1-1-1978

The South Dakota Grain Marketing System

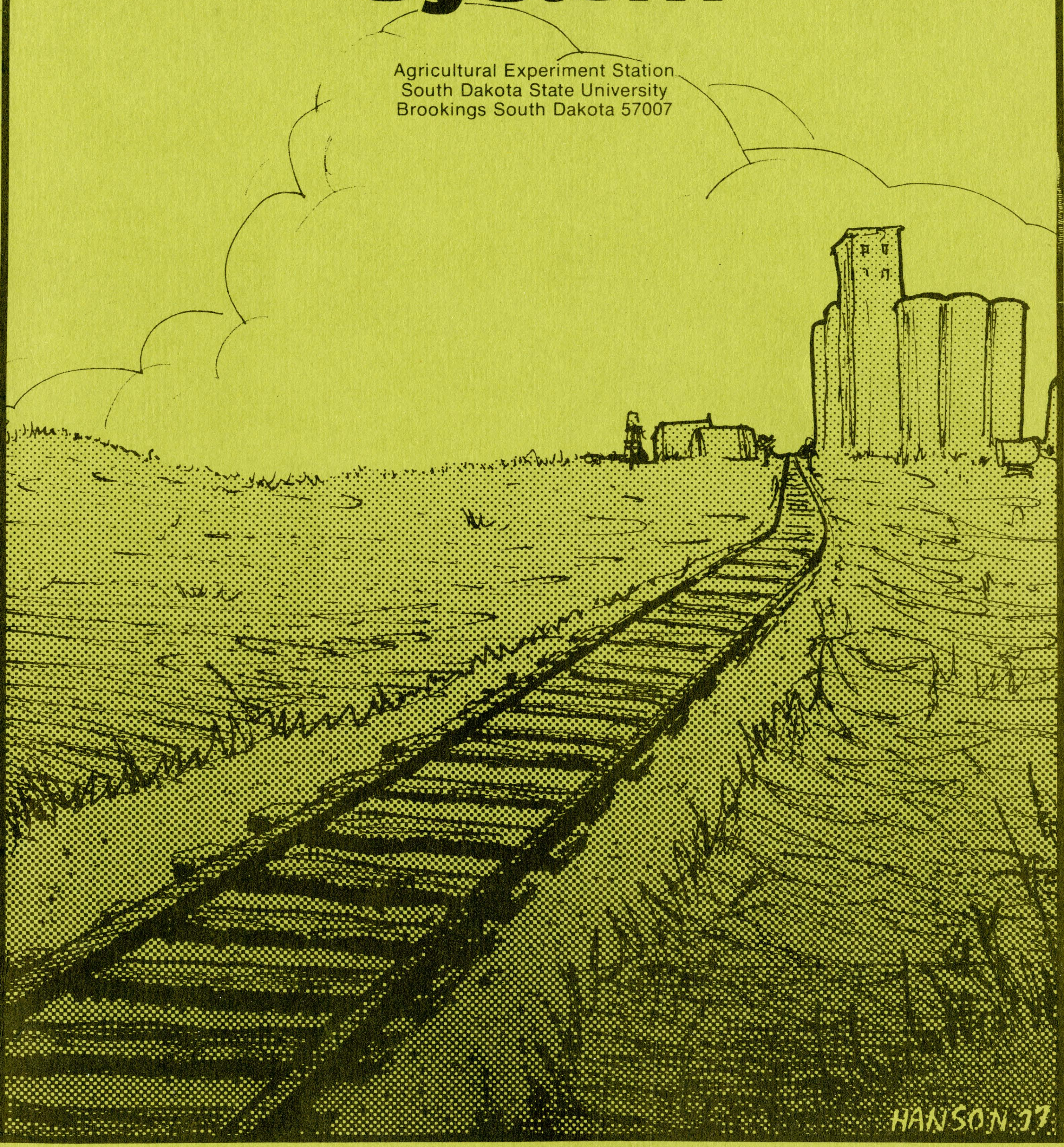
C. E. Lamberton

R. Rudel

B 654

The South Dakota Grain Marketing System

Agricultural Experiment Station
South Dakota State University
Brookings South Dakota 57007



THE SOUTH DAKOTA GRAIN MARKETING SYSTEM

Charles Lamberton
Richard Rudel

Contents

This report is based primarily on a study entitled, "A Pilot Study to Investigate Efficient Grain Transportation and Marketing Systems for South Dakota." The study was made under contract with the U.S. Department of Transportation (DOT-OS-50229), June 1976.

Published in accordance with an Act passed in 1881 by the 14th Legislative Assembly, Dakota Territory, establishing the Dakota Agricultural College and with the Act of re-organization passed in 1887 by the 17th Legislative Assembly, which established the Agricultural Experiment Station at South Dakota State University. 250 printed at estimated $1.10 each--1-78mb

I. Introduction

Total production of grain in South Dakota varies considerably from year to year because of the effects of weather conditions, the incidence of disease and insect damage, and changes in government policy influencing the number of acres to be planted. Even though these factors have often adversely affected production, a 14 year linear trend indicates that total grain production has been increasing at the average rate of over 3.5 million bushels per year from 1962 through 1975. (See Figure I, Table I, and the map of districts on page 5) The secular increase in production has been due to the adoption of new farming technology. Examples of such changes are irrigation, fertilizers, pesticides, herbicides, new grain varieties, and improved farm machinery and grain harvesting equipment and methods.

While all of these factors have led to more grain being produced and sold, the innovations in grain harvesting equipment and methods have provided an additional dimension which has substantially affected grain transportation and marketing. The combination of the picker-sheller, the large grain combines, and artifical drying equipment has reduced the length of harvest periods to days or weeks. As a result farmers have a substantial amount of grain ready to deliver for storage or sale at harvest. Grain elevators and processors are thus faced with the peak demands for their services during a relatively short period usually occurring at harvest time. When these services are not provided by the grain elevator or processor, the producer has to develop on-farm storage and drying facilities.

On-farm storage capacity in South Dakota is substantial. In 1974 South Dakota's on-farm storage was estimated at 450 million bushels.(14) This is equal to about 1½ times the average annual total production of grain in South Dakota from 1970 to 1974. In most instances this large amount of farm storage allows producers to spread out their delivery and market grain in response to the prices being paid for grain at different times of the year.

TABLE I.

GRAIN PORDUCTION IN SOUTH DAKOTA FROM 1962 TO 1975 (IN 1000 BU.)[a]

District	1962	1963	1964	1965	1966	1967	1968	1969
I	26,018	33,162	32,525	30,374	31,889	47,366	51,300	33,780
II	49,524	49,910	36,656	47,121	42,473	57,210	58,187	45,607
III	38,129	45,845	28,755	53,021	45,270	54,192	56,561	53,387
IV	25,097	29,273	16,633	21,053	19,707	27,175	33,605	27,636
V	57,166	77,142	48,228	60,972	52,245	58,583	66,341	82,455
VI	71,700	69,935	47,781	68,755	67,690	64,506	57,453	85,146
Totals*	267,634	305,267	210,578	281,296	259,274	309,032	323,447	328,011

TABLE I. -- Continued

District	1970	1971	1972	1973	1974	1975	14 Year Average	% of State Total Average	1974	1975
I	35,368	46,960	55,164	49,652	36,725	42,385	39,477	13.3	15.3	15.1
II	47,743	62,037	49,239	33,954	23,374	42,311	46,096	15.6	9.8	15.1
III	49,849	66,299	39,036	44,945	22,707	42,306	45,736	15.4	9.5	15.1
IV	24,906	29,723	40,445	40,995	23,936	25,316	27,535	9.3	10.0	9.0
V	67,407	71,218	81,244	95,854	67,138	69,442	68,245	23.0	28.1	24.7
VI	55,229	84,169	88,206	88,406	65,218	59,357	69,540	23.4	27.3	21.1
Totals*	280,502	360,406	353,334	353,805	239,098	281,097	296,629	100.0	100.0	100.0

[a] South Dakota Crop and Livestock Reporting Service, South Dakota Agriculture, 1974, Sioux Falls, South Dakota and previous years.

*Includes wheat, corn, barley, oats, sorghum, flax, and soybeans. Excludes rye.

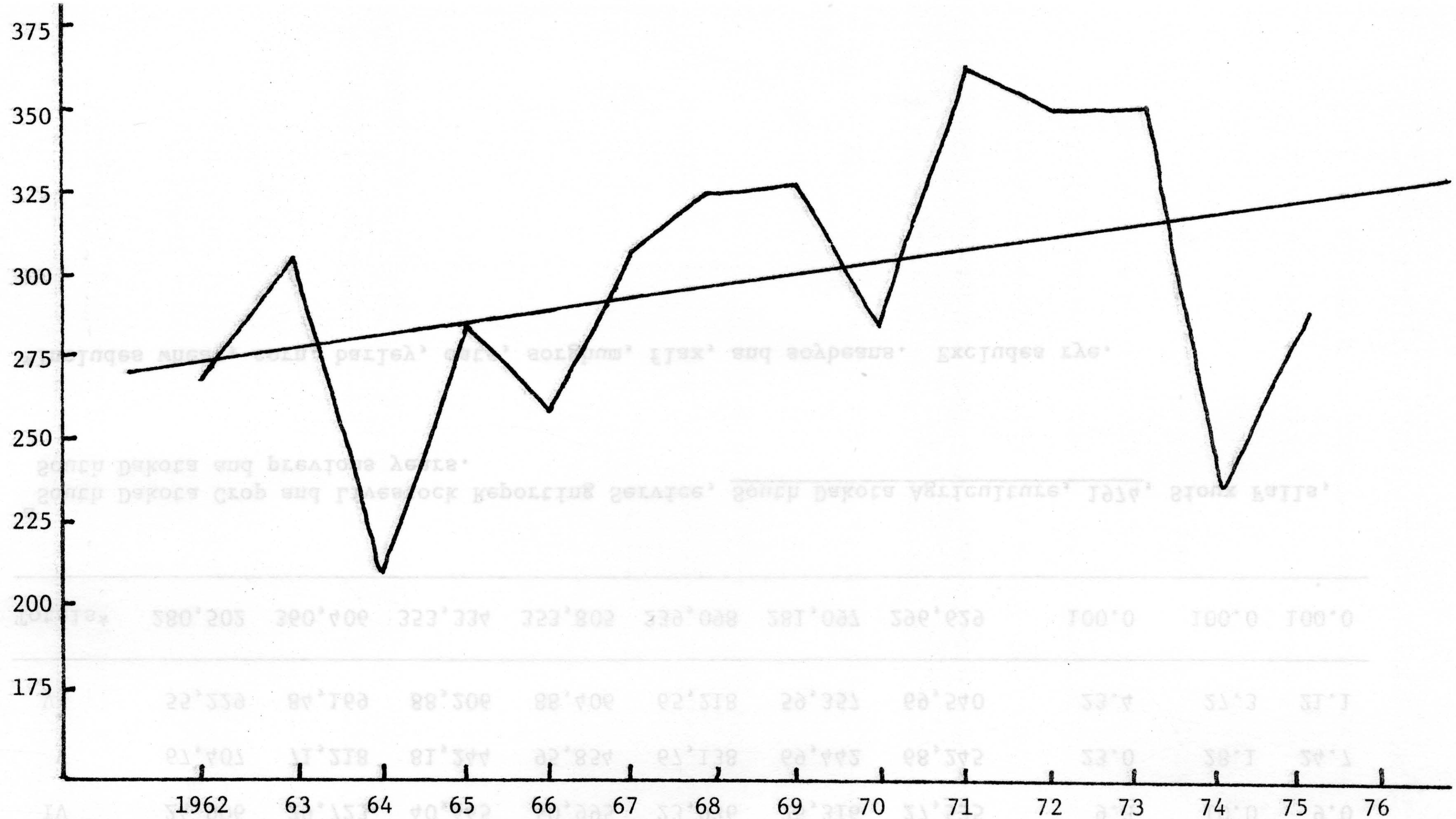
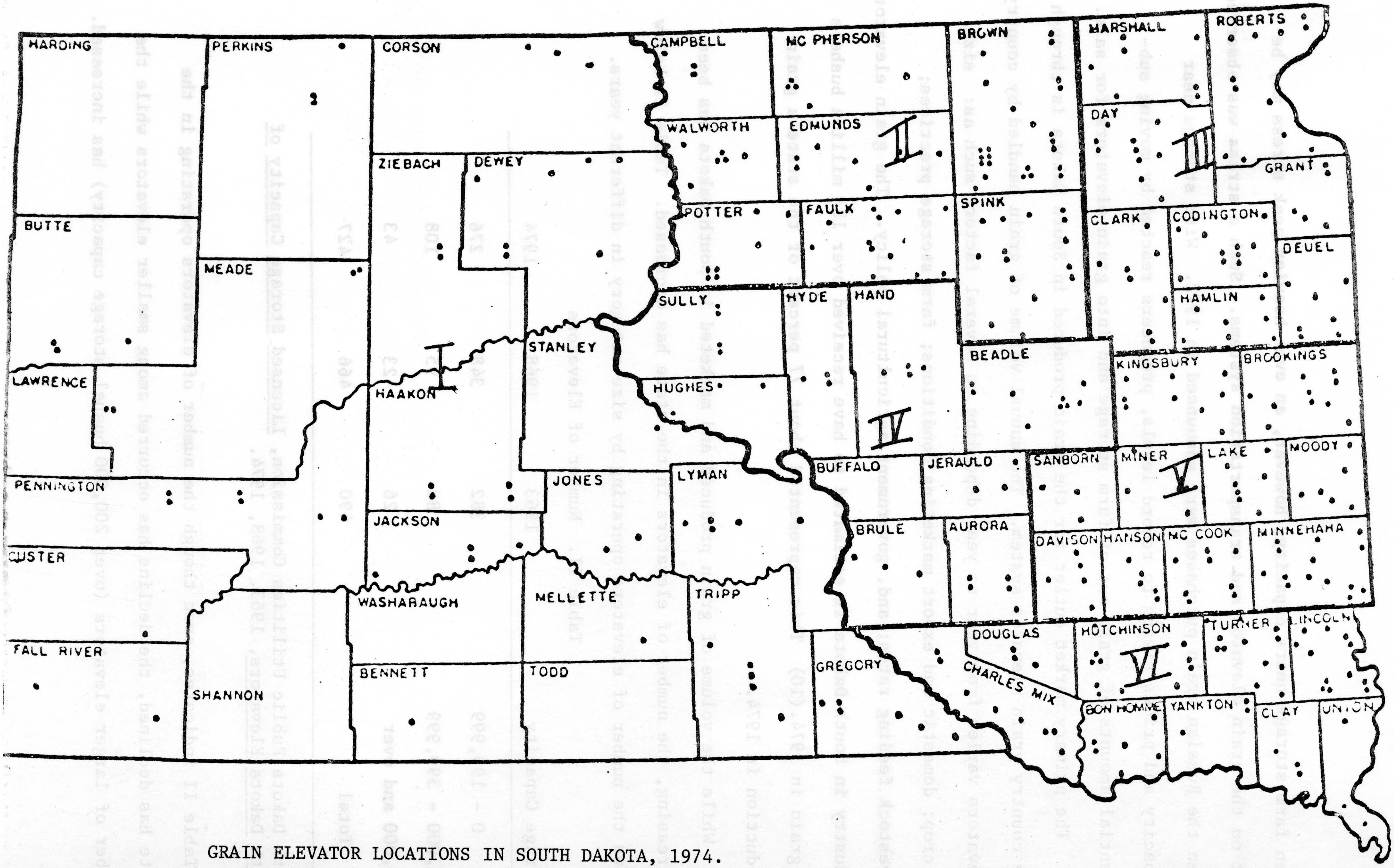


FIGURE I. FOURTEEN YEAR SOUTH DAKOTA GRAIN PRODUCTION, TREND AND PROJECTION[a]

[a]Data from South Dakota Crop & Livestock Reporting Service, South Dakota Agriculture, 1975, Sioux Falls, South Dakota; and previous years.

Trend equation: Production Year X = 269,180 + 3,660 (Year X - 1962)



GRAIN ELEVATOR LOCATIONS IN SOUTH DAKOTA, 1974.

When farm storage nears capacity, however, an even heavier peak stress may be put on the grain elevator and transportation systems. Such a stress was observed when the Russian grain purchases were announced in 1972. With storage near capacity and prices rising to record levels, producers reacted by moving substantial amounts of grain out of farm storage and into grain elevators for sale.

The primary market outlet for the grain produced in South Dakota is through the country grain elevator system. The annual volume of grain handled by country elevators varies from year to year depending on several factors such as: size of crop; domestic and export marketing conditions; farm storage practices; livestock feeding rates; and, government agricultural policy. The grain elevator industry in South Dakota is estimated to have received over 184 million bushels of grain in 1974.(10) This represented about 77 percent of the state's grain production in 1974.

While the volume of grain produced and marketed in South Dakota has been increasing, the number of elevators in the state has decreased. Table II below shows the number of elevators operating by size category in different years.

Table II. Number of Elevators

Storage Capacity	1963	1968	1974
0 - 199,999	382	348	276
200,000 - 399,999	82	95	108
400,000 and over	26	23	43
Total	490	466	427

South Dakota Public Utilities Commission, Licensed Storage Capacity of South Dakota Elevators, 1963, 1968, 1974.

As Table II indicates, even though the number of elevators operating in the state has declined, the decline has occurred among smaller elevators while the number of larger elevators (over 200,000 bushel storage capacity) has increased.

As a consequence of this shifting pattern of elevator size the total storage capacity of South Dakota elevators increased by five percent between 1965 and 1974 - from 80.3 million bushels to 84.3 million bushels.(22) With the decline in elevator numbers has come a decline in the number of communities with elevators from 356 in 1965 to 330 in 1972 and 315 in 1974.

This decrease in elevator numbers and the relatively small increase in storage capacity have also been attributed in part to changes in the structure of agriculture. The decline in the number of farms and farmers has resulted in fewer farm customers per elevator. The increase in on-farm storage capacity has allowed farmers to market more grain directly through terminals or indirectly through livestock. These abilities have tended to compete business away from country grain elevators.

Some, primarily larger, elevators have added farm supply and farm service activities to their primary business of grain handling. These elevators have thus expanded their base of operations and their ability to grow while competing business away from other, usually smaller, elevators. These smaller elevators have been unable or too slow to add these lines of business. The decline in Commodity Credit Corporation storage programs has also reduced elevators' storage income and placed some in financial difficulty.

In addition to these changes in agriculture, the decline in elevator numbers has also been due in part to changes in grain handling and assembly technology. One objective of this paper is to examine the scale economies inherent in larger elevator operations and the increased efficiency in grain assembly. These enable farmers to transport grain to elevators located farther from the farm. The increase in grain production and marketing and the decrease in the number of elevators indicates that a smaller number of elevators have adjusted to handle more grain. They are able to move more grain through their facilities by transporting more grain to processors, terminal markets, or back to producers for use on farms. The movement of more grain is possible because of an increased supply of transportation equipment, increased utilization of rail cars and trucks used in moving grain between elevators and markets, and improved loading facilities at elevators.

The second objective of this paper is to analyze the economic structure and cost relationships of South Dakota's grain marketing system. This analysis is based primarily on information and data derived in a 1976 study done by the Department of Economics at South Dakota State University under a contract with the U.S. Department of Transportation.(10) This study is also the basis for a third objective of this paper which is to discuss the changes likely to occur in the structure and costs of the state's grain marketing system in response to changes in technology.

The DOT study was based on data collected from South Dakota elevators on grain receipts, shipments, and costs. The study used a cost minimizing linear programming transportation model to determine an optimum grain transportation and marketing system under alternative conditions. The alternatives included variations in relative transportation costs, in market demands, and in elevator handling volumes.

II. Economic Structure of the Grain Elevator System

Country grain elevator firms deal in a variety of products and services. As described in the introduction, the number and variety of elevator products and services has increased in recent years in response to changes in farm and elevator technology and costs. There is evidence that the rate of growth of elevator profits in South Dakota has been closely related to the ability of the elevator to offer farm supplies and services such as bulk, bagged, and anhydrous fertilizers, farm mapping, liquid feed, seed cleaning, feed grinding, customer record keeping, trucking, petroleum, hardware, and lumber.(17)

While the profit growth rate is related to an elevator's ability to supply these ancillary products and services, the primary function of the country elevator remains the storage and handling of grain. Elevator net profit is closely related to these grain services. For this reason and because this study deals with the grain marketing system, the following description of the economics of elevator grain handling and storage assumes that these two functions are separable from the ancillary functions performed by elevators.

Grain handling refers to the receiving and shipping of grain and includes such activities as weighing, sampling, dumping, elevating, binning, coopering rail cars, loading rail cars and trucks, and making out bills of lading. Grain storage refers to the holding of grain between the receiving and shipping activities and may involve turning, drying, and fumigating to maintain grain quality. Several studies have examined the costs of these activities.(7;27;28;30)

A. Storage Cost Relationships

In the short-run an elevator's plant size can be measured by its storage capacity. The fixed costs incurred for a given capacity include depreciation, interest on investment, real estate taxes, insurance, and license expenses for the storage facilities. Variable costs include repair and maintenance, electricity, grain insurance, and labor expenses. For any given storage capacity the variable expenses are small in comparison with the fixed costs. Thus, increasing the volume of grain stored results in rapidly declining storage costs per bushel stored up to that volume representing the elevator's storage capacity. Storing of grain beyond the elevator's capacity requires the elevator to rent additional facilities or use ground storage. Either of these alternatives increases the cost per bushel and, while cost per bushel may decrease as volume stored increases by a small amount, the short-run average cost curve soon rises for volumes greater than the elevator's storage capacity. Figure II shows these cost relationships. Each of the SRAC curves represents the cost per bushel of storing or handling various volumes of grain with a given plant size. The successive SRAC curves represent larger plant size.

Grain storage also evidences economies of scale so that large capacity elevators have a lower cost per bushel than small capacity elevators when both are operating near their capacity grain volume. For any given volume of grain to be stored the lowest cost per bushel occurs for that elevator whose storage

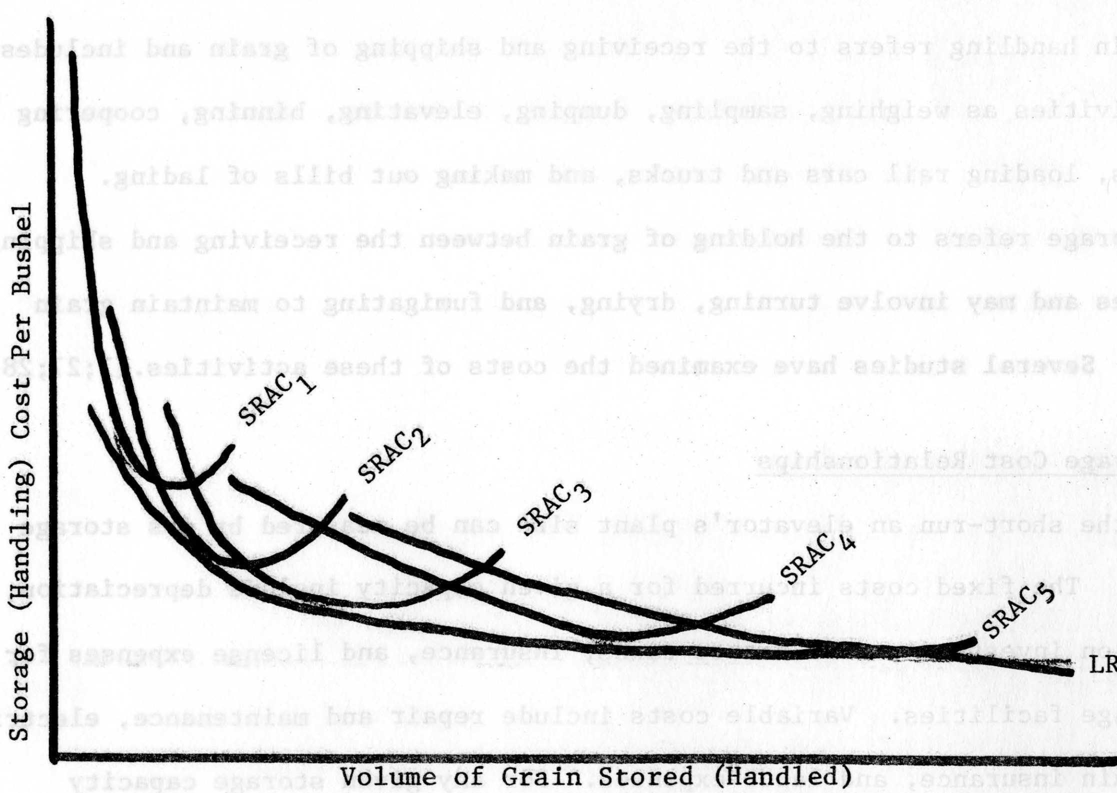


FIGURE II. LONG AND SHORT RUN STORAGE (HANDLING) COSTS PER BUSHEL capacity equals the volume to be stored. That is, for a given volume to be stored, V, cost per bushel increases as storage capacity increases beyond V because of the larger investment in capacity. For elevators with capacity less than V, the rising short-run cost curve lies above that for the V-rated elevator.

B. Handling Cost Relationships

Although variable costs such as labor, grading, and inspection expenses are a larger proportion of total costs for grain handling than for grain storage, fixed costs are still the dominant costs in grain handling. For any given capacity of receiving and loading equipment, cost per bushel decreases as the volume handled increases up to the maximum designed capacity of the equipment. For volumes beyond the maximum designed capacity, cost per bushel increases sharply. The long-run average cost curve also reflects increasing returns to scale for grain handling. That is, the handling cost per bushel decreases as equipment of greater maximum designed capacity is employed.

The economics of elevator grain handling and storage alone would lead to the conclusion that the most efficient (least cost) system for marketing grain would consist of relatively few, large elevators in South Dakota. This, however, ignores two other cost factors that influence the number and location of elevators: the cost of assembling grain and the cost of distributing grain.

C. Assembly and Distribution Cost Relationships

While storage and handling costs per bushel decrease as an elevator's volume increases, assembly cost per bushel increases with volume. The increase is caused by increased transportation cost per bushel as an elevator reaches farther out into its supply area to assemble a larger volume of grain. However, the assembly distances, and therefore costs, increase less than in proportion to the increases in volume assembled. Figure III illustrates the shape of the assembly cost per bushel function as well as the elevator costs per bushel and combined elevator and assembly costs per bushel. The curves represent the long-run cost

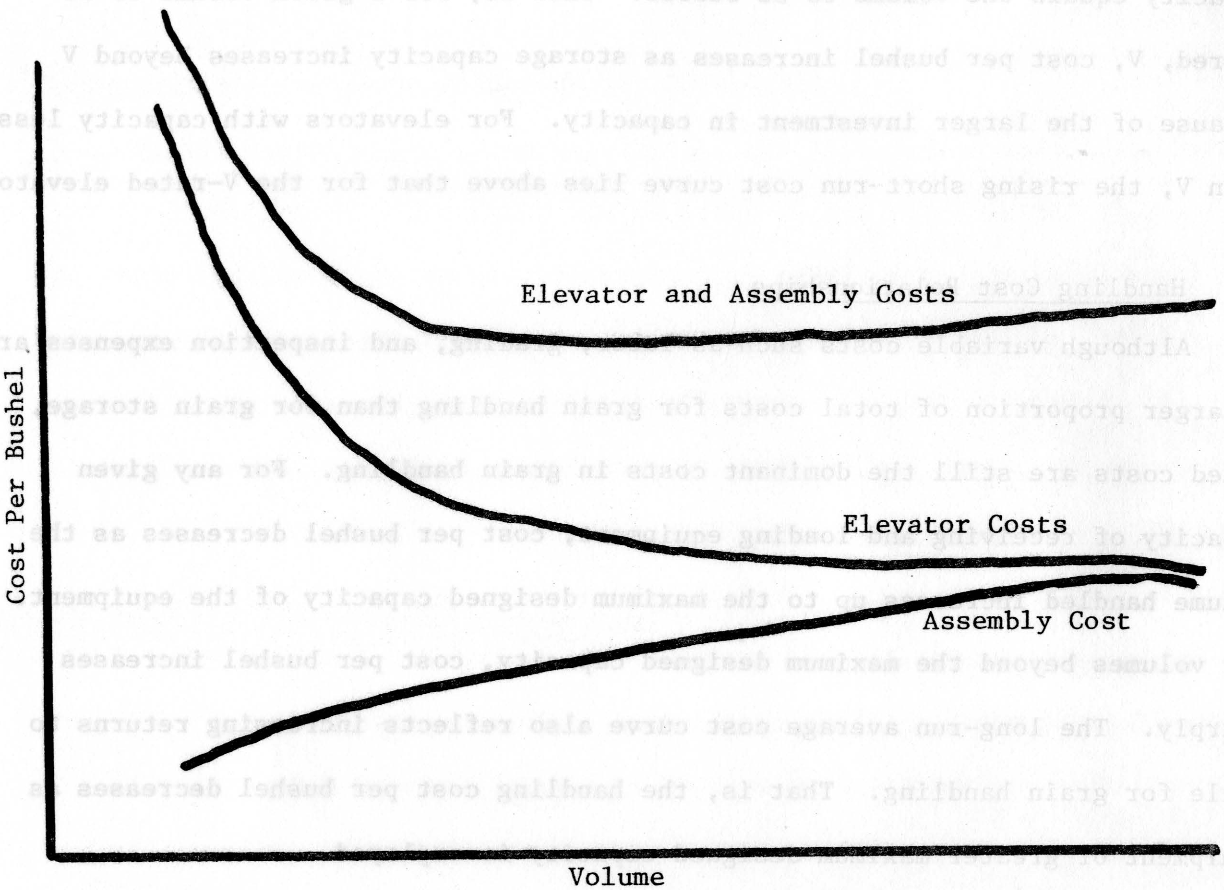


FIGURE III. ASSEMBLY, ELEVATOR (STORAGE AND HANDLING), AND COMBINED COST PER BUSHEL

per bushel for various volumes of grain handled when plant size is adjusted with volume handled so as to maintain the minimum achievable cost per bushel.

As volume increases the decline in elevator costs is offset by the rise in assembly costs so that the combined elevator and assembly costs per bushel reach a minimum and then begin to rise. Therefore, there is a most efficient (least cost per bushel) elevator plant size. This implies an optimum solution with more and smaller elevators than the solution implied when elevator costs alone are considered.

The cost of distributing grain from country elevators tends to increase less than in proportion to the distance from elevator to terminal destination. This occurs whether distribution is by truck or rail. The short-run cost per bushel is approximately a linear, nonhomogeneous function of the distance traveled. In the long-run technological changes in transportation such as hopper cars, unit trains, faster highways, and larger trucks tend to offset some of the distance induced cost increase as larger volumes are distributed from an elevator. Thus, maintaining once again the minimum elevator cost per bushel for all volumes, for a given distance from elevator to terminal, larger elevators can realize economies of scale in distribution costs. This is illustrated by Figure IV.

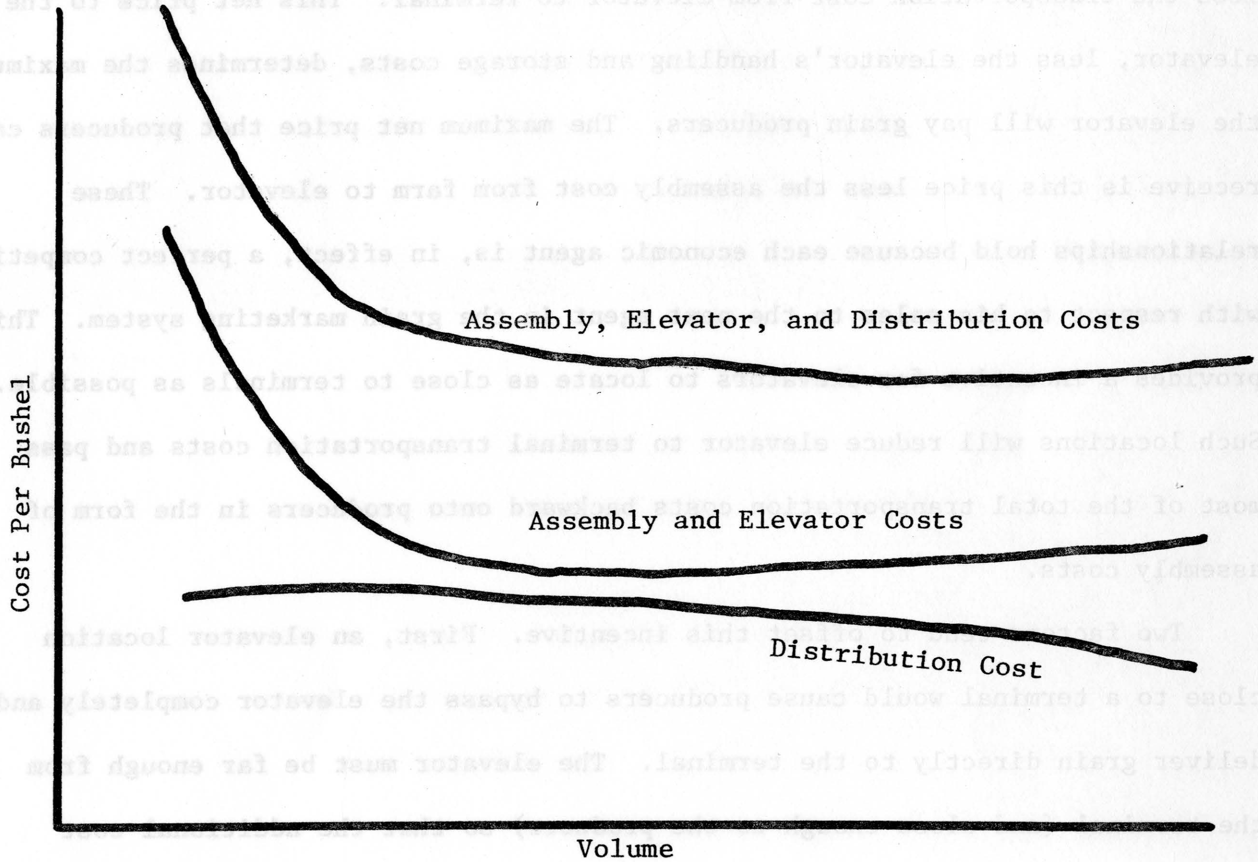


FIGURE IV. ASSEMBLY AND ELEVATOR (STORAGE AND HANDLING), DISTRIBUTION, AND COMBINED COST PER BUSHEL

D. Elevator Locations

When distribution cost per bushel is added to assembly and elevator costs, the optimum number of elevators will be fewer and their optimum size larger than the optimum number and size determined from assembly and elevator costs alone (for a given elevator location). Since short-run distribution costs increase linearly with elevator to terminal distance and long-run distribution costs reflect increasing returns to scale, there is a cost basis for locations farther from terminals to have fewer and larger elevators than locations closer to terminals for a given volume of grain handled.

For any elevator the price received at the terminal is determined by a bid from the buying firm. The price bid is based on the price established by supply and demand in the grain market. The elevator receives the terminal market price less the transportation cost from elevator to terminal. This net price to the elevator, less the elevator's handling and storage costs, determines the maximum the elevator will pay grain producers. The maximum net price that producers can receive is this price less the assembly cost from farm to elevator. These relationships hold because each economic agent is, in effect, a perfect competitor with respect to his sales to the next agent in the grain marketing system. This provides a incentive for elevators to locate as close to terminals as possible. Such locations will reduce elevator to terminal transportation costs and pass most of the total transportation costs backward onto producers in the form of assembly costs.

Two factors tend to offset this incentive. First, an elevator location close to a terminal would cause producers to bypass the elevator completely and deliver grain directly to the terminal. The elevator must be far enough from the terminal (and close enough to the producer) so that the additional cost to the producer of delivering directly to the terminal exceeds the charge made by the elevator for handling the producer's grain.

In addition, the threat from potential elevator competitors causes an elevator to locate close enough to producers so that potential competitors will not become actual competitors by locating between the original elevator and producers. Such a new elevator would cause producers to forsake the original elevator by lowering the producers' assembly costs.

These incentives to locate elevators close to producers were dominant in an earlier technology and an elevator location pattern developed which placed many small elevators around the state. There was an elevator near each group of producers large enough to supply the handling capacity of the small elevator. Technological change has induced changes in the locational pattern of elevators. Larger, faster trucks and better roads have reduced assembly costs. Economies of scale allow lower costs of elevator storage and handling and rail transportation. Without regulation the private sector has been willing and able to take advantage of the new technology and reduce assembly, elevator, and truck distribution costs relative to rail distribution costs. The consequence has been the evolution of an elevator location pattern involving fewer, larger elevators; greater average farm to elevator distance; and, increased use of trucks in distributing grain to terminals.

III. Methodology for Estimating Grain Marketing Volume and Costs

The evolution in the location and distribution system is not as far advanced in South Dakota as it is in other Midwestern states. As it proceeds the regulated component, railroads, are beginning to apply their new technology in South Dakota. As they abandon some of their light density branchlines they are rebuilding main lines and realizing the scale economies of the larger hopper cars. The emerging pattern has fewer elevators with the larger elevators shipping by covered hopper cars on main line track and smaller elevators shipping by truck.

A. Elevator Receipts and Shipments

In conjunction with a recent study at SDSU, questionnaires were mailed to the 387 elevators operating in South Dakota in 1974.(10)* Of these 185, or 47.8 percent responded. The responding elevators were classified into categories by their licensed storage capacity and crop reporting district of location. From the grain receipts reported by the responding elevators, elevator receipts turnover rates (elevator receipts/storage capacity) were calculated for the elevators in each size category by district. The districts are shown on the map in Figure I and the receipts turnover rates are shown in Table III.

TABLE III**

ELEVATOR RECEIPTS TURNOVER RATES

Size Category \ District	I	II	III	IV	V	VI
0 - 199,999	1.26	1.39	3,35	2.19	4.02	5.13
200,000 - 399,999	1.14	1.60	1.72	.86	3.65	4.34
400,000 - 599,999	2.73	0.40	3.17	1.73	2.78	3.10
600,000 and over	1.70	1.25		1.27	0.67	

*Forty of the 427 elevators (Table II) operating in 1974 were excluded from the studies because they were primarily feed and/or milling operations or private farm elevators.

**Unless otherwise noted, subsequent tables are taken from (10).

Table III shows that elevator turnover rates tend to increase as one moves across the state from northwest to southeast. This pattern reflects the similar patterns in both crop production density and crop diversity. Greater production density toward the southeast means that more grain is produced in any given area surrounding an elevator. Greater crop diversity allows elevators toward the southeast to use the same facilities over a greater part of the year as both summer and fall harvested grains are handled.

Turnover rates were determined separately for the various capacity categories because of the differences in operating characteristics among different size categories described above. Within each district the table indicates that the turnover rate tends to vary inversely with the size of the elevator. If these data are assumed to represent a long-run equilibrium of the industry, then the data imply decreasing, rather than the increasing, returns to scale found in the studies referred to above. The 1974 data probably do not represent a long-run industry equilibrium, however, and the pattern of turnover rates is due to the adjustment occurring as larger elevators continue to bid grain receipts away from smaller elevators. Therefore, if the studies finding increasing returns to scale are correct, the adjustment is continuing and it can be expected that an increasing proportion of grain produced in South Dakota will be marketed through larger elevators. This also suggests that small elevators will receive a smaller share of the increasing grain deliveries although the actual volume of grain handled by small elevators may not decrease or may decrease less rapidly than their share.

To estimate total elevator grain receipts for the entire state, the turnover rates from responding elevators in Table III were used to estimate receipts at nonresponding elevators. For each of the 202 nonresponding elevators the turnover rate for elevators of its size and district was multiplied by its licensed storage capacity. The total of reported receipts at responding elevators plus estimated receipts at nonresponding elevators was 184 million bushels.

Total grain shipped out of South Dakota elevators was estimated in a manner analogous to that used to estimate elevator receipts. Combined truck and rail shipments from responding elevators were determined by elevator licensed capacity size category and crop reporting district. Shipments turnover rates were calculated by dividing each of these sums by the corresponding summed licensed capacity. The calculated shipments turnover rates are shown in Table IV.

TABLE IV.

ELEVATOR SHIPMENTS TURNOVER RATES

Size Category \ District	I	II	III	IV	V	VI
0 - 199,999	1.162	1.220	2.335	1.590	2.835	3.113
200,000 - 399,999	.701	.909	1.170	.994	1.989	1.910
400,000 - 599,999	.341	.230	1.954	.969	2.108	1.884
600,000 and over	1.022	1.372	0.000	.559	.166	0.000

Grain shipments from each nonresponding elevator were estimated by multiplying the elevator's licensed capacity by the turnover rate corresponding to the elevator's size and district. The combined shipments from responding and non-responding elevators to terminals outside South Dakota were estimated to exceed 126 million bushels in 1974.

Grain shipped from South Dakota elevators to out-of-state terminals in 1974 was delivered to numerous destinations. Many of these destinations received relatively small amounts of grain. The grain shipped to these destinations from responding elevators was subsumed under the total grain shipped to the four largest recipients of South Dakota grain: Minneapolis, Sioux City, the West Coast, and Duluth. The resulting pattern of grain distribution from responding elevators to these four destinations is shown in Table V.

TABLE V

DISTRICT GRAIN DISTRIBUTION PATTERNS
(Percent)

Dist. \ Dest.	Minneapolis	Sioux City	West Coast	Duluth	Total
I	63.5	27.9	5.6	3.0	100.0
II	80.0	11.8	1.9	6.3	100.0
III	85.6	4.6	5.7	4.1	100.0
IV	76.5	18.1	0.0	5.4	100.0
V	52.3	43.8	3.9	0.0	100.0
VI	3.4	94.2	2.5	0.0	100.0

The estimated shipments from nonresponding elevators were allocated to destinations by multiplying total estimated shipments from nonresponding elevators in each district by the percentages for the various destinations in the corresponding district. This procedure assumes that the nonresponding elevators in a district, in total, ship grain following the same distribution pattern as the responding elevators in that district in total. The estimated shipments from nonresponding elevators from each district to each destination and to all destinations are shown in Table VIII.

TABLE VI.

BUSHELS SHIPPED BY TRUCK AND RAIL FROM RESPONDING ELEVATORS

Dist. \ Dest.	Minneapolis	Sioux City	West Coast	Duluth	Total
		(Thousands of Bushels)			
I	5,430	2,385	475	258	8,548
II	7,852	1,161	188	618	9,819
III	12,793	686	855	615	14,949
IV	3,303	779	0	235	4,317
V	8,909	7,474	664	0	17,047
VI	419	11,746	310	0	12,475
Total	38,706	24,231	2,492	1,726	67,155

TABLE VII.

ESTIMATED BUSHELS SHIPPED BY TRUCK AND RAIL FROM NONRESPONDING ELEVATORS

Dist. \ Dest.	Minneapolis	Sioux City	West Coast	Duluth	Total
		(Thousands of Bushels)			
I	3,590	1,595	342	171	5,698
II	9,465	1,420	236	710	11,831
III	10,581	622	747	498	12,448
IV	2,881	674	0	187	3,742
V	7,250	6,135	558	0	13,943
VI	408	10,961	292	0	11,661
Total	34,175	21,407	2,175	1,566	59,323

TABLE VIII.

ESTIMATED TOTAL BUSHELS SHIPPED BY TRUCK AND RAIL FROM ALL ELEVATORS

Dest. / Dist.	Minneapolis	Sioux City	West Coast	Duluth	Total
		(Thousands of Bushels)			
I	9,020	3,980	817	429	14,246
II	17,317	2,581	424	1,328	21,650
III	23,374	1,308	1,602	1,113	27,397
IV	6,184	1,453	0	422	8,059
V	16,159	13,609	1,222	0	30,990
VI	827	22,707	602	0	24,136
Total	72,881	45,638	4,667	3,292	126,478

B. Assembly Costs

To estimate the cost per bushel of assembling grain from farms to elevators, it was assumed that assembly cost per bushel is the same for all commodities. The existing structure of the elevator system in South Dakota was taken as a base system and the marketing receipts area of each existing elevator was considered an originating area. Each elevator location was an assembly destination. Whenever an elevator's grain handling volume was changed, its assembly costs were adjusted by increasing the size of the originating area served by the elevator. This means that an elevator assembles grain from its own originating area regardless of changes in its size.

The cost of assembling grain in the area served by a country elevator is a function of the volume of grain received at the elevator, the marketed density of the area, and the cost of operating and maintaining the equipment used in moving grain. Total grain receipts for each elevator which responded to the questionnaire were taken to be the reported receipts. Estimated receipts for nonresponding elevators were the receipts projected using the calculated receipts turnover rates.

Marketed density for each county was determined by dividing total elevator receipts in the county by the area of the county in square miles. The area of each county is shown in Table IX. The marketed density for each county is thus assumed to be homogeneous over the entire county. Marketed densities also appear in Table IX.

Marketed density varies extensively from county to county. Two important reasons for these variations are differences in the composition of crops produced and differences in land use. The crops produced in the state fall into two basic categories: food grain and feed grain. The food grains, such as wheat and soybeans, are generally shipped to out-of-state processing plants, while much of the state's feed grains remains on local farms. This directly affects the marketed density. For example, in District I the major crop is wheat, which is marketed in its entirety. Alternatively, Districts III, IV, V, and VI produce primarily oats and corn. A large percentage of these crops remains on local farms. In areas where most grain is fed on local farms, one important function of a country elevator may be to grind grain for feed or to act as a "grain bank" which stores grain for local farmers. These alternative uses of country elevators are commonly observed in southeastern South Dakota.

The second source of divergence in marketed density is land use. Marketed density was determined by dividing a county's total marketed production by the total square miles in that county. Thus the lower the proportion of land allocated to grain production, the lower the density per square mile. This was an important factor contributing to the low marketed density in western South Dakota.

The data for the costs of operating and maintaining the equipment necessary to move grain from farm to elevator were derived primarily from the results of a South Dakota study of farm trucking costs.(9) The study determined that the "typical" farm truck used in South Dakota was a two ton truck capable of

TABLE IX.

MARKETED GRAIN PRODUCTION AND MARKETED DENSITY BY COUNTY FOR SOUTH DAKOTA, 1974

County	Marketed Production (1,000 bu.)	Square Miles	Marketed Density (bu./sq. mi.)
District I			
Butte	1,213	2,250	539.16
Corson	1,515	2,470	613.27
Dewey	872	2,351	371.05
Harding		2,682	
Perkins	1,734	2,860	606.13
Ziebach	463	1,981	233.72
Haakon	2,460	1,816	1,354.42
Jackson	885	808	1,095.48
Lawrence		800	
Meade	876	3,465	252.67
Pennington	1,210	2,779	435.50
Stanley	1,178	1,414	832.91
Bennett	567	1,181	480.10
Custer	73	1,557	46.89
Fall River	111	1,743	63.72
Shannon		2,100	
Washabaugh		1,061	
Gregory	3,065	997	3,074.47
Jones	709	973	728.51
Lyman	3,763	1,683	2,236.12
Mellette	247	1,306	189.41
Todd		1,388	
Tripp	2,282	1,620	1,408.67
Total	23,223	41,285	562.50
District II			
Brown	11,444	1,674	6,836.32
Campbell	1,366	732	1,866.25
Edmunds	2,996	1,154	2,595.99
Faulk	3,536	906	3,903.34
McPherson	1,309	1,147	1,141.22
Potter	3,107	869	3,575.82
Spink	4,788	1,505	3,181.20
Walworth	678	718	944.43
Total	29,224	8,705	3,357.15
District III			
Clark	4,455	964	4,621.74
Codington	6,376	687	9,280.85
Day	4,667	1,030	4,531.05
Deuel	2,131	639	3,334.90

TABLE IX -- Continued

County	Marketed Production (1,000 bu.)	Square Miles	Marketed Density (bu./sq. mi.)
District III - Continued			
Grant	3,549	681	5,211.43
Hamlin	3,883	511	7,598.83
Marshall	3,457	848	4,076.26
Roberts	9,784	1,108	8,830.32
Total	38,302	6,468	5,921.77
District IV			
Aurora	1,153	709	1,626.77
Beadle	1,955	1,260	1,551.86
Brule	607	818	742.14
Buffalo		482	
Hand	1,055	1,432	736.93
Hughes	693	748	926.47
Hyde	1,060	863	1,228.48
Jerauld	1,104	527	2,095.15
Sully	3,040	1,004	3,027.95
Total	10,667	7,843	1,360.07
District V			
Brookings	5,160	800	6,449.84
Davison	3,427	432	7,932.87
Hanson	2,267	430	5,271.10
Kingsbury	5,697	818	6,964.16
Lake	7,024	567	12,387.57
McCook	4,455	575	7,748.59
Miner	2,028	570	3,558.72
Minnehaha	9,577	813	11,780.39
Moody	5,516	523	10,547.10
Sanborn	657	570	1,152.63
Total	45,808	6,098	7,511.97
District VI			
Bon Homme	4,412	560	7,878.12
Charles Mix	4,917	1,097	4,481.88
Clay	975	405	2,407.41
Douglas	487	435	1,120.55
Hutchinson	5,774	815	7,084.86
Lincoln	10,191	576	17,692.77
Turner	5,188	612	8,477.69
Union	2,248	452	4,973.34
Yankton	5,001	519	9,635.11
Total	39,193	5,471	7,163.77
State Total	153,396	75,870	2,021.83

carrying 300 bushels of grain. Total annual truck costs are composed of fixed costs (depreciation, interest, shelter, license, and insurance) and variable costs (tires, oil, lubrication, fuel, labor, maintenance, and repairs).

Total annual fixed costs were calculated using replacement costs of the equipment. The typical two ton truck replacement cost in 1974 was $9,300. The annual economic cost was estimated by using a fifteen year useful life and an annual decline in market value of twenty percent of the value at the beginning of any year. It was assumed that truck purchases are evenly distributed over time to average out the cyclical nature of actual truck purchases. Thus, the average truck was in its eighth year and the average depreciation cost was twenty percent of the value at the end of the seventh year of a truck's life or \$390 ($= .2 \times (.8)^7 \times$ \$9300).

An opportunity interest cost representing the foregone alternative of earning a rate of return on the investment in the truck was calculated. The value of the truck at the beginning of the eighth year was \$1950 (= $(.8)^7 \times$ \$9300). The foregone alternative was best represented by the rate on savings or approximately six percent in South Dakota in 1974. The interest cost of truck investment was thus $117.

Shelter costs for the equipment were based on $82.50 as the cost of the building (33 square yards at $2.50 per square yard) and include $0.83 as maintenance (one percent of cost); $4.13 as building depreciation (straight line for twenty years); and $4.95 as interest on the building investment (six percent on $82.50). Shelter costs in total were $9.91. License and insurance costs on the truck were $252.35.

Total annual fixed costs were:

$390.00	Depreciation
117.00	Interest on Investment
9.91	Shelter
252.35	License and Insurance
$769.26	

or approximately $770.

It was estimated that the "typical" South Dakota farmer delivers from 20,000 to 30,000 bushels of grain to the elevator annually with an average per farm near 24,000 bushels. With each trip from farm to elevator carrying approximately 275 bushels, this represents nearly ninety trips. The total mileage driven hauling grain then depends upon the farm to elevator distance.

The mean farm-to-elevator distance (d) for each originating area was calculated on the assumptions:

i) grain marketing is spread homogeneously over the area;

ii) farmers deliver grain to the nearest elevator; and,

iii) the rural road system is a grid.(5)

Therefore, $d = \frac{2}{3} \times \sqrt{\frac{R}{2D}}$ where R is the volume of grain received by an elevator and D is the marketed density of the county (Table IX).

The calculated mean farm-to-elevator distance in South Dakota in 1974 was approximately 5.5 miles. For ninety trips annually, this eleven mile round trip distance represents 990 total miles or approximately one-half of the annual farm truck mileage of 2,000 to 2,500 miles. Consequently, one-half of the fixed truck costs, or $385, were charged to hauling grain.

Total variable costs per mile of operating a two ton truck are listed below:

Expense	Dollars/Mile
Tires	$0.0120
Oil & Lubrication	0.0042
Fuel	0.0740
Labor	0.0750
Maintenance & Labor	0.0280
Dead-Haul Labor	0.5630/d

(Dead-haul labor represents the driver's waiting time while loading and unloading the truck; d is the one way farm to elevator distance.)

Thus total variable costs per mile are: TVC/mile = $0.1932 + $0.0563/d. For the average one way farm to elevator distance of 5.5 miles, this represents a variable cost per mile of $0.2956.

Total variable costs are the product of \$0.2956 and the total annual mileage the equipment is driven. For any farmer the total annual mileage (M) is:

$$M = \frac{P}{AL} \times 2d$$

where P is bushels of grain marketed and AL is the average bushels per truck-load. For the two ton truck carrying an average of 275 bushels and the average one way distance of 5.5 miles:

$$M = .0400 \times P$$

Therefore, total annual variable costs were:

$$\begin{aligned} TVC &= \$0.2956 \times M \\ &\$0.2956 \times .0400 \times P \\ &\$0.01182 \times P \end{aligned}$$

Total costs, the sum of fixed and variable costs, were:

$$TC = \$385.00 + \$0.01182 \times P$$

and assembly cost per bushel was:

$$AAC = \$385.00/P + \$0.01182 = \$0.01604 + \$0.01182 = \$0.02786$$

assuming there were 24,000 bushels hauled per truck used.

To determine the cost of assembling grain at each elevator it was assumed that each farm operates one grain truck. The fixed cost per bushel per truck of \$0.01604 was therefore assumed to apply to each bushel received at the elevator and the elevator's fixed costs of assembly were \$0.01604 x R. (R is the elevator's grain receipts in bushels.)

The variable costs of assembling grain at the elevator were based on the statewide variable truck costs per mile of \$0.2956. Total miles driven hauling grain to each elevator from its originating area are:

$$M = \frac{R}{AL} \times 2d$$

where R = grain from each originating area received at its elevator;

AL = 275 average bushels per trip; and,

2d = mean round trip distance driven assembling each truckload.

Thus, total variable assembly costs of assembling grain at each elevator from its own originating area were:

$$TVC = \$0.2956 \times R \times .0073d$$

(where $.0073 = 2 \div 275$)

and variable assembly costs per bushel were:

$$AVC = \$0.2956 \times .0073d = \$0.00216d$$

Therefore, AAC = \$0.01604 + \$0.00216d represents the cost per bushel of assembling grain from each originating area at the elevator serving that originating area.

C. Handling Costs

The two main functions of a country grain elevator are handling and storing grain. Other functions, such as cleaning and drying, are considered as necessary parts of the two main functions. Elevator costs are categorized as fixed and variable as listed below.

Fixed Costs	Variable Costs
Building & Equipment	Direct Labor
Insurance	Administrative Overhead
Taxes	Electricity, heat, etc.
Depreciation	Truck Expenses
Interest on Investment	Building Repairs
Licenses and Bonds	Equipment Repairs
	Insurance on Grain
	Taxes on Grain
	Fumigation
	Other
	Interest on Working Capital

Depreciation and interest on investment were based on the estimated cost of replacing the elevator's physical plant assets at 1974's price level. Depreciation was calculated using standardized depreciation rates. Elevator age varies from the newly constructed plant to the totally depreciated and exhausted plant. Therefore, it was assumed that one-half of the 1974 replacement value of building and equipment was unrecovered in 1974. Interest on investment was calculated using a rate of 8 percent applied to one-half of this 1974 replacement value. Interest on working capital was estimated at 7 percent of one-fourth of the total out-of-pocket costs.

Following the two main functions of country grain elevators, costs were allocated to handling and storage. Handling costs were further broken down into costs of receiving and outloading grain. These depend upon the mode of receiving and outloading. For South Dakota elevators all grain was assumed to be received by truck and outloaded by either truck or rail.

Studies of elevator costs often use monotone decreasing average cost functions. Using the volume of grain handled as the index of elevator production, decreasing long-run average costs reflect increasing returns to scale.(7;27;28; 30;31) Grain handled can be measured as bushels received, outloaded, or the average of receipts and outloadings. Elevator scale can be measured by an index of receiving, loading, storing, and drying capacities of the elevator. In practice the elevator's storage capacity was used as the measure of elevator plant size.

As described in Section II, diminishing short-run average costs reflect the increasing average productivity of a given scale of plant. This is due to the ability of an elevator of a given scale to handle larger volumes of grain by increasing its turnover rate - the ratio of grain handled to plant size. The turnover rate can be varied in two ways. First, the rate of grain handling can be changed. This type of variation would follow the curved production function and U-shaped average cost curve of traditional microeconomic theory. (Figure II)

Second, the time of operation can be varied by changing the number of hours worked per day or week. This type of variation would reflect an approximately linear production and average cost function. Variation of the turnover rate is dominated by changes in the time of operation rather than the rate of operation. This is due to the technological characteristics of any given receiving and loading equipment which has only two speeds, off and on, where "on" represents a given number of bushels per time unit; that is, a given rate of grain handling.

Studies of elevator costs have reflected this dominance of the time component by using linear average cost curves or equivalently, constant marginal cost curves. One possible difficulty presented by such monotone decreasing linear average cost functions is that they must eventually represent zero average costs at some positive volume of grain handled - an implausible economic result.

Lorenz has avoided this problem by using an average elevator handling cost function which approaches zero asympototically:(12)

$$(AHC)^{-1} = a + bV.$$

This function leaves at least two remaining and related economic difficulties. First, the function approaches zero rather than some positive average cost as the volume of grain handled increases. Second, while it is plausible that the long-run cost curve is not observed to have a positive slope since firms would not construct plants larger than optimal, it is not plausible that the short-run average cost curve should not have a positive slope at some output level. When the elevator operates at its maximum rate for the maximum hours in the relevant time period, the short-run average costs should increase rapidly and marginal costs approach infinity.

There are two possible explanations of why elevators' short-run average costs have not been observed to increase with volume of grain handled. The curve may not be smooth but have a corner at the maximum attainable handling level. This implies an infinite marginal cost at that point and consequently no firm would operate beyond the corner. A second explanation is that all firms have completed any long-run plant adjustments when the data is obtained. This implies that all elevators, of whatever storage capacity, are operating as optimally sized plants for their level of grain handling. Thus, each elevator would reflect non-increasing average costs.

The Lorenz study of the costs of grain elevators in South Dakota used accounting data from thirty elevators in four size categories. Six different average cost functions were tested using the accounting data. Using both the t-test and F-test, each of the functions was found to be significant at the 0.01 level. The function with the greatest coefficient of determination ($r^2 = 0.74$) using the 1970 cost data was:

$$(AHC)^{-1} = .0377 + .00000019 \cdot (LC)$$

where LC is elevator licensed storage capacity. The predictions of this function compare favorably with those of several other studies made in other states.(7;27; 29;30;31)

From this average cost function the total elevator cost function is:

$$THC = \frac{V}{.0377 + .00000019 \cdot LC}$$

where V is the annual volume of grain handled. For any given licensed capacity, total cost is a linear (and linearly homogeneous) function of volume handled. The linearity of this short-run cost function implies constant and equal short-run average and marginal cost functions:

$$SRAHC = SRMHA = \frac{1}{.0377 + .00000019 \cdot LC} .$$

For any given volume handled, average cost varies inversely with licensed capacity. As LC increases, AHC decreases at a decreasing rate and approaches zero asymptotically.

$$\left.\frac{d(AHC)}{d(LC)}\right| V = -\frac{.00000019}{[.0377 + .00000019 \cdot LC]^2} < 0$$

$$\left.\frac{d^2(THC)}{d(LC)^2}\right| V = \frac{(2)\ (.00000019)^2}{[.0377 + .00000019 \cdot LC]^3} > 0$$

When the parameters are adjusted for the 45 per cent increase in the Wholesale Price Index from 1970 to 1974, this average cost function becomes:

$$AHC = \frac{THC}{V} = \frac{1}{.026 + .000131(LC)}$$

where LC is licensed capacity in thousands of bushels. This function was used to determine elevator handling and storage costs. The constant short-run average cost function (for any given plant size) reflects the technological constraint described above. A higher turnover rate ($\frac{V}{LC}$) is primarily the result of extending the hours of operation and not of an increase in the rate of operation.

Since the actual licensed capacity of each elevator was known, the handling and storage cost per bushel was calculated for each elevator using the average cost function above. The following table shows the handling and storage cost per bushel of grain received for elevators of various typical licensed capacities.

Licensed Capacity	100	175	250	500	750	1000	1500	2000	(000's of bu.)
Cost Per Bushel	25.58	20.44	17.02	10.93	8.05	6.37	4.49	3.37	(¢)

D. Distribution Costs

Distribution costs are costs of moving grain from the country elevators to the first destination terminal. Costs associated with moving grain from the elevator back to the farm were not calculated. The destination terminals for South Dakota grain are Minneapolis and Duluth in Minnesota; Sioux City, Iowa; and the West Coast.

The two transportation modes serving South Dakota elevators are railroads and motor carriers. The cost of moving grain from elevator to terminal was determined separately for the two modes.

1. Truck Rates

The elevators responding to the questionnaire supplied data on truck rates charged and bushels of each commodity shipped by truck to each destination. It was assumed that the truck rate charged per bushel to a given destination was a function of distance only. The distance from each elevator to each destination was estimated by using a standard highway map. The trucks were assumed to travel the shortest route on suitable highways as measured from a point in the center of each county to the various terminals, except the West Coast. The distance from any elevator to the West Coast was measured from the center of the crop reporting district in which the elevator was located to Seattle, Washington.

From the data supplied by the responding elevators, a truck rate function was estimated using ordinary least squares. Such a function is of limited reliability for various reasons. For some commodities only a few rates were reported and the function could not be relied upon as representative of the entire state. In some areas, particularly the east and southeast parts of the state, the opportunities for backhaul from the Twin City and Sioux City markets resulted in diverse rate quotations from the same area for the same commodity. When a backhaul is available, a trucker is often willing to haul grain at a reduced rate since the backhaul revenue covers the costs of the return trip. Much of the grain shipped out of South Dakota was sent to non-terminal destinations scattered throughout Nebraska, Kansas, Colorado, and Missouri. These shipments were frequently outright sales made at the elevator so that the elevator could report only the quantity and destination but no rate was available.

To arrive at a function consistent with the assembly and elevator costs, the truck rate function was derived by first adjusting the rates quoted for hundredweight to rates per bushel. These rates were weighted by the number of bushels shipped by truck and a rate-distance function calculated as:

$$S = \$0.11339 + \$0.00043 \cdot M. \qquad (t = 13.86 \; ; \; r = .74)$$

where S is the truck rate per bushel and M is the measured distance in miles. Therefore, $ADC = \$0.11339 + \$0.00043 \cdot M$ is the average truck distribution cost from any given elevator to any given terminal. The rates determined by this function were checked to see that they did not exceed the maximum rates prescribed by the South Dakota Public Utilities Commission.

2. Rail Rates

The cost per bushel of distributing grain from each elevator to each terminal destination by rail was obtained from the railroad rates quoted by the Minneapolis Grain Exchange.(13)

3. Total Distribution Costs

Total distribution costs from each elevator to each destination were calculated as the sum of total truck distribution costs plus total rail distribution costs. Total truck distribution costs are the products of the average distribution costs from the truck rate function and the volume of grain shipped by truck.

$$TDC_t = ADC_t \cdot V_t = (\$0.11339 + \$0.00043 \cdot M) \cdot V_t$$

Total rail distribution costs are the product of the railroad rate from the quoted rate book and the volume of grain shipped by rail.

$$TDC_r = ADC_r \cdot V_r$$

Then total distribution costs were:

$$TDC = TDC_t + TDC_r = (\$0.11339 + \$0.00043 \cdot M)V_t + ADC_r \cdot V_r$$

where the volumes shipped were those discussed in Section III.

IV. Costs of Marketing South Dakota Grain

The marketing and cost data described above were used to estimate the actual flow of grain out of South Dakota and the marketing costs incurred. In addition, a linear programming transportation model was used to estimate the least cost marketing system for alternative relative truck-rail rates and assembly patterns. The purpose of these estimates was to suggest how the pattern and cost of grain marketing would adjust in response to changes in distribution costs and the elevator system.

As a cross-section analysis utilizing data from one year only, it was not possible to sort out trends or single year anomalies. For example, the 1974 grain distribution pattern may reflect some distortion from a normal pattern due to the large export demand in 1973 and 1974. This might have caused an unusually large diversion of South Dakota grain from Sioux City to Minneapolis which offers better barge service to the Gulf ports.

A. Marketing of Grain in 1974

Using the costs and terminal receipts data estimated above the least cost pattern of grain distribution from each district to terminals by truck and rail was determined. Table X shows the grain distribution pattern and Table XI shows the corresponding costs. The total cost of marketing 126,480,000 bushels was $53,170,000 or an average of $.42 per bushel from all districts to all terminals. These costs represent the minimum cost if grain is shipped by the lowest cost mode and in the most efficient pattern while continuing to ship the reported total quantities to each terminal.

Therefore, even though each terminal receives the same amount of grain as estimated from the responding elevators' information, the source of each terminal's receipts is different than the reported shipments information. The reported pattern of shipments is shown in Table XIII. Since this table includes only reported shipments and not total estimated shipments, both the reported and least cost shipping patterns are shown in percentage terms in Tables XIV and XV, respectively.

TABLE X

BUSHELS SHIPPED BY MODE
(000's of Bushels)

Dest. / Dist.	Minneapolis Truck	Minneapolis Rail	Sioux City Truck	Sioux City Rail	West Coast Truck	West Coast Rail	Duluth Truck	Duluth Rail
I		2,688	1,343	5,204	1,703	2,558		750
II	5,229	15,540				407		475
III	2,616	22,715						2,066
IV	2,490	3,327		2,242				
V	6,330	11,947		12,714				
VI			2,262	21,874				
Total	16,665	56,217	3,605	42,034	1,703	2,965		3,291

TABLE XI

COST OF SHIPMENTS
(000's of Dollars)

Dest. / Dist.	Minneapolis Truck	Minneapolis Rail	Sioux City Truck	Sioux City Rail	West Coast Truck	West Coast Rail	Duluth Truck	Duluth Rail
I		1,376	605	1,964	1,603	2,386		398
II	2,251	6,299				341		228
III	1,089	9,120						745
IV	1,329	1,421		880				
V	2,989	4,829		4,672				
VI			924	7,721				
Total	7,658	23,045	1,529	15,237	1,603	2,727		1,371

TABLE XII

COST OF SHIPMENTS
(Dollars per Bushel)

Dist.	Minneapolis		Sioux City		West Coast		Duluth	
Dist.	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
I		.51	.45	.38	.94	.93		.53
II	.43	.41				.84		.48
III	.42	.40						.36
IV	.53	.43		.39				
V	.47	.40		.37				
VI			.41	.35				
Total	.46	.41	.42	.36	.94	.92		.42

TABLE XIII

REPORTED SHIPMENTS BY RESPONDING ELEVATORS
(000's of Bu.)

Dest. Dist.	Minneapolis Truck	Minneapolis Rail	Sioux City Truck	Sioux City Rail	West Coast Truck	West Coast Rail	Duluth Truck	Duluth Rail
I	2,662	2,768	1,422	963	145	330	8	250
II	2,973	4,879	475	686	25	163	110	508
III	2,714	10,079	22	664		855	11	604
IV	444	2,859	151	628				235
V	5,372	3,537	3,308	4,166	547	117		
VI	196	223	3,171	8,575	310			
Total	14,361	24,345	8,549	15,682	1,027	1,465	129	1,597

TABLE XIV

REPORTED SHIPMENTS BY RESPONDING ELEVATORS
(Percent of District i Total to Destination j by Mode m)

Dest. Dist.	Minneapolis Truck	Minneapolis Rail	Sioux City Truck	Sioux City Rail	West Coast Truck	West Coast Rail	Duluth Truck	Duluth Rail
I	31.1	32.4	16.6	11.3	1.7	3.9	.1	2.9
II	30.3	49.7	4.8	7.0	.3	1.7	1.1	7.2
III	18.2	67.4	.1	4.4		5.7	.1	4.0
IV	10.3	66.2	3.5	14.5				5.4
V	31.5	20.7	19.4	24.4	3.2	.7		
VI	1.6	1.8	25.4	68.7	2.5			

TABLE XV

PERCENT OF SHIPMENTS BY MODE

Dest. / Dist.	Minneapolis Truck	Minneapolis Rail	Sioux City Truck	Sioux City Rail	West Coast Truck	West Coast Rail	Duluth Truck	Duluth Rail
I		18.9	9.4	36.5	12.0	18.0		5.3
II	24.2	71.8				1.9		2.2
III	9.6	82.9						7.5
IV	30.9	41.3		27.8				
V	20.4	38.6		41.0				
VI			9.4	90.6				

These results indicate that the shipments from any district would have been much more concentrated among terminals than actually reported if the conditions of the least cost model had been met. There are several reasons why the reported shipping pattern is less concentrated than the least cost pattern. First, variations in truck rates due to availability of backhauls and seasonal variations in demand for transportation would lead to modal and terminal substitution over the course of the year. Second, total distribution costs to the shipper include more than just the truck or rail rate charged. The costs include inventory costs while grain is in transit and costs due to grain damage and losses. These costs are usually higher for rail than for truck shipments and would cause reported shipments to rely on trucks more than indicated by the least cost model. A third reason is that the least cost model necessarily assumes that the set of relative terminal prices for grain is unchanged over the year. Any variation in the set of relative terminal prices reflecting variations in relative terminal demands and/or transhipment costs would cause interterminal substitution in the least cost model. For all of these reasons, the reported modal and destination patterns are more diverse than the results of the least cost model.

TABLE XVI

PERCENT OF GRAIN SHIPPED BY MODE

	Reported Data		Least Cost		Higher Truck Rates	
	Truck	Rail	Truck	Rail	Truck	Rail
I	49.5	50.5	21.4	78.6	14.1	85.9
II	36.5	63.5	24.2	75.8	9.5	90.5
III	18.4	81.6	9.6	90.4	3.8	96.2
IV	13.8	86.2	30.9	69.1	2.5	97.5
V	54.1	45.9	20.4	79.6	7.5	92.5
VI	29.5	70.5	9.4	90.6	4.7	95.3
Total	35.8	64.2	17.4	82.6	6.9	93.1

Table XVI indicates that the factors listed above contributed to a substantial substitution of truck service for rail transportation. Only District IV in the center of the state reported using truck service less intensively than the least cost model. The district is crossed by two east-west rail lines and one north-south line. These are some of the better service lines in the state with direct service to Minneapolis and Sioux City. The district has remained free of short branchlines. Consequently, communities and elevators have been located along the three long, better service branchlines. This location pattern has resulted in a set of elevators which has retained good rail service so the cost of shipping by rail has remained lower than the cost of shipping by truck. (See Figure I for the location of Districts.)

The other districts reported using truck service more intensively than the least cost model. The reason again appears to lie in the relative costs of using the two modes but the reasons for different relative costs varies among the districts. District I has no rail service in much of the district and where rail service exists it is generally poor. The district does have an interstate highway crossing from west to east providing good truck access to terminals for the southern half of the district. The northern half does not have as good a highway system but has virtually no rail service so that trucking becomes necessary.

Districts II and III have good mainline rail service from west to east but much of these districts, away from the mainline, is served only by short branchlines which provide relatively poor, expensive service. At the same time, these districts have a good highway network. Districts III and V are located on the eastern edge of the state closest to the Minneapolis terminal. They are within 200 to 300 miles of the terminal, a distance for which truck rates are often competitive with rail rates. This is particularly the case when backhauls are available as they often are from Minneapolis. District VI in the southeast is closest to Sioux City and is served by good highways including both east-west and north-south interstate highways. These eastern districts are also dotted with communities and elevators located on short branchlines which have been allowed to deteriorate due to light density rail traffic. The poor service has raised the relative cost of rail shipping at the same time that the improved highways have lowered the relative cost of truck shipping.

B. Response of Grain Marketing to Alternative Distribution Costs

To estimate the response of the grain marketing pattern to changes in the relative cost of shipping by rail and truck, all truck rates were raised ten percent and the least cost marketing pattern determined. Tables XVII and XVIII show the pattern of distribution in bushels and percentages respectively with the higher relative truck costs. The tables are comparable to Tables X and XV above.

The impact on the pattern of grain distribution from each district to each terminal is shown in Table XIX below. The primary impact appears in a shift between Districts I and II in supplying Minneapolis and the West Coast. With its rail connection to the West Coast and higher truck rates, District II ships more grain to the West Coast and less to Minneapolis. District I, while located farther from Minneapolis and closer to the West Coast than District II,

TABLE XVII

BUSHELS SHIPPED BY MODE
(000's of Bushels)

Dest. / Dist.	Minneapolis Truck	Minneapolis Rail	Sioux City Truck	Sioux City Rail	West Coast Truck	West Coast Rail	Duluth Truck	Duluth Rail
I	382	3,846	1,590	5,055	31	2,963		378
II	2,056	16,404				1,673		1,518
III	1,044	24,957						1,396
IV		5,618	199	2,242				
V	2,318	16,256		12,416				
VI			1,126	23,010				
Total	5,800	67,081	2,915	42,723	31	4,636		3,292

TABLE XVIII

PERCENT OF SHIPMENTS BY MODE

Dest. / Dist.	Minneapolis Truck	Minneapolis Rail	Sioux City Truck	Sioux City Rail	West Coast Truck	West Coast Rail	Duluth Truck	Duluth Rail
I	2.7	27.0	11.2	35.5	.22	20.8		2.7
II	9.5	75.8				7.7		7.0
III	3.8	91.1						5.1
IV		69.7	2.5	27.8				
V	7.5	52.5		40.1				
VI			4.7	95.3				

TABLE XIX

Percent of Each District's Grain Shipments Going to Each Terminal

	Minneapolis			Sioux City		
	Reported Data	Original Cost	Higher Truck Rates	Reported Data	Original Cost	Higher Truck Rate
I	63.5	18.9	29.7	27.9	46.0	46.6
II	80.0	95.9	85.3	11.8		
III	85.6	92.5	94.9	4.6		
IV	76.5	72.2	69.7	18.0	27.8	30.3
V	52.3	59.0	59.9	43.8	41.0	40.1
VI	3.4			94.2	100.0	100.0

	West Coast			Duluth		
	Reported Data	Original Cost	Higher Truck Rates	Reported Data	Original Cost	Higher Truck Rates
I	5.6	29.9	21.0	3.0	5.3	2.7
II	1.9	1.9	7.7	6.3	2.2	7.0
III	5.7			4.1	7.5	5.1
IV				5.4		
V	3.9					
VI	2.5					

ships more to Minneapolis and less to the West Coast. Without rail service to the west, the higher truck rates cause shipments from District I to be diverted from the long haul west to the relatively short haul to Minneapolis. Market demand for grain at the West Coast is then satisfied by increased shipments from District II.

The impact of higher relative truck rates on the modal distribution of grain is shown in Table XVI. A substantial substitution of rail for truck service occurs in all districts. This indicates the high degree of substitutability between the two modes. It also suggests that the unregulated truck rates may be quite sensitive to rail rates. The truck rate function, derived from reported truck rates, appears to provide rates just low enough to capture a significant share of the grain transportation business.

While all districts substitute rail for truck service when relative truck rates are raised, such substitution is not as feasible in District I which becomes the district using the highest percentage of truck service. This reflects again the limited availability and quality of rail service in District I. When the relative truck rate is raised, the biggest shift from truck to rail occurs in Districts II and IV where better rail service is available.

C. Response of Grain Marketing to Alternative Assembly Systems

The costs of assembling and handling grain at each elevator were estimated as described in III above. A rough estimate was made of the potential reduction of total marketing costs through application of the economies available in the improved transportation and elevator systems now in place. Transportation efficiency has been improved through the construction of better highways and larger, faster trucks. These have reduced the cost of farm to elevator assembly and provided an economic incentive to haul grain to larger elevators farther from the producer. The construction of larger elevators with more efficient grain handling systems has provided the other side of this incentive. Improved highways and trucks have also lowered distribution costs from elevator to terminals.

Throughout South Dakota many small and relatively inefficient elevators continue to handle grain at costs greater than those at more efficient elevators. To estimate the potential saving in marketing costs available through use of better technology, the cost minimizing model was adjusted so that grain produced in each district was assembled at the most efficient elevators. The existing system of elevators was assumed to be fixed in physical terms but variable in operating terms. The number and licensed capacity of all existing elevators was left unchanged. The rate of grain handling was adjusted.

Adjustments in elevator grain handling were made by shifting the original pattern of elevator receipts and shipments used in the initial analysis. The shadow prices generated in the first model were used as the basis for shifting elevator receipts and shipments. For the j-th terminal a shadow price, d_j, was calculated which represented the implicit cost of shipping one more bushel of grain to that terminal from the elevator which could supply the terminal at the lowest cost. Similarly, a shadow price, o_i, was determined for each elevator. This represented the additional cost of handling one more bushel of grain through the i-th elevator.

For each elevator-terminal distribution route chosen by the cost minimizing routine:

$$d_j - c_{ij} = o_i$$

where c_{ij} was the distribution cost per bushel from elevator i to terminal j by the least cost transportation mode. Thus for two elevators, i and k, shipping to the same terminal, j, if $o_i > o_k$, then $d_j - c_{ij} > d_j - c_{kj}$ or $c_{ij} < c_{kj}$. Shipping one less bushel from elevator k and one more from elevator i would result in a net saving of $(c_{kj} - c_{ij})$ dollars due to the lower combination of costs (assembly, handling, and distribution) for elevator i.

As the grain originally shipped from elevator k was rerouted through elevator i, the elevator receipts also had to be rerouted between the two elevators. Increasing the grain receipts of elevator i meant that the mean farm to elevator distance in assembling grain at elevator i increased. Consequently, the assembly costs per bushel increased as described in III. This elevator's lower handling and distribution costs were (partially) offset by higher assembly costs.

The rerouting of elevator grain receipts within each district was accomplished by reducing (to zero) the receipts at elevators with the lowest shadow prices and increasing them at nearby elevators with the highest shadow prices. The rerouting was done on a case-by-case basis. The assumption implicit in using this approach is that any changes which will occur in the elevator system in response to the economic forces operating in the grain marketing sector will evolve out of the present elevator system. For example, if economic forces dictate that a new elevator system will contain fewer and larger elevators than the present system, the new system will consist primarily of survivors from the present set of elevators. Thus the survivors will remain in their present locations.

The rerouting of grain within each district from elevators with low shadow prices to those with high shadow prices was constrained by a maximum receipts turnover rate determined for each district. The maximum turnover rate was based on the weighted average turnover rate for the district and the standard deviation of turnover rates in the district, assuming the turnover rates to be normally distributed.

For Districts I, II, and IV the maximum turnover rate used was four, approximately equal to the weighted mean rate plus two standard deviations. The primary crops produced in these districts are wheat, barley, and oats which are harvested in summer. The maximum feasible turnover rate was lower in these districts because of the coincident harvesting of these primary crops during the summer months.

Districts I, II, and IV have 23, 25, and 25 percent of their respective elevator capacities in large elevators with licensed capacities greater than 600,000 bushels. These elevators were operating at turnover rates below the weighted average rate in these districts. The studies indicating increasing returns to scale in elevator grain handling suggest that as grain deliveries are rerouted from the smaller elevators to these larger elevators, their turnover rates can increase substantially and exceed those of the smaller elevators. Therefore, the maximum feasible turnover rates in these districts were assumed to be approximately two standard deviations above the present weighted average turnover rate.

In the east, Districts III, V, and VI have a greater diversity of crop production and consequently a more even balance between the share of production harvested in the summer and the share harvested in the fall. This allowed elevators in these districts to have higher turnover rates than elevators in the western districts. In addition, a larger proportion of eastern production is in feed grains which are often delivered to the elevator and returned quickly to livestock feeders in the area. The short storage time required for these transactions allows relatively high receipts turnover rates. Although rare, turnover rates as high as fifteen can occur in the southeast area, District VI.

While elevators in the eastern districts had higher turnover rates than those in the western districts, it was believed that their present turnover rates were closer to the maximum feasible turnover rates without investment in larger elevators. Large elevators with licensed capacity greater than 600,000 bushels comprised 0, 5, and 0 percent of total capacity in Districts III, V, and VI respectively. Since the potential improvement in turnover rates was thus limited with the present elevator sizes, the maximum feasible turnover rates in these districts were assumed to be only one standard deviation above the present weighted average turnover rate of each eastern district.

TABLE XX

Maximum Feasible Turnover Rates

District	I	II	III	IV	V	VI
Wtd Avg T/O	1.4	1.3	2.8	1.3	3.3	4.4
Std. Deviation	1.2	1.2	2.3	1.3	2.9	3.7
Max. T/O	4	4	5	4	6	8

The elevators with high shadow prices received the rerouted grain deliveries. Each such elevator was allowed to receive grain it received in the original model plus rerouted grain from the same county and adjacent counties as long as its turnover rate did not exceed the maximum shown in Table XX. The rerouting of grain from elevators with low shadow prices; i.e., those elevators least efficient at assembling, handling, and distributing grain delivered by producers and purchased at the terminals, meant that the model treats the grain handling function of these elevators as abandoned. The number of elevators still operating and the change from the first model were:

TABLE XXI

Number of Operating Elevators

District	I	II	III	IV	V	VI	Total
Elevators: original #	61	81	69	35	75	66	387
Remaining in operation	24	13	27	8	31	34	137
% Change	-61	-84	-61	-77	-59	-48	-65

The number of elevators remaining in the grain handling business under the conditions described was 137. This represented only 35 percent of the 387 elevators actually receiving grain in 1974. The cost of marketing grain in this situation and a comparison with the costs of the first model are shown in Table XXII.

TABLE XXII

CHANGE IN GRAIN MARKETING COSTS DUE TO REROUTING GRAIN

Model District	Least Cost	Fewer Elevators	% Change
I	$ 8,332	$7,077	-15.1
II	9,119	9,008	- 1.2
III	10,954	9,974	- 8.9
IV	3,630	3,032	-16.5
V	12,490	11,519	- 7.8
VI	8,645	7,785	- 9.9
Total	$53,170	$48,395	- 9.0

These results indicate that there exists substantial excess elevator capacity in South Dakota. This excess capacity is measured only in terms of the costs of assembling, handling, and distributing grain to terminal markets. The value of "abandoned" elevators in providing storage capacity and ancillary products and services is ignored. Therefore, abandonment as used here refers only to the elevator's role in the system of moving grain from South Dakota producers to out of state terminal destinations. Most of these abandoned elevators would continue to operate by selling feed and fertilizer and many of the other products and services described in II. Thus, a change in product mix and management practices would probably occur. The effect of introducing the value of storage capacity and changes in product mix and management practices for those elevators abandoning their distribution function was left as an avenue for further analysis beyond this study.

The greatest excess capacity in terms of elevator numbers appeared in Districts II and IV. In District II this was due to the present system of numerous small elevators scattered throughout the district and relatively large, efficient elevators capable of handling much of the district's grain. In

District IV the system consists of several small elevators but these were not scattered over the district. Rather, they were concentrated along the two east-west rail lines which cross the district. Several of these elevators could abandon their grain distribution function without significantly increasing assembly costs. Given the existing set of elevators, producers must bring their grain through a country elevator.

In District I (West River) the solution set would abandon 61 percent of the elevators and save 15.1 percent of marketing costs. The saving was limited by the longer assembly distances and thus higher assembly costs in this larger, less productive district.

Because the eastern districts (III, V, and VI) have many small elevators scattered over smaller regions, the solution allowed the abandonment of a smaller percentage of elevators with a significant cost saving. Since there were few large elevators in these districts, there were few opportunities for a large elevator to allow the abandonment of several small elevators. Therefore, the percentage of elevators abandoned was lower than in the Western Districts. The existence of many small elevators in a smaller area meant that assembly costs did not increase dramatically as some elevators were abandoned. Thus, the saving in handling costs was not offset by higher assembly costs. In these districts the solution set would abandon 56 percent of the elevators and save 8.8 percent of marketing costs.

After the rerouting of grain as described above, the number and location of the 137 elevators which continued to handle grain was based entirely upon the reported licensed capacities, the calculated assembly, handling and distribution costs, and the elevator locations. Some of the omitted variables which could influence this solution set include ancillary services offered by elevators, loading facilities available at elevators, abandonment of rail branchlines, changes in rail or truck rates, or changes in export demand.

The number and locations of surviving elevators resulting from this model are approximations indicating the direction of future changes in the elevator system. The inclusion of the effects of the variables omitted from the model might significantly alter the quantitative results, i.e., the exact number and locations of surviving elevators. The savings in marketing costs were less than 10 percent and might be reduced when other variables are introduced. It is not likely, however, that the qualitative results would be affected. There exists substantial excess elevator marketing capacity in South Dakota in the sense that much of this capacity could be abandoned either without increasing marketing costs, or more probably, with a reduction in marketing costs. When combined with the cost saving available through elevator economies of scale the efficiencies demonstrated were significant.

The solution set resulting in Table XXII represents an improved grain marketing network in the sense of a lower cost system. Given that South Dakota grain sales are perfectly competitive at terminals, this solution suggests that nine or ten percent of current grain marketing costs could be saved to South Dakotans in the short-run. This savings represents approximately five million dollars.

The evolution toward such a solution would be directed by economic forces. The more efficient elevators, in recognition of their cost advantages, would offer higher prices to producers and bid grain supplies away from less efficient elevators. These elevators faced with dwindling supplies from producers and reduced profits due the higher prices paid producers, would be forced out of the industry. The surviving elevators would capture the profits of abandoned elevators but lose part of those profits to producers in the form of higher grain prices. Producers located near abandoned elevators but farther from a surviving elevator would gain from the grain prices but lose some or all of this advantage due to the greater assembly costs they would incur.

The group which would benefit the most would be the producers located near surviving elevators. This group would receive the higher grain prices but incur no additional assembly costs. Thus it might be predicted that in any given area, producer groups such as cooperatives might attempt to ensure that at least one of the elevators in their area is a survivor.

Over a longer time period as elevators are abandoned the surviving elevators might be able to recapture a greater share of the savings from producers. This possibility would arise where surviving elevators derive monopsony power as nearby competitive elevators are abandoned. Producers, faced with longer hauls and higher assembly costs to market their grain through alternative elevators, would accept a lower grain price once again. This longer run result is not likely in the Eastern Districts (III, V, and VI) where the solution set retains several elevators within a relatively short distance from any producer. In the Western Districts (I, II, and IV) this result is more likely to occur.

Although the evolution of the present elevator system might occur as described above, the description is in terms of a short-run or intermediate-run period of a few years. The evolution as described is not likely to occur, however, without interacting with the longer run process of merging elevator capacities and investment in larger elevators and better transportation. This is not only because long-run adjustment processes occur simultaneously with short-run adjustments as in all industries. It is also because the economic incentives for the short-run adjustment appear to be insufficient to cause rapid adjustment. The economies of scale due to larger elevators and the introduction of multicar rates for these larger elevators would substantially increase the incentives to adjust.

The cost differential between elevators in the present system is not large in most situations. This is evidenced by the existence of many elevators of similar size in the state and the relatively small savings (nine percent) of marketing costs which can be realized. As a consequence the price differential which the most efficient elevators can offer producers over the price offered by less efficient elevators would be small in most cases and relatively small amounts of grain deliveries would be diverted over any short-run period. The present positive profit rate of even the less efficient elevators and the very low opportunity cost of continuing to operate them suggest that these elevators would continue in operation for some time. Additional considerations in the adjustment are: grain elevators sell other products and services; external developments in livestock feeding or other enterprises may alter trends; and, other assumptions may give different optimum solutions.

Therefore, an evolution toward the solution set of this study cannot be expected to be rapid unless spurred by longer-run forces. Some longer-run variables which might accelerate such an evolution are railroad branchline abandonment, highway construction, investment in in-state grain processing facilities, and merger in the elevator system.

Variations of the two basic models described above were also run. The purposes of these variations were to estimate the sensitivity of the grain distribution pattern to changes in relative grain demand at the various terminals, to indicate the effect of the more efficient elevator system on modal and terminal distribution patterns, and to indicate the effect on the distribution pattern of shipping all grain to least cost terminals. The results of these variations are included in the Summary below.

D. Summary

This study has taken as given the grain receipts and shipments and the assembly and handling costs of South Dakota elevators. One phase of the study considered variations in distribution costs to estimate reactions of the distribution pattern. This phase thus suggests how the grain distribution system might respond in the short run to changes in the structure of relative distribution costs to the various terminals. During this short-run period no net investment (positive or negative) is allowed in the elevator, distribution or terminal systems. The conclusions of this phase are:

1. Truck and rail distribution services are close substitutes to all terminals for South Dakota grain. Small changes in relative truck and rail rates result in a relatively large substitution between modes.
2. The allocation of grain to the various terminals from districts III, V, and VI is insensitive to changes in the overall truck rate-rail rate ratio. The other districts' distribution, particularly that of District I, is sensitive to these changes. Increases in the truck-rail rate ratio cause District I to supply a substantially larger share of the receipts at Minneapolis and smaller shares at the other three terminals. Both Districts II and IV supply smaller shares of Minneapolis receipts with District II increasing its share of West Coast and Duluth receipts and District IV increasing its Sioux City share. These results are consistent with anticipated results given the relative district to terminal distances and locations.
3. Increasing the truck-rail rate ratio for longer distances relative to shorter distances shows that the distribution pattern is destination sensitive as well as mode sensitive. A higher long distance truck-rail rate ratio causes District I to supply a larger share of Sioux City and smaller shares at the West Coast and Duluth. Districts II, III, and IV supply a smaller share at Minneapolis with District II increasing its share at Duluth, District III at the West Coast, and District IV at Sioux City. District V supplies a smaller share at Sioux City and a larger share at Minneapolis.
4. Minneapolis and Duluth are relatively close substitutes as terminals for receiving South Dakota grain. This is true in the sense that a change in the relative demand price at the terminals or the relative distribution cost to them of 2.5¢ to 5¢ per bushel can divert as much as thirty percent of the total receipts at Minneapolis to Duluth.

5. Minneapolis and Sioux City are close substitutes as terminals for receiving South Dakota grain. The ratio of distribution costs to Minneapolis and to Sioux City falls generally within the range of 1.0 to 1.5. This suggests an elasticity of substitution between the two terminals in the range of 12 to 18 and they appear to be very close substitutes. Therefore, minor shifts in relative demand prices and/or distribution costs can cause major shifts in the pattern of distribution of South Dakota grain between the two terminals.

In the second phase of the study, elevator receipts and shipments, and therefore assembly costs per bushel, were varied. Receipts and shipments were rerouted from high to low cost elevators subject to a constraint on each elevator's receipts turnover rate. This constraint reflects the given size (licensed capacity) of each elevator. The conclusions suggested by this phase are:

1. There exists a significant amount of excess elevator capacity in South Dakota in terms of the cost of assembling, handling, and distributing grain to terminal markets. It does not necessarily mean that there is excess grain storage capacity.

2. The results suggest that within the framework of the existing elevator system, the operating economies inherent in large scale elevators may lead to the abandonment of grain handling operations by many small elevators. In the extreme case, rerouting grain deliveries from less efficient to more efficient elevators could reduce total marketing costs by eliminating grain handling operations by nearly 250 elevators, or over sixty percent of the existing elevators in operation in 1974. The reduction in marketing costs are small enough, however, to suggest that any such adjustment in the structure of the marketing system will probably only take place over an extended number of years through abandonment of worn out facilities.

3. This rerouting of grain deliveries could result in a saving of nine or ten percent of the combined assembly, handling, and distribution costs incurred in marketing South Dakota grain. This would amount to approximately $5 million.

4. Most likely to gain from a rerouting are the producers located near elevators which continue their grain handling operations. This would include most producers in the eastern districts. Elevators gaining monopsony power due to an isolated location which imposes high costs on producers who would deliver grain to distant competitive elevators may also gain from the rerouting. West River elevators are the only elevators likely to so gain.

5. The rerouting of grain deliveries causes a slight rerouting of grain shipments to terminals and of the delivery modes used. Trucks increase their share of grain traffic going to Minneapolis and railroads capture a greater share of traffic to Sioux City and Duluth. All grain moving to the West Coast continues to go by truck.

6. When the constraint on terminal receipts is removed, all South Dakota grain is shipped to Minneapolis and Sioux City even when export demand and distance cost adjustments are made. The rerouting of grain deliveries through more efficient elevators suggests that such an improved marketing system would leave South Dakota grain a minor element in U.S. grain exports.

7. Without significant changes in rail service such as branchline abandonment or upgrading, use of covered hopper cars, or multi-car rates, the consolidation of grain marketing through the more efficient elevators now operating, would not significantly alter the division of grain traffic between truck and rail systems.

V. Conclusions

The system of moving grain produced in South Dakota to terminal destinations has been undergoing changes in recent years. The most dramatic change has occurred in the increasing use of trucks for hauling grain from country elevators to grain terminals. The increase in truck traffic has been at the expense of railroad usage.

Coincident with the shift in transportation modes for distributing grain has been both an absolute and relative deterioration in rail service in South Dakota. Absolute deterioration has taken the form of abandonment of some branchline service and failure to maintain the track and roadbed of other branchlines and rail equipment. These losses result in a deterioration of South Dakota rail service relative to other grain producing states in the region.

Most of the rail system in South Dakota is incapable of carrying the larger covered hopper cars and since most elevators in the state are incapable of loading rail cars fast enough, multi-car and unit-train rail rates have not been available. These technological and economic inadequacies also place South Dakota producers and shippers at a relative disadvantage. As part of the shift in transportation mode usage, improvements in the highway system including east-west and north-south Interstate highways have occurred. Therefore, technological and economic changes have encouraged substitution of trucks for railroads in distributing South Dakota grain.

Changes in elevator handling have also begun as new, large grain handling facilities have been constructed. These new elevators lower the cost of handling grain and induce farmers to bring their grain directly to the larger facilities rather than their local branchline country elevator. Higher farm income in the early 1970's allowed farmers to invest in newer, larger trucks allowing them to bypass local country elevators and reducing the demand for rail service on many branchlines.

This study has examined the grain marketing system in South Dakota, the distribution of South Dakota grain to the principle terminals, and the costs of getting the grain from producers to elevators and from elevators to terminals. The effects of moving toward a system of fewer, more efficient elevators were also considered.

The details of the study's results are discussed in IV.D. above. In general, the results display a great degree of substitutability between the truck and rail transportation modes and between grain terminal outlets for South Dakota grain. Consequently, the study suggests that changes in the relationship between truck and rail rates; e.g., higher fuel costs or highway taxes for trucks, would lead to substantial substitution between both modes of transportation and destinations of grain deliveries.

The marketing of South Dakota grain from farms to terminals involved a cost of approximately $53 million or $.42 per bushel in 1974. The study indicates that approximately ten percent of this cost - less than $5 million or $.038 per bushel - could be saved by handling grain through only the more efficient elevators now operating. This relatively small difference in costs implies that, while the grain marketing system continues to evolve toward a smaller number of larger grain handling facilities with more truck deliveries to and rail shipments from these facilities, the small country elevators will continue operating for some time. The small cost differential combined with low operating and opportunity costs for small elevators should allow them to compete with the larger facilities at least until they face major reinvestment decisions.

BIBLIOGRAPHY

1. Araji, Ahmed A. and Richard G. Walsh, "Effect of Assembly Costs on Optimum Grain Elevator Size and Location," Canadian Journal of Agricultural Economics, 17 (July 1969), 36-45.

2. Baumel, Phillip C., Thomas P. Drinka, and Dennis R. Lifferth, and John L. Miller, An Economic Analysis of Alternative Grain Transportation Systems: A Case Study, Report No. FRA-OE-7-3-4, Prepared for Dept. of Transportation, FRA, Washington, D.C., (Iowa State University, Ames, Iowa) 1973; p. 35.

3. Fair, Marvin L. and Ernest W. Williams, Economics of Transportation and Logistics, Business Publications, Inc., Dallas, Texas, 1975.

4. Fedeler, Jerry A., Earl O. Heady, and Won W. Koo, An Interregional Analysis of U.S. Domestic Grain Transportation, Center for Agricultural and Rural Development, Report 54T, Iowa State University, Ames, Feb. 1975.

5. French, Ben C. "Some Considerations in Estimating Assembly Cost Functions for Agricultural Process Operations," Journal of Farm Economics, XLII (November, 1960), 767-778.

6. Friedlaender, Ann F. The Dilemma of Freight Transportation Regulation, Brookings Institution, Washington, D.C., 1969.

7. Fuller, S.W. and M.L. Manuel, "Factors That Affect Country Grain Elevator Efficiency," Bul. 550, Agricultural Experiment Station, Kansas State University, Manhattan, Kansas, February 1972.

8. Hill, Lowell D. and Gene C. Shove, "Drying Corn at the Country Elevator," Cir. 1053, Cooperative Extension Service, University of Illinois.

9. Keehn, Kenneth, "Cost of Assembling Grain in South Dakota," Unpublished Masters Thesis, Economics Department, South Dakota State University, Brookings, SD, 1975.

10. Lamberton, C.E. and Richard K. Rudel, A Pilot Study to Investigate Efficient Grain Transportation and Marketing Systems for South Dakota, State Dakota State University, Brookings, July 1976.

11. Locklin, D. Philip. Economics of Transportation, Richard D. Irwin, Inc., Homewood, Illinois, 1972.

12. Lorenz, Frederick, "South Dakota Grain Elevator Location and Cost Analysis," Masters Thesis, Economics Department, South Dakota State University, Brookings, South Dakota, 1972, pp. 59-69.

13. Minneapolis Grain Exchange, Grain Rate Book No. 11:X-305-A Rates in Effect on June 20, 1974, (Minneapolis: Grain Exchange Building, 1974).

14. Minneapolis Grain Exchange Transportation Topics, No. 447, Minneapolis Grain Exchange, August 22, 1975.

15. Payne, Wm. F. "Primary Destinations of South Dakota Wheat, Soybeans, and Flaxseed," Agricultural Experiment Station, Bul. 601, South Dakota State University, Brookings, 1972.

16. Payne, Wm. F. "Primary Destinations of South Dakota Corn, Oats, Barley, and Grain Sorghum," Agricultural Experiment Station, Bul. 605, South Dakota State University, Brookings, 1972.

17. Raeder, Albert E. "Some Factors Affecting the Growth of Grain Elevators in South Dakota," Unpublished MS Thesis, South Dakota State University, 1970.

18. Railway Line Clearances, Including Weight Limitations of Railroads in the United States, Canada, and Mexico, No. 182, The Railway Equipment and Publication Company, New York, 1972.

19. Rudel, R.K. and W.F. Payne, "Moving Grain in '75," Agricultural Experiment Station, South Dakota State University, Brookings, SD.

20. Sorenson, L. Orlo. "Rail-Barge Competition in Transporting Winter Wheat," American Journal of Agricultural Economics, December 1973. The Replacement of Alton Locks and Dam 26. Advisory Report of the Department of Transportation to the Senate Commerce Committee, September 1975.

21. South Dakota Crop and Livestock Reporting Service, South Dakota Agriculture, 1974, Sioux Falls, SD, 1974 and previous years.

22. South Dakota Public Utilities Commission, "Licensed Grain Elevators in South Dakota," S.D.P.U.C., Pierre, South Dakota, 1975.

23. South Dakota Public Utilities Commission, "Report on the South Dakota Railroad Industry Yesterday and Today," S.D.P.U.C., Pierre, South Dakota, September 1974.

24. U.S. Dept. of Agriculture, Economic Research Service, "Cost of Storing and Handling Grain in Commercial Elevators, 1971-72 and Projections for 1973-74," U.S. Dept. of Agr. Res. Serv. Bul. 513. Washington, D.C., April 1973.

25. U.S. Dept. of Agriculture, Statistical Reporting Service, Field Crops Production, Disposition, and Value, U.S. Dept. of Agr., Washington, D.C., 1972-75.

26. U.S. Senate, Committee of Agriculture and Forestry, Prelude to Legislation to Solve the Growing Crisis in Rural Transportation, Washington, D.C., February 1975.

27. Van Ausdle, S.L. and D.L. Oldenstadt, "Costs and Efficiencies of Grain Elevators in the Pacific Northwest," Bul. 713, Agricultural Experiment Station, Washington State University, November 1969.

28. Van Oppen, M. and L.D. Hill, "Grain Elevators in Illinois: Factors Affecting Their Number and Location," AERR 180, Agricultural Experiment Station, University of Illinois, November 1970.

29. Wilcox, Clair. Public Policies Toward Business, Richard D. Irwin, Inc., Homewood, Illinois, 1971.

30. Yu, Terry Yu-Hsien, "Analysis of Factors Affecting the Optimum Size and Number of Country Elevators in Indiana," Ph.D. Thesis, Purdue University, 1967.

31. Zasada, Don and Om. P. Tangri, "An Analysis of Factors Affecting the Cost of Handling and Storing Grain in Manitoba Country Elevators," Research Report No. 13, Department of Agricultural Economics and Farm Management, University of Manitoba, Winnipeg, July 1967.