
500	23.15	21.61	16.92	15.80
600	26.76	24.98	19.62	18.31
700	30.38	28.35	22.32	20.83
800	33.99	31.73	25.01	23.35
900	37.61	35.10	27.71	25.86
1000	41.22	38.48	30.41	28.38

50 Car Cost Coefficients Variable Cost
Per Bushel (Cents Per Bushel)

	Hopper	
Miles	Soybeans	Corn
100	5.25	4.90
200	6.88	6.42
300	8.51	7.95
400	10.14	9.47
500	11.77	10.99
600	13.40	12.51
700	15.03	14.03
800	16.66	15.55
900	18.29	17.07
1000	19.92	18.59

APPENDIX C

DIRECTORY OF GRAIN HANDLING ELEVATORS

The following elevators were sent mail surveys. They represent all elevators in the 16-county area believed to be grain handling elevators.

Andrew County

Rea Feed & Grain Co.
Rea, Missouri 64480

Burns Farm Supply, Inc.
Savannah, Missouri 64485

Atchison County

Fairfax Elevator Co.
Fairfax, Missouri 64446

Bentley Grain Co.
Langdon, Missouri 64464

Feeders Grain & Storage Company
Tarkio, Missouri 64491

Stanton Grain Co.
Watson, Missouri 64496

Watson Grain Co.
Watson, Missouri 64496

Langdon Elevator
Langdon, Missouri 64464

Stanton Grain Co.
Rockport, Missouri 64482

Tarkio Pelleting Co.
Tarkio, Missouri 64491

Caldwell County

Consumers Oil & Supply Co.
Braymer, Missouri 64624

Ludlow Braymer Grain Supply Co.
Braymer, Missouri 64624

M.F.A. Exchange Elevator
Cowgill, Missouri 64637

M.F.A. Exchange Elevator
Hamilton, Missouri 64644

Polo Grain Co., Inc.
Polo, Missouri 64671

Clinton County

Cameron Coop Elevator Association
Cameron, Missouri 64429

M.F.A. Exchange Elevator
Cameron, Missouri 64429

Robison Elevator
Lathrop, Missouri 64465

United Cooperatives, Inc.
Plattsburg, Missouri 64477

Turney Elevator
Turney, Missouri 64493

Gower Feeders Supply
Gower, Missouri 64454

Sur-Gro
Plattsburg, Missouri 64477

Daviess County

M.F.A. Exchange Elevator
Gallatin, Missouri 64640

Farmers Produce Company
Jamesport, Missouri 64648

Jamesport Farm Supply, Inc.
Jamesport, Missouri 64648

K&W Farm Service, Inc.
Jamesport, Missouri 64648

M.F.A. Elevator
Lock Springs, Missouri 64654

M.F.A. Elevator
Pattonsburg, Missouri 64670

Windy Ridge Gas & Fertilizer
Winston, Missouri 64689

Pattonsburg Feed Co.
Pattonsburg, Missouri 64670

De Kalb County

MFA Exchange Elevator
Maysville, Missouri 64469

Brock Milling Co.
Maysville, Missouri 64469

United Cooperatives, Inc.
Osborn, Missouri 64474

Gentry County

MFA Elevator
Albany, Missouri 64402

MFA Elevator
Stanberry, Missouri 64489

King City AG Service, Inc.
King City, Missouri 64463

Alldredge Feed & Seed Co.
Stanberry, Missouri 64489

Grundy County

MFA Exchange
Laredo, Missouri 64652

MFA Exchange
Spickard, Missouri 64679

MFA Exchange Elevators
Trenton, Missouri 64683

Hoffman & Reed, Inc.
Trenton, Missouri 64683

Harrison County

CTL Farm Service
Bethany, Missouri 64424

New Hampton Mill & Elevator
New Hampton, Missouri 64471

MFA Exchange Elevators
Bethany, Missouri 64424

Gilman Mill
Gilman City, Missouri 64642

Holt County

Corning Elevator
Corning, Missouri 64435

Community Elevator
Craig, Missouri 64437

White Cloud Grain Co.
Fortescue, Missouri 64452

Cargill, Inc.
Forest City, Missouri 64451

Rother Grain & Feed Co.
Maitland, Missouri 64466

Desert Gold Elevators, Inc.
Mound City, Missouri 64470

Holt County Coop Assoc.
Mound City, Missouri 64470

Mound City Elevator
Mound City, Missouri 64470

Morris Grain Co.
Bigelow, Missouri 64425

Fortescue Elevator
Fortescue, Missouri 64425

Rickel, Inc.
Craig, Missouri 64437

Linn County

Ag-Land, Inc.
Brookfield, Missouri 64628

Cattey Feed & Seed
Brookfield, Missouri 64628

MFA Exchange Elevators
Brookfield, Missouri 64628

MFA, Inc.
Browning, Missouri 64630

MFA Exchange Elevator
Linneus, Missouri 64653

MFA Exchange
Marceline, Missouri 64658

Bucklin Grain
Bucklin, Missouri 64631

Butterfield Grain Co.
Meadville, Missouri 64659

Livingston County

MFA Exchange Elevators
Chillicothe, Missouri
64601

Reeds Seeds, Inc.
Chillicothe, Missouri
64601

Chula Farmers Coop.
Chula, Missouri 64635

Wheeling Grain-Feed
Wheeling, Missouri 64688

Grand River Grain
Chillicothe, Missouri
64601

Milbank Mills
Chillicothe, Missouri
64601

Mercer County

Bryan Feed & Fertilizer
Princeton, Missouri 64673

Nodaway County

Check-R-Board Store
Barnard, Missouri 64423

Fars Elevator Company
of Barnard
Barnard, Missouri 64423

MFA Exchange Elevator
Barnard, Missouri 64423

MFA Exchange Elevator
Conception Junction,
Missouri 64434

MFA Elevator
Elmo, Missouri 64445

Check-R-Board Store
Maryville, Missouri 64468

Consumers Oil Co.
Maryville, Missouri 64468

Nodaway AG Service, Inc.
Maryville, Missouri 64468

MFA State Exchange
Maryville, Missouri 64468

MFA Exchange Elevator
Ravenwood, Missouri 64479

Farmer's Produce
Maryville, Missouri 64468

Sullivan County

MFA Exchange
Green City, Missouri 63545

MFA State Exchange
Milan, Missouri 63556

B.A. Fowler & Sons
Newtown, Missouri 64667

Harris Farm Service
Harris, Missouri 64645

Borron Elevator
Winnigan, Missouri 63566

Worth County

MFA Exchange Elevator
Grant City, Missouri 64456

MFA Exchange Elevator
Sheridan, Missouri 64486

Non-Licensed Warehouses

Farmers Feed Store
Breckenridge, Missouri
64625

Newby Brothers, Inc.
Plattsburg, Missouri 64477

Reeds Seeds, Inc.
Jamesport, Missouri 64648

Owings Mill & Produce
Gallatin, Missouri 64640

Union Star Elevator
Union Star, Missouri 64494

Smith Feed & Grain, Inc.
Blythedale, Missouri 64426

Prairie Vu Enterprises, Inc.
Bethany, Missouri 64424

Consumers Oil Co.
Ridgeway, Missouri 64481

Curley Feed-Grain
Laclede, Missouri 64651

Skidmore Feed Co.
Skidmore, Missouri 64487

Baird Milling Co.
Maryville, Missouri 64468

Jacobs' Sales
Gentry, Missouri 64453

APPENDIX D

RESULTS OF MISSOURI GRAIN MARKETING AND FARM TRUCK SURVEY

This report represents the results of a farm truck survey taken in ten counties of northwest Missouri. The survey was intended to provide some insights into the nature of farm-to-elevator movements of grain.

The sample of grain farmers was drawn from the University of Missouri Extension Division Agricultural Information Mailing List. Only those farmers showing an interest in receiving University publications on small grains, corn, and soybeans comprised the population from which the sample was drawn. To assure geographic distribution, the sample was drawn from the mailing list in such a way that each zip code area in each county was represented.

Counties included in the survey and the distribution of usable responses are listed below.

Counties Surveyed	Number of Questionnaires Mailed	Number of Usable Responses	Percent
Atchison	57	11	19.3
Clinton	56	2	3.6
Daviess	65	5	7.7
Gentry	63	10	15.9
Grundy	60	10	16.7
Harrison	60	5	8.3
Holt	57	10	17.5
Mercer	64	8	12.5
Nodaway	59	14	23.7
Worth	54	8	14.8
Total	595	83	13.9

There were 103 responses, 20 of which were classified as unusable either because no grain was produced, the farm was no longer operative, or the questionnaire was not completed. Twelve questionnaires were returned "undeliverable" because of insufficient or obsolete addresses. Thus, the actual response rate was 17.7% (103/583). The table above shows that the response rate varied considerably from a low of 3.6% in Clinton County to a high of 23.7% in Nodaway County.

Summary of Findings

A copy of this questionnaire as distributed is included at the end of this appendix.

Farm Size. The eighty-three farms ranged in size from 80 acres to 2,000 acres, with the average being 573 acres. The distribution of farm size appears in Figure 1.

Yields. Yield per acre calculated from production figures reported in the questionnaire are:

Corn	98.14 bu. per acre	(n = 74)
Soybeans	32.38 bu. per acre	(n = 63)
Wheat	33.21 bu. per acre	(n = 17)

Farmers in the sample on the average sold:

43.22% of their corn crop to elevators
95.84% of their soybean crop to elevators
74.13% of their wheat crop to elevators.

These figures, of course, do not reflect any subsequent purchases by farmers for feed purposes.

Grain Dryers. The 83 respondents reported on-farm dryers as follows:

40 had no dryer
27 had only one dryer
5 had two dryers
4 had three dryers
3 had more than three
4 no response

Drying Capacity. Since grain dryers vary in size and type, it is difficult to draw any conclusions from the data reported. Drying capacity per hour where one dryer is reported varies from 10 bu. per hour to 860 bu. per hour.

On-Farm Storage. Seventy-five farmers responding to the farm storage question provided an average on-farm storage of 16,468 bu. The range is 500 bu. to 135,600 bu. The distribution of farm storage is shown in Figure 2.

Mileage to Local Elevator. Of 73 respondents, 9 farmers trucked their grain more than 25 miles one way to the sales point. In these cases the grain moved directly to either St. Joseph or Kansas City. One might expect these farmers to rely on hired custom hauling, yet only 3 of the 9 reported using hired trucks.

Excluding these long distance haulers, the remaining 64 farmers moved their grain to elevators over distances which averaged 8.2 one-way miles.

Figure 1. Sample Distribution of Farm Size of Respondents to Farm Truck Survey, Northwest Missouri, 1975

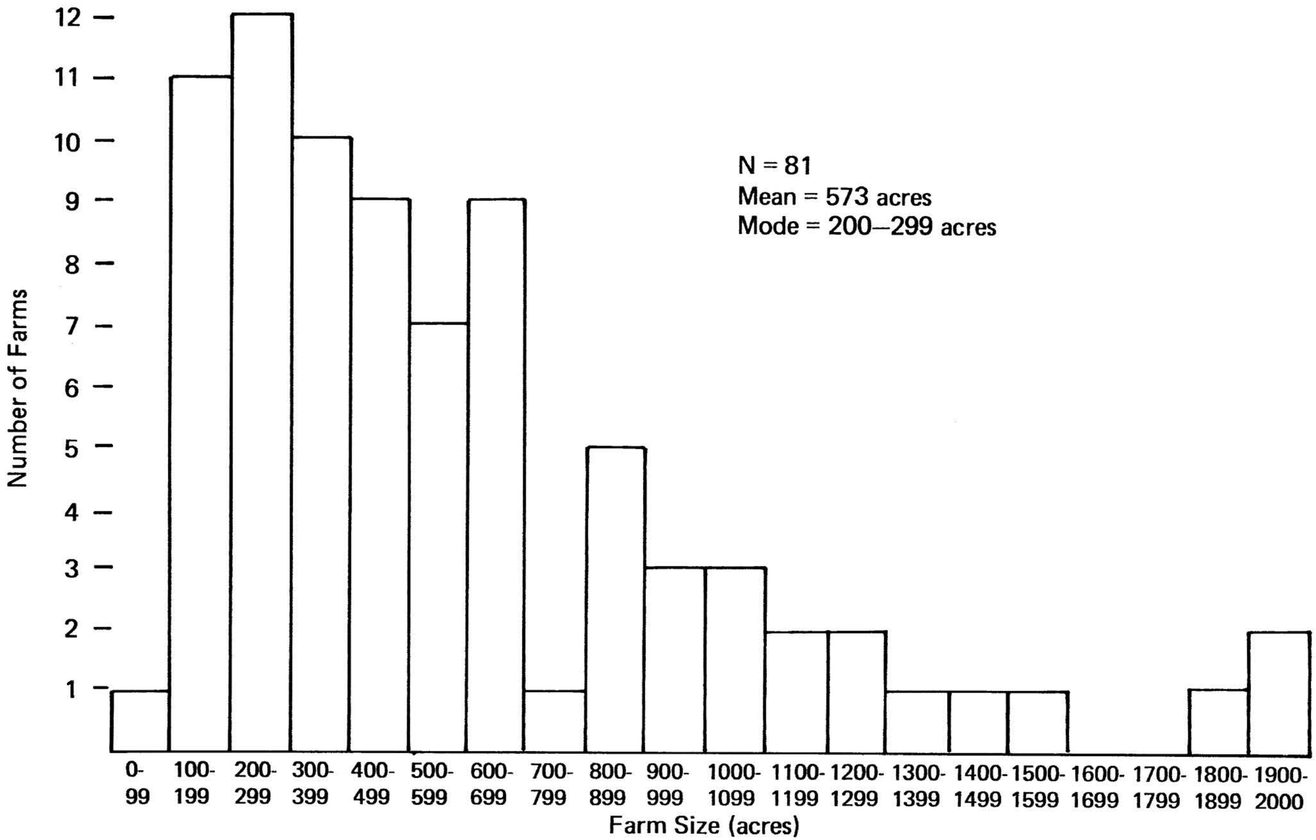
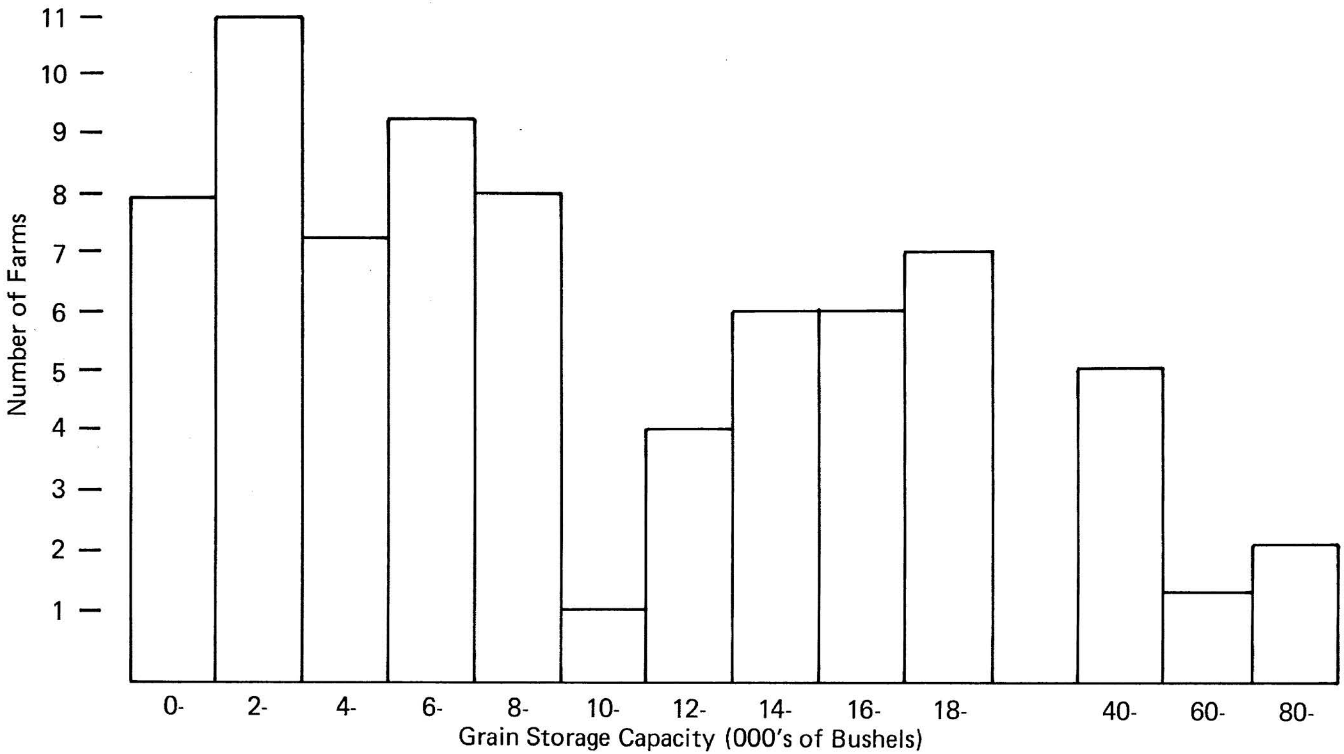


Figure 2. Sample Distribution of Farm Storage Capacity of Respondents to Farm Truck Survey, Northwest Missouri, 1975.



Farm-to-elevator marketing patterns seemed fairly stable. Only 10 of the 83 respondents reported selling grain to a different elevator than during the previous harvest.

Traveling Speed. Data supplied in question no. 9 was used with mileage data to calculate traveling speeds. For wagon movements speeds average 9.9 mph, while truck speeds averaged 28.58 mph.

Waiting Time at Elevator. Question 10 asks for average waiting time for unloading at the elevators. The 66 respondents to this item gave the following distribution:

no waiting	6
5-10 minutes	8
10-15 mins.	16
over 15 mins.	36

Unfortunately the question did not distinguish harvest-time from non-harvest time. Most likely the "no-waiting" respondents were referring to non-harvest times.

Of those in the over 15 minute category, most indicated the specific waiting time. This averaged one hour and 8 minutes.

Backhaul. The survey reveals that 21 farmers (26%) reported some backhauling from the elevator. For those who reported backhauling, the average frequency of backhaul was calculated to be 12.5% of all trips.

Hired Trucking to Elevators. Only 21 of 74 respondents (28.3%) reported using hired or custom hauling of grain to the elevator. The percent of grain crop moved by hired truck was distributed over the 21 respondents as follows:

Percent of Crop Moved by Hired Truck	Number of Respondents
0-50%	5
51-100%	16

From question 12, the custom hauling rates were calculated. These exhibited a wide range of fluctuation, perhaps reflecting the informal hauling arrangements between neighboring farmers or perhaps partial payment in-kind. Rates ranged from:

$.001833 to $.05 per bu. per mile.

The average custom hauling rate was $.010143.

Farmers who hauled some or all of their own grain reported an average of 40% of all truck mileage was due to grain hauling. This figure might serve to allocate fixed costs of farm truck operations to grain hauling.

Type of Farm Truck Used in Grain Hauling. Of the 83 respondents, 24 either did not own farm trucks or failed to respond to question 15. The remaining 59 respondents revealed that:

36 used at least one 300 bu. truck to haul grain,
10 used at least one 450 bu. truck to haul grain,
14 used a pickup truck to haul part of their grain, and
21 used a wagon to haul part of their grain.

Looking more closely at the data on 300 bu. trucks only and combining information from questions 3, 7, 14, and 15 shows that 300 bu. trucks on the average traveled a total of 1954 miles per year, with 673 miles being grain haul miles (34% of total mileage).

Age of Trucks. The typical model year of the 300 bu. truck was 1963, while the typical model for the 450 bu. truck was 1967.

The distribution of all trucks by model year is shown in Figure 3. 64 respondents indicated the make of truck. These were:

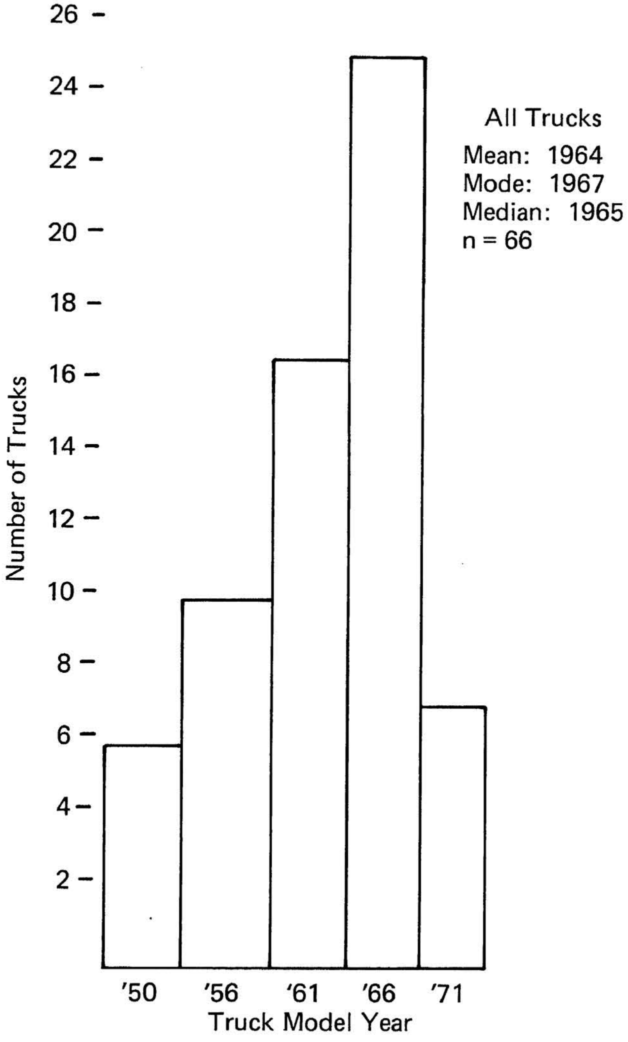
Ford	25
Chevrolet	21
International	10
GMC	8

Maintenance and Repair Costs. Respondents showed a wide variation in response to question 16 dealing with annual maintenance and repair expenses.

For the 300 bu. truck, the figures ranged from $50 per year to $2000. The most frequent figure given was $200. Deleting the few extreme figures yields an average maintenance and repair figure of $276.36 per year for 300 bu. trucks.

Maintenance and repair figures for 450 bu. trucks yield an average of $197.14 per year (excluding one extreme figure, n = 7). The size of this figure relative to the 300 bu. figure might be explained by the average 4-year difference in the ages of the two types of trucks.

Figure 3. Age Distribution of All Farm Trucks of Respondents to Farm Truck Survey, Northwest Missouri, 1975



Miscellaneous. Looking only at those respondent questionnaires which showed the use of wagons in hauling grain reveals that the average distance to the elevator was 4.9 miles (range $\frac{1}{2}$ mile to 10 miles).

In contrast, the overall average distance to the elevator was 8.2 miles.

Thus, it seems that wagons are rarely used in hauling grain to elevators farther than 5 miles from the farm.

(Sample Questionnaire)

CONFIDENTIAL

For Research Purposes Only

Department of Agricultural Economics
University of Missouri-Columbia

Date______________________________

Missouri Grain Marketing and Farm Truck Survey

Name____

Address of Farm______________________________________

County____

Return this questionnaire to:

David E. Moser
Department of Agricultural Economics
University of Missouri
Columbia, Missouri 65201

Missouri Grain Marketing and Farm Truck Survey

Confidential: For Research Purposes Only

1. What is the approximate location of your farm? ______

____

What county? ______________________

2. How many acres do you farm? ______________

3. What was your grain production for September 1972 through August 1973?

	Acres	Total Bushels Produced	Total Bushels Sold to Elevators
Corn	_____	_______	_______
Soybeans	_____	_______	_______
Wheat	_____	_______	_______

4. Do you have a grain dryer? Yes _____ No _____

If yes: (a) How many grain dryers? __________
(b) What is your total drying capacity?

_______ bu. per hour

5. How much grain can you store on your farm?
_______ bushels

6. What is the name and address of the grain elevator to which your grain above was sold? ______________

____

7. What is the approximate mileage from your farm to the elevator above? ______________ miles

8. Did you sell to the same elevator the year before?
Yes _____ No _____

9. Approximately how much time does it take to drive from your farm to the elevator on a typical grain-haul trip?

tractor-wagon ______________ minutes

truck ______________ minutes

10. Approximately how much time, on the average, do you have to wait to unload grain at the elevator?

usually no waiting _____
5-10 minutes _____
10-15 minutes _____
over 15 minutes _____
how long? _________

11. What proportion of the time do you haul goods on your return trip back from the elevator during the harvest season? ____________%

12. Did you use hired trucks during the harvest season?
Yes_____ No_____

If yes: (a) name of hired trucker____________________

(b) address of hired trucker____________________

(c) cost per bu. _______ or: cost per load________
average load_____bu.

13. What percentage of your grain crop was moved by hired truck?_____%

14. What proportion of your total annual farm truck mileage is due to hauling grain to the elevator?_____%

15. For the hauling equipment that you own, please fill out the following table:

Capacity and Type	% of Grain Hauled by	Model Year	Make	Licensed Gr. Vehicle Wt. (Lbs)	Single or Double Axle
Wagon		----	----	----	----
300-bu. truck					
450-bu. truck					
Others (specify)					
____________					
____________	100%				

16. For each type of truck you own, please estimate the annual expense for maintenance and repairs (do not include expenses for tires, licenses, and insurance).

300-bu. truck $______________per year

450-bu. truck $______________per year

Others (specify)

____________ $______________per year

____________ $______________per year

APPENDIX E

PROJECTIONS OF GRAIN MARKETINGS FOR SIXTEEN COUNTIES IN NORTHWEST MISSOURI, 1975-1985

The purpose of this portion of the study is to derive projections of commercial corn and soybean sales to 1980 and 1985 per origin within each of the 16 counties of the study area.

The equation for grain sales is:

(equation 1):

$$\text{Commercial Grain Sales} = \text{Grain Production} - \text{Grain Usage by Livestock}$$

Hence, arriving at grain sales is a two-step procedure. Estimates of grain production must first be derived; estimates of grain usage by livestock in the area must then be derived. The latter is then subtracted from the former to arrive at commercial grain sales.

Grain Production

The sequence to follow in making grain projections for each county is as follows:

(1) Project corn and soybean production to 1979 and 1984 for the U.S.;
(2) project corn and soybean production to 1979 and 1984 for the state;
(3) project the shares of corn and soybean production of each of the 16 counties on the basis of past shares; and
(4) derive county production by multiplying the projected state production total by the county percentage share of total production.

A detailed presentation of this procedure follows.

Missouri's Projected Corn and Soybean Production

Missouri's historical share of U. S. corn and soybean production is estimated by

(equation 2)

$$MoSh_{kt} = \frac{MoP_{kt}}{U.S.P_{kt}}$$

where

$MoSh_{kt}$ = Missouri's share of grain type k production in year t.

k = either corn or soybeans

MoP_{kt} = Missouri's production of grain type k in year t.

$U.S.P_{kt}$ = U. S. Total Production of grain type k in year t.

Historical figures for 1960 through 1974 for corn and soybean production within Missouri are taken from various issues of Missouri Farm Facts [9]. Historical figures for U.S. production of corn and soybeans for the same time period are taken from the U.S. Department of Agriculture publication, Agricultural Statistics [1]. Thus, Missouri's historical share for each crop and each year is arrived at.

Considering equation (2), the next step is to project U.S. production of corn and soybeans. Yearly U.S. projections for corn and soybean production for 1975-1985 are based on several sources [5, 16, 2]. The figures are presented in Table 1.

Next, Missouri's share of U.S. corn and soybean production is projected to 1985 by

(equation 3)

$$MoSh_{kt} = at^{b}$$

where t = 1960 through 1985

a and b are parameters to be estimated, and where information pertaining to Missouri shares exists for the dependent variable from 1960 through 1974.

Equation (3) is a simple non-linear trend equation and is the same one used in the Iowa State study [5]. The parameter estimates for each crop are as follows:

	a	b
Soybeans	.0978	-0.07
Corn	.0573	-0.1298

These parameter estimates are then substituted into equation (3) to get Missouri's share of corn and soybean production from 1975 through 1985. Along with these values, U.S. projections of corn and soybean production to 1985 can be substituted into equation (2) to get projections of Missouri production of corn and soybeans to 1985. These projections are presented in Table 2.

TABLE I

PROJECTION OF U. S. GRAIN PRODUCTION TO 1985
(Bushels)

Year	Corn	Soybeans
1975	5,093,333,600	1,351,240,000
1976	5,535,500,200	1,469,055,000
1977	5,977,666,800	1,586,870,000
1978	6,419,833,400	1,704,685,000
1979	6,862,000,000	1,822,500,000
1980	6,962,700,000	1,887,300,000
1981	7,063,400,000	1,952,100,000
1982	7,164,100,000	2,016,900,000
1983	7,264,800,000	2,081,700,000
1984	7,365,500,000	2,146,500,000
1985	7,466,200,000	2,211,300,000

Source: U. S. Department of Agriculture, Economic Research Service Report #518, April 1973 and U. S. Department of Agriculture, Economic Research Service Report #544, February 1974.

TABLE II

PROJECTION OF MISSOURI GRAIN PRODUCTION TO 1985
(Bushels)

Year	Corn	Soybeans
1975	203,639,400	109,840,100
1976	219,583,100	118,911,400
1977	235,370,300	127,934,900
1978	251,012,900	136,914,000
1979	266,521,100	145,852,000
1980	268,724,900	150,522,800
1981	270,970,300	155,184,800
1982	273,252,300	159,838,000
1983	275,566,500	164,482,700
1984	277,910,000	169,118,700
1985	280,279,000	173,746,600

Sixteen Counties' Projected Corn and Soybean Production

County historical shares of Missouri corn and soybean production were estimated by equation (4), which is similar to equation (2):

(equation 4):

$$CoSh_{kit} = \frac{CoP_{kit}}{MoP_{kt}}$$

where

$CoSh_{kit}$ = county i's share of grain type K production in year t

CoP_{kit} = county i's production of grain type K in year t.

MoP_{kt} = Missouri's production of grain type K in year t.

Missouri historical production information has already been derived and used in equation (1), and historical county production figures for corn and soybean production are likewise available from various issues of Missouri Farm Facts. Thus, it is easy to estimate equation (4) for county historical shares.

Next, each county's share of Missouri corn and soybean production is projected to 1985 by

(equation 5):

$$CoSh_{kit} = at^{b}$$

where again

t = 1960 through 1985;
a and b are parameters to be estimated;
i represents each of 16 counties, and where information pertaining to county shares exists for the dependent variable from 1960 through 1974.

Once the parameters are arrived at, they are substituted into equation (5) to get each county's share of corn and soybean production from 1975 through 1985. These are presented in Table 3 for each county in the study. Along with these values, Missouri projections of corn and soybean production to 1985 can be substituted into equation (4) to get projections of the sixteen counties' production of corn and soybeans to 1985. Since grain information for only 1979 and 1984 is necessary for each county, just this information is presented in Table 4 through Table 7.

TABLE III

COUNTY SHARES OF MISSOURI CORN AND SOYBEAN PRODUCTION, NORTHWEST MISSOURI FOR 1979 AND 1984

County	Share of Missouri Soybean Production		Share of Missouri Corn Production	
	1979	1984	1979	1984
Andrew	.0113	.0112	.0156	.0158
Atchison	.0266	.0330	.0248	.0240
Caldwell	.0087	.0086	.0262	.0265
Clinton	.0068	.0068	.0295	.0301
Daviess	.0158	.0153	.0185	.0192
DeKalb	.0077	.0075	.0128	.0130
Gentry	.0086	.0082	.0165	.0171
Grundy	.0082	.0080	.0141	.0148
Harrison	.0096	.0093	.0200	.0210
Holt	.0200	.0296	.0329	.0335
Linn	.0071	.0070	.0109	.0109
Livingston	.0175	.0173	.0127	.0127
Mercer	.0039	.0039	.0092	.0095
Nodaway	.0032	.0034	.0157	.0148
Sullivan	.0037	.0035	.0069	.0070
Worth	.0033	.0031	.0112	.0113

TABLE IV

COUNTY PROJECTIONS OF SOYBEAN PRODUCTION
FOR 1979, NORTHWEST MISSOURI
(Bushels)

County	1979 County Share	x	1979 Missouri Production	=	1979 County Production
Andrew	.0113		145,852,000		1,648,127.6
Atchison	.0266		145,852,000		3,879,663.2
Caldwell	.0087		145,852,000		1,268,912.4
Clinton	.0068		145,852,000		991,793.6
Daviess	.0158		145,852,000		2,304,461.6
DeKalb	.0077		145,852,000		1,123,060.4
Gentry	.0086		145,852,000		1,254,327.2
Grundy	.0082		145,852,000		1,195,986.4
Harrison	.0096		145,852,000		1,400,179.2
Holt	.0200		145,852,000		2,917,040.0
Linn	.0071		145,852,000		1,035,549.2
Livingston	.0175		145,852,000		2,552,410.2
Mercer	.0039		145,852,000		568,822.8
Nodaway	.0032		145,852,000		466,726.4
Sullivan	.0037		145,852,000		539,652.4
Worth	.0033		145,852,000		481,311.6

TABLE V

COUNTY PROJECTIONS OF SOYBEAN PRODUCTION
FOR 1984, NORTHWEST MISSOURI
(Bushels)

County	1984 County Share	x	1984 Missouri Production	=	1984 County Production
Andrew	.0112		169,118,700		1,894,129.4
Atchison	.0330		169,118,700		5,580,917.0
Caldwell	.0086		169,118,700		1,454,420.8
Clinton	.0068		169,118,700		1,150,007.1
Daviess	.0153		169,118,700		2,587,516.1
DeKalb	.0075		169,118,700		1,268,390.2
Gentry	.0082		169,118,700		1,386,773.3
Grundy	.0080		169,118,700		1,352,949.6
Harrison	.0093		169,118,700		1,572,803.9
Holt	.0296		169,118,700		5,005,913.5
Linn	.0070		169,118,700		1,184,309.0
Livingston	.0173		169,118,700		2,925,753.5
Mercer	.0039		169,118,700		659,562.9
Nodaway	.0034		169,118,700		575,003.5
Sullivan	.0035		169,118,700		591,915.4
Worth	.0031		169,118,700		524,267.9

TABLE VI

COUNTY PROJECTIONS OF CORN PRODUCTION
FOR 1979, NORTHWEST MISSOURI
(Bushels)

County	1979 County Share	x	1979 Missouri Production	=	1979 County Production
Andrew	.0156		266,521,100		4,157,729.1
Atchison	.0248		266,521,100		6,609,723.2
Caldwell	.0262		266,521,100		6,982,852.8
Clinton	.0295		266,521,100		7,862,372.4
Daviess	.0185		266,521,100		4,930,640.3
DeKalb	.0128		266,521,100		3,411,470.0
Gentry	.0165		266,521,100		4,397,598.1
Grundy	.0141		266,521,100		3,757,947.5
Harrison	.0200		266,521,100		5,330,422.0
Holt	.0329		266,521,100		8,768,544.1
Linn	.0109		266,521,100		2,905,079.9
Livingston	.0127		266,521,100		3,384,817.9
Mercer	.0092		266,521,100		2,451,994.1
Nodaway	.0157		266,521,100		4,184,381.2
Sullivan	.0069		266,521,100		1,838,995.5
Worth	.0112		266,521,100		2,985,036.3

TABLE VII

COUNTY PROJECTIONS OF CORN PRODUCTION
FOR 1984, NORTHWEST MISSOURI
(Bushels)

County	1984 County Share	x	1984 Missouri Production	=	1984 County Production
Andrew	.0158		277,910,000		4,390,978.0
Atchison	.0240		277,910,000		6,669,840.0
Caldwell	.0265		277,910,000		7,364,615.0
Clinton	.0301		277,910,000		8,365,091.0
Daviess	.0192		277,910,000		5,335,872.0
DeKalb	.0130		277,910,000		3,612,830.0
Gentry	.0171		277,910,000		4,752,261.0
Grundy	.0148		277,910,000		4,113,068.0
Harrison	.0210		277,910,000		5,836,110.0
Holt	.0335		277,910,000		9,309,985.0
Linn	.0109		277,910,000		3,029,219.0
Livingston	.0127		277,910,000		3,529,457.0
Mercer	.0095		277,910,000		2,640,145.0
Nodaway	.0148		277,910,000		4,113,068.0
Sullivan	.0070		277,910,000		1,945,370.0
Worth	.0113		277,910,000		3,140,383.0

Livestock Production

It is necessary that projections of county livestock numbers be derived in order to estimate 1980 and 1985 grain feeding requirements. These county feeding requirement figures will in turn be subtracted from county grain production figures to get county commercial grain sales figures for 1980 and 1985.

The classes of livestock considered in the county projections are milk cows, beef cows, hogs, and grain-fed cattle.

Sheep and lambs, hens and pullets, and turkeys are not explicitly taken into account in the projections because county data are not available with respect to these items. It is believed that this should not bias the results too badly since: (1) the number of sheep and lambs on feed in Missouri has been rapidly decreasing since 1960, (2) turkey and hen and pullet production concentrate in other Missouri counties, and (3) the annual feeding rate in bushels per head of these animals is minute compared to the livestock for which projections are made.

Estimation procedures were derived to take account of (1) state projections of each type of livestock for 1975 through 1985, and (2) county projections of each type of livestock for 1975 through 1985. Inshipments and deaths of each type of livestock were calculated on the basis of past information and combined with the livestock estimation procedures to arrive at the following equation which determines the particular type of livestock marketed in each county:

(Equation 6)

$$L_{kit} = PC_{kit}\left(1 - \frac{DS_{kt}}{PCS_{kt}} - \frac{IS_{kt}}{PCS_{kt}} \right)$$

where

L_{kit} = livestock type k for county i in year t.

k = milk cows, beef cows, hogs marketed, grain-fed cattle.

PC_{kit} = county i's production of livestock type k in year t.

PCS_{kt} = the state's production of livestock type k in year t.

DS_{kt} = livestock type k deaths in the state, year t.

IS_{kt} = shipments of livestock type k in the state in year t.

Linear instead of non-linear regression was used to calculate the trend for the four livestock categories. Both procedures were tried, but the linear method provided the better results in terms of the fit of the equation.

The form of each equation for milk cows, beef cows, hogs, and grain-fed cattle is:

(equation 7)

$$PCS_{kt} = a + bt$$

State projections for each type of livestock for 1975 and 1980 are presented in Table 8.

A tabulation of cattle shipped into Missouri for breeding and feeding is presented in Table 9. The figures were taken from 1966 to 1974 issues of Agricultural Statistics. In the same table is presented an enumeration of cattle deaths in Missouri. The figures were taken from Missouri Farm Facts.

The same type of information with respect to hogs is presented in Table 10. The source of all the hog information is Missouri Farm Facts.

Averages for the columns of both Table 9 and Table 10 were computed. It is evident that the averages are pretty fair representations of inshipments and deaths of hogs and cattle for each year. These averages will be used in computation dictated by equation (6).

To apply equation (6) specifically to each of the 16 counties for milk cow, beef cow, hog and grain-fed cattle production, county information for each of these specific categories is needed and has been supplied by Missouri Farm Facts. On the basis of historical information, predictions of each type of livestock per county were derived for 1980 and 1985 using a linear time trend. In this manner, the variable PC_{kit} in equation (6) is calculated. This information is presented in Tables 11, 12, 13 and 14.

Next, the dependent variable in equation (6), livestock marketed in each county for 1980 and 1985, is estimated. The amounts DS_{kt} and IS_{kt} in equation (6) are divided among the three types of cattle depending upon what proportion of the total each type is for either 1980 or 1985. These proportions are presented in Table 15.

Inshipment and death figures for hogs can be taken directly from Table 10. On the basis of equation (6) and the development of each of its variables, each of the four types of livestock marketed per county is presented in Tables 16, 17, 18 and 19.

TABLE VIII

PROJECTIONS OF STATE PRODUCTION FOR
FOUR TYPES OF LIVESTOCK
(Number of Animals)

Type	1980 Projection	1985 Projection
Milk cows	194,000	99,000
Beef cows	2,873,450	3,321,516
Hogs*	4,982,725	5,301,329
Grain-fed cattle	3,392,934	3,713,021

*The numbers are likely to underproject state production of hogs since an error was made and the inventory of hogs on farms January 1 was used instead of the pig crop as a basis for the production projection. The error was discovered too late to correct the analysis. The net result is that the amount of corn projected for market is overprojected because the hog production is underprojected.

TABLE IX

INSHIPMENTS AND DEATHS OF CATTLE IN MISSOURI
(Number of Animals)

Year	Inshipments	Deaths
1966	345,000	162,000
1967	376,000	175,000
1968	352,000	167,000
1969	369,000	165,000
1970	334,000	185,000
1971	358,000	211,000
1972	336,000	250,000
1973	390,000	330,000
1974	400,000	290,000
Average	362,000	215,000

TABLE X

INSHIPMENTS AND DEATHS OF HOGS IN MISSOURI
(Number of Animals)

Year	Inshipments	Deaths
1966	6,000	460,000
1967	8,000	440,000
1968	7,000	403,000
1969	7,000	430,000
1970	7,000	477,000
1971	4,000	460,000
1972	5,000	385,000
1973	6,000	450,000
1974	8,000	430,000
Average	6,500	437,222

TABLE XI

COUNTY PROJECTIONS OF MILK COW PRODUCTION, NORTHWEST MISSOURI
(Number of Animals)

County	1980	1985
Andrew	3310	2575
Atchison	238	63
Caldwell	1322	788
Clinton	1144	777
Daviess	1405	397
DeKalb	1494	902
Gentry	916	241
Grundy	1516	0
Harrison	2644	1244
Holt	216	0
Linn	1044	0
Livingston	311	0
Mercer	1227	0
Nodaway	2800	1116
Sullivan	694	336
Worth	1988	0

TABLE XII

COUNTY PROJECTIONS OF BEEF COW PRODUCTION, NORTHWEST MISSOURI
(Number of Animals)

County	1980	1985
Andrew	22,381	25,109
Atchison	21,965	22,527
Caldwell	26,239	26,985
Clinton	30,214	34,580
Daviess	31,001	36,173
DeKalb	24,516	27,282
Gentry	34,840	38,462
Grundy	17,888	18,225
Harrison	42,999	47,086
Holt	19,990	22,447
Linn	32,958	35,953
Livingston	20,577	22,170
Mercer	25,952	28,794
Nodaway	65,010	71,941
Sullivan	18,219	19,914
Worth	42,101	46,453

TABLE XIII

COUNTY PROJECTIONS OF HOG PRODUCTION, NORTHWEST MISSOURI*
(Number of Animals)

County	1980	1985
Andrew	95,566	109,450
Atchison	63,827	60,602
Caldwell	57,605	59,197
Clinton	76,288	79,022
Daviess	66,655	69,238
DeKalb	88,877	99,494
Gentry	62,894	69,369
Grundy	59,838	66,913
Harrison	77,111	85,694
Holt	58,888	65,755
Linn	62,405	66,063
Livingston	61,027	67,586
Mercer	38,572	40,413
Nodaway	199,200	244,450
Sullivan	30,216	33,041
Worth	40,100	42,116

* These projections are likely to be low because of reasons given earlier. See Table VIII.

TABLE XIV

COUNTY PROJECTIONS OF GRAIN-FED
CATTLE PRODUCTION
(Number of Animals)

County	1980	1985
Andrew	42,131	48,404
Atchison	51,013	52,501
Caldwell	19,294	20,415
Clinton	54,969	63,445
Daviess	49,177	58,621
DeKalb	40,251	45,552
Gentry	32,637	35,263
Grundy	22,196	24,158
Harrison	47,834	54,031
Holt	33,821	38,222
Linn	40,903	45,760
Livingston	28,106	30,616
Mercer	31,804	36,647
Nodaway	94,717	106,795
Sullivan	18,270	20,391
Worth	43,622	50,324

TABLE XV

PROJECTED STATE DEATHS AND INSHIPMENTS OF CATTLE IN 1980 AND 1985
(Number of Animals)

Type of Cattle	Percent of 1980 Production Projection	Projected 1980 Death Figure	Projected 1980 Inshipments	Percent of 1985 Production Projection	Projected 1985 Death Figure	Projected 1985 Inshipments
Milk cows	.030	6,450	10,860	.013	2,795	4,706
Beef cows	.444	95,460	160,728	.465	99,975	168,300
Grain-fed cattle	.525	112,875	190,050	.520	111,800	188,240
	1.000	215,000	362,000	1.000	215,000	362,000

TABLE XVI

COUNTY PROJECTIONS OF MILK COWS,
NORTHWEST MISSOURI*
(Number of Animals)

County	1980	1985
Andrew	3376	2600
Atchison	243	63
Caldwell	1348	795
Clinton	1167	784
Daviess	1433	401
DeKalb	1524	911
Gentry	934	243
Grundy	1546	0
Harrison	2697	1256
Holt	220	0
Linn	1065	0
Livingston	317	0
Mercer	1251	0
Nodaway	2856	1127
Sullivan	707	339
Worth	2028	0

*Corrected for deaths and inshipments.

TABLE XVII

COUNTY PROJECTIONS OF BEEF COWS, NORTHWEST MISSOURI*
(Number of Animals)

County	1980	1985
Andrew	22,828	25,611
Atchison	22,404	22,977
Caldwell	26,763	27,524
Clinton	30,818	35,271
Daviess	31,621	36,896
DeKalb	25,006	27,827
Gentry	35,536	39,231
Grundy	18,245	18,589
Harrison	43,858	48,027
Holt	20,389	22,895
Linn	33,617	36,672
Livingston	20,988	22,613
Mercer	26,471	29,369
Nodaway	66,310	73,379
Sullivan	18,583	20,312
Worth	42,943	47,382

*Corrected for deaths and inshipments.

TABLE XVIII

COUNTY PROJECTIONS OF HOGS MARKETED,
NORTHWEST MISSOURI*
(Number of Animals)

County	1980	1985
Andrew	87,920	100,694
Atchison	58,720	55,753
Caldwell	52,996	54,461
Clinton	70,184	72,700
Daviess	61,322	63,698
DeKalb	81,766	91,534
Gentry	57,862	63,819
Grundy	55,050	61,559
Harrison	70,942	78,838
Holt	54,176	60,494
Linn	57,412	60,777
Livingston	56,144	62,179
Mercer	35,486	37,179
Nodaway	183,264	206,494
Sullivan	27,798	30,397
Worth	36,892	38,746

*Corrected for deaths and inshipments. These projections are likely to be low because of reasons given earlier. See Table VIII.

TABLE XIX

COUNTY PROJECTIONS OF GRAIN-FED CATTLE
MARKETED, NORTHWEST MISSOURI*
(Number of Animals)

County	1980	1985
Andrew	42,973	49,372
Atchison	52,033	53,551
Caldwell	19,679	20,823
Clinton	56,068	64,713
Daviess	50,160	59,793
DeKalb	41,056	46,463
Gentry	33,289	35,968
Grundy	22,639	24,641
Harrison	48,790	55,111
Holt	34,497	38,986
Linn	41,721	46,675
Livingston	28,668	31,228
Mercer	32,440	37,379
Nodaway	96,611	108,930
Sullivan	18,635	20,798
Worth	44,494	51,330

*Corrected for deaths and inshipments.

Estimating Corn Sales

The equation for estimating commercial corn sales in each county is as follows:

(equation 8):

$$Cs_{it} = CP_{i(t-1)} - \left[\sum_{k=1}^{4} (L_{kit})(FR_{kit}) \right]$$

where

CS_{it} = corn sales for county i, year t;

$CP_{i(t-1)}$ = corn production for county i, year t - 1;

L_{kit} is defined as in equation (6);

FR_{kit} = corn feeding rates to each class of livestock in county i, year t.

Rather than developing feeding rates, those derived by the Iowa State study were used under the assumption that the environments of Iowa and Missouri are similar enough to warrant the same feeding rates. Table 20 presents the annual feeding rate in bushels per head for each class of livestock.

All of this information is then put together in terms of equation (8) for marketings (or deficits) of corn production over livestock requirements and is presented in Table 21 for 1980 and in Table 22 for 1985.

Since unprocessed soybeans do not enter into the diet of livestock, soybean production is presented as soybean marketings, found in Table 4 for 1980 and in Table 5 for 1985.

TABLE XX

ANNUAL FEEDING RATE IN BUSHELS PER HEAD

Class of Livestock	1980	1985
Milk Cows	74.0	77.0
Beef Cows	4.0	4.0
Hogs Marketed	14.2	14.2
Grain-Fed Cattle Marketed	56.0	57.8

TABLE XXI

PROJECTED MARKETINGS (OR DEFICIT) OF CORN IN 1979-80, NORTHWEST MISSOURI

County	County Production (in Bushels) (Taken from Table VI)	Livestock Feeding Requirements (in Bushels)	Marketings (or Deficit) of County Production Over Livestock Feeding Requirements (in Bushels)
Andrew	4,157,729	3,978,504	179,225
Atchison	6,609,723	3,843,526	2,766,197
Caldwell	6,982,852	2,050,772	4,932,080
Clinton	7,862,372	4,332,014	3,530,358
Daviess	4,930,640	3,899,994	1,030,646
DeKalb	3,411,470	3,656,660	(245,190)
Gentry	4,397,598	2,885,512	1,512,086
Grundy	3,757,947	2,236,878	1,215,796
Harrison	5,330,422	4,114,626	1,215,796
Holt	8,768,544	2,798,967	5,969,577
Linn	2,905,079	3,361,204	(456,125)
Livingston	3,384,817	2,510,062	874,755
Mercer	2,451,994	1,909,214	542,780
Nodaway	4,184,381	8,489,148	(4,304,767)
Sullivan	1,838,995	1,564,941	274,054
Worth	2,985,036	3,337,374	(352,338)

TABLE XXII

PROJECTED MARKETINGS (OR DEFICIT) OF CORN
IN 1984-85, NORTHWEST MISSOURI

County	County Production (in Bushels) (Taken from Table VI)	Livestock Feeding Requirements (in Bushels)	Marketings (or Deficit) of County Production Over Livestock Feeding Requirements (in Bushels)
Andrew	4,390,978	4,526,564	(135,586)
Atchison	6,669,840	3,929,708	2,740,132
Caldwell	7,364,615	2,120,676	5,243,939
Clinton	8,365,091	4,876,905	3,488,186
Daviess	5,335,872	4,478,434	857,438
DeKalb	3,612,830	4,111,322	(498,492)
Gentry	4,752,261	3,119,277	1,632,984
Grundy	4,112,068	2,340,319	1,772,749
Harrison	5,836,110	4,533,879	1,302,231
Holt	9,309,985	3,160,698	6,149,287
Linn	3,029,219	3,658,041	(628,822)
Livingston	3,529,457	1,870,460	1,658,997
Mercer	2,640,145	2,417,978	222,167
Nodaway	4,113,068	9,480,221	(5,367,153)
Sullivan	1,945,370	1,718,395	226,975
Worth	3,140,383	3,657,782	(517,399)

Once county marketing figures for corn and soybeans per county have been derived, it is necessary that these amounts be apportioned to each of the "5 mile square origins" by some method.

The method chosen has been (1) to consult topographical maps of the 16-county region, (2) to classify each "5 mile square origin" according to its apparent topographical characteristics on a scale of 0 to 4, where a zero implies that the origin is not conducive to crop production whereas a four implies that the origin is very favorable for crop production and (3) to apportion each square's share of marketings on the basis of its rating and total county marketings.

It is necessary that grain receipts by elevators be analyzed to determine which times of the year characterize heavy receipt periods.

The section of the elevator mail questionnaire (Appendix F) dealing with grain receipts by elevators provided this data. Only those elevators with complete yearly information were used because of the necessity of arriving at accurate percentage figures for each quarter.

Hence, quarterly percentages were calculated for those elevators having complete information for three years, for two years, or for only one year. Given this information, aggregate quarterly percentages were calculated for each year, and finally an average quarterly percentage over all three years was calculated. The following is the pattern of grain receipts over all three years for the 26 grain elevators in the questionnaire with complete information.

	Pattern of Quarterly Receipts	
Quarter	Corn	Soybeans
Oct-Nov-Dec	46.8%	68.6%
Jan-Feb-Mar	30.4%	21.6%
Apr-May-June	10.6%	5.1%
Jul-Aug-Sept	12.2%	4.7%

APPENDIX F

ELEVATOR MAIL QUESTIONNAIRE

CONFIDENTIAL
For Research Purposes Only

Department of Agricultural Economics
The University of Missouri-Columbia

Date____________________________

Missouri Grain Transportation Survey

Please complete one survey form for each location you operate.

Name of Company____

Address of Company____

Location of Elevator____

Name and title of person completing the survey form

____

Code No. ____

Code No. ____________________

1. The commodities you handle as a percent of sales are:

   grain __________, fertilizer ___________, feed __________,

   chemicals ___________, other farm supplies _________.

2. How many bushels of storage space did you have on December 31, 1973 at the above location?

   Flat _____________ bushels

   Upright _____________ bushels

3. What was the maximum percent of your storage capacity used during the following seasons?

	1971	1972	1973
Total bushels capacity	_____	_____	_____
Percent used	_____	_____	_____

4. (a) What is your present receiving capacity for:

   Corn ____________ bushels per hour

   Soybeans ________ bushels per hour

   Corn and soybeans received at the same time

   _________________ bushels per hour

   Wheat ___________ bushels per hour

   Grain sorghum __________ bushels per hour

   (b) What is the maximum amount of high moisture corn you can receive and handle in a day?

   ________ bushels at 18-22 percent average moisture

   ________ bushels at over 22 percent average moisture

   ________ bushels at over 25 percent average moisture

5. Do you have a dryer(s)? Yes _____ No _____. If yes, what is the rated total dryer capacity at 5% moisture removal? _______________ bushels per hour.

6. About what percent of the corn which you received was over 18% moisture in:

	Sept	Oct	Nov	Dec-Feb	Mar-May	Jun-Aug
1970-71	___	___	___	___	___	___
1971-72	___	___	___	___	___	___
1972-73	___	___	___	___	___	___

7. How many bushels of corn did you dry in each of the last 3 years? (Include corn dried for farmers and for your own account.) Estimate if necessary.

Sept. 1	Bushels Dried	Estimated Average Harvest Moisture Content Before Drying
		Percent
1970-71	________	______
1971-72	________	______
1972-73	________	______

8. (a) Are you served by a rail line? Yes___No___. If yes, what is the name of the railroad?

____

Can you ship out in fully loaded 100 ton hopper cars? Yes _____ No _____.

(b) How many bushels of grain can you load out in an 8 hour day in:

box cars __________bushels per 8 hour day

hopper cars __________bushels per 8 hour day

trucks __________bushels per 8 hour day

(c) How many rail cars will your siding presently hold?______box cars ______hopper cars

9. (a) How many rail cars did you ship out in the past three years (Sept. 1 through August 31)?

	1970-71	1971-72	1972-73
No. of box cars	______	______	______
No. of hopper cars	______	______	______

(b) What percentage of your total rail grain movement is in:

single car shipments _____%

2-10 cars per shipment _____%

over 10 cars per shipment _____%

100 %

10. Do you have official loading out weights? Yes__ No__. If yes, please estimate the average bushel loss per box car shipment.

_______ corn _______ soybeans

_______ wheat _______ grain sorghum

11. Do you have origin grades? Yes ___ No ___.

12. Are you capable of loading out hopper cars? Yes ____ No ____. If no, please explain.

____

____

13. Do you lease hopper cars? Yes ____ No ____. If yes, how many? ______

14. How much time do you spend per car preparing box cars for loading? _______ minutes per car.

15. How many bushels of the corn you received in the past three years were received in the following months? Receipts should include company owned grain, grain stored under warehouse receipts for patrons, grain banking and CCC.

	1970-71	1971-72 (bushels)	1972-73
Sept.	______	______	______
Oct.	______	______	______
Nov.	______	______	______
Dec.	______	______	______
Jan.	______	______	______
Feb.	______	______	______
Mar.	______	______	______
April	______	______	______
May	______	______	______
June	______	______	______
July	______	______	______
Aug.	______	______	______

16. How many bushels of the soybeans which you received in the past three years were received in each of the following months? Receipts should include company owned grain, grain stored under warehouse receipts for patrons, grain banking and CCC.

	1970-71	1971-72	1972-73
Sept.	________	________	________
Oct.	________	________	________
Nov.	________	________	________
Dec.	________	________	________
Jan.	________	________	________
Feb.	________	________	________
Mar.	________	________	________
Apr.	________	________	________
May	________	________	________
June	________	________	________
July	________	________	________
Aug.	________	________	________

17. If you received at least 10,000 bushels of wheat per year, how many bushels of the wheat you received in the past three years were received in the following months? Receipts should include company owned grain, grain stored under warehouse receipts for patrons, grain banking and CCC.

	1970-71	1971-72	1972-73
Sept.	________	________	________
Oct.	________	________	________
Nov.	________	________	________
Dec.	________	________	________
Jan.	________	________	________
Feb.	________	________	________
Mar.	________	________	________
Apr.	________	________	________
May	________	________	________
June	________	________	________
July	________	________	________
Aug.	________	________	________

18. How much of the corn you shipped out in the year Sept. 1, 1972-August 31, 1973 was sent back to farmers as whole grain or in feed? ______________ bushels

19. How much of the total grain you shipped out in the year Sept. 1, 1972-August 31, 1973 was moved in the following ways:

	Bushels		
	Corn	Soybeans	(Other)
By barge	______	______	______
By rail**	______	______	______
By truck	______	______	______

**If due to the boxcar shortage, less was shipped by rail than you intended, indicate amount diverted to truck:

Corn	Soybeans	(Other)
______	______	______

20. Of the total grain shipped Sept. 1, 1972-August 31, 1973, how much went by rail, by destination:

	Bushels		
Destination	Corn	Soybeans	(Other)
St. Joseph	______	______	______
Kansas City	______	______	______
Other (Please list)			
______	______	______	______
______	______	______	______
______	______	______	______
______	______	______	______

21. Of the total grain shipped Sept. 1, 1972-August 31, 1973, how much went by company-owned trucks, by destination:

	Bushels		
Destination	Corn	Soybeans	(Other)
St. Joseph	______	______	______
Kansas City	______	______	______
Other (Please list)	______	______	______
______	______	______	______
______	______	______	______
______	______	______	______
______	______	______	______

22. Of the total grain shipped Sept. 1, 1972-August 31, 1973, how much went by hired trucks by destination:

	Bushels		
Destination	Corn	Soybeans	(Other)
St. Joseph	______	______	______
Kansas City	______	______	______
Other (Please list)			
______	______	______	______
______	______	______	______
______	______	______	______
______	______	______	______

23. How many bushels of grain you shipped out in 1972-73 were transported in the following months by the following modes:

	Rail	Own Trucks	Hired Truckers	Itinerant (Buy-Sell) Truckers	Other
Sept.	______	______	______	______	______
Oct.	______	______	______	______	______
Nov.	______	______	______	______	______
Dec.	______	______	______	______	______
Jan.	______	______	______	______	______
Feb.	______	______	______	______	______
Mar.	______	______	______	______	______
Apr.	______	______	______	______	______
May	______	______	______	______	______
June	______	______	______	______	______
July	______	______	______	______	______
Aug.	______	______	______	______	______

24. What is your preferred method of transportation for shipping grain? Are there any problems that you have encountered with this mode?

25. (a) About what percent of your grain receipts arrive by:

tractor and wagon ______%
pickup truck ______%
101-200 bu. truck ______%
201-300 bu. truck ______%
over 300 bu. truck ______%

(b) What is the average size of the wagon load you receive?

____________________bushels

26. Please indicate on the attached map the trade area from which you presently receive 90% of your grain.