# AN ANALYSIS OF THE ASSEMBLING AND MERCHANDISING OF GRAIN TO FIT THE MULTIPLE-CAR TRAIN CONCEPT IN NORTH DAKOTA

By

David C. Nelson and Kent J. Horne

UGPTI Publication No. 13
November 1970

# AN ANALYSIS OF THE ASSEMBLING AND MERCHANDISING OF GRAIN TO FIT THE MULTIPLE-CAR TRAIN CONCEPT IN NORTH DAKOTA

BY


DAVID C. NELSON
KENT J. HORNE

UPPER GREAT PLAINS TRANSPORTATION INSTITUTE
NORTH DAKOTA STATE UNIVERSITY
P. O. BOX 5074
FARGO, NORTH DAKOTA 58105


NOVEMBER 1970

## TABLE OF CONTENTS



## LIST OF TABLES

LIST OF FIGURES

## HIGHLIGHTS

The overall major goal throughout this study was to develop and present a simplified way to determine the optimum size and location for grain-handling facilities within a given area of production.

The overall study encompasses evaluation of processing, assembly, and distribution costs as well as cost aggregation analysis for determining optimum least cost solutions. The major importance of this study, however, is the ability to utilize the material in "workbook" or "cookbook" fashion selecting the desired or expected costs of assembly, processing, and distribution. These selected costs then are evaluated as a unit.

### Conclusions

Conclusion 1. Unit-trains would be employable within the state of North Dakota at a cost savings to shippers if and when sufficient volumes were processed, blended, and made available to utilize the capacity of these transportation facilities.

Conclusion 2. A portion of the cost savings could be expected to be passed on to the producer as an incentive by the subterminal management to capture additional market shares. A portion of the cost savings could also be expected to be included in profits to the subterminal management.

Conclusion 3. Depending upon which hypothetical elevator demise approach utilized or other methods not considered here from the three presented in this study, elevator elimination could vary from moderate to a level which could be considered wholesale elimination of the country elevator.

Conclusion 4. Railroad branch lines would be expected to shut down where distance from the common market system of country elevators would result in inadequate operating revenues for the branch line.

Conclusion 5. With railroad branch lines and country elevators being eliminated, small towns could be expected to die out faster due to a removal of business traffic, some employment, and tax revenue to support social services.

Conclusion 6. Cost savings involved in trainload shipments of grain commodities would result in more business and, therefore, more revenue for the railroad lines which would allow them to remain more competitive with other modes of transportation.

# AN ANALYSIS OF THE ASSEMBLING AND MERCHANDISING OF GRAIN TO FIT THE MULTIPLE-CAR TRAIN CONCEPT IN NORTH DAKOTA

David C. Nelson and Kent J. Horne*

## INTRODUCTION

Changes are occurring in the physical characteristics of railroad boxcars and covered hopper cars which will have significant impact upon grain handling, processing, and merchandising procedures traditionally utilized in the Upper Great Plains. New forms of deployment and make-up of trains are developing because of increasing unit capacity and declining ownership of rail grain-carrying cars. It is clear that greater aggregation and centralization of car ownership into multiple- and unit-trains will be necessary to improve the utilization of the existing car flux.

It, therefore, is important to determine the optimum size and location for grain-handling facilities within a given area of production which will facilitate employment of modern techniques of train operation in the Upper Great Plains.

Establishment of the type of grain-handling facility within an area of production suitable to meet the demands of shippers and carriers should provide the owners a price advantage over a large segment of the existing grain merchandising system. Any such advantage would be in response to differences in freight rates as well as any internal plant efficiencies available from larger size facilities and increased volume handled.

The current trend of country elevator consolidation or disappearance would probably be accelerated. The segment of the grain marketing industry continuing in operation would tend to become collection plants for later or immediate movement to larger subterminal facilities by rail or motor carrier.

In contrast to this, a properly located and efficient high-volume, low storage capacity subterminal would require a certain amount of country elevator assemblage capacity within given radii. Since the larger facility would, due to the inherent economies of operation involved, desire to operate throughout the year, this too would contribute to the need for efficient and adequate country elevator capacity within those same radii.

This structure of the grain marketing system would contribute to the efficiency of the agricultural trucking industry through

---

*Nelson is Director, Upper Great Plains Transportation Institute, North Dakota State University, Fargo. Horne was a graduate assistant in the Institute and a graduate student in Agricultural Economics at North Dakota State University.

reductions in length of haul and, therefore, to more intensive use of trucking equipment.

## Objectives

This study involved two major objectives:

1. Determination of necessary size and optimum volume handled of grain merchandising facilities (subterminals) required to take advantage of potential changes in the transportation industry, primarily rail and truck.

2. Definition of impacts of those changes upon the existing grain merchandising system of North Dakota.

## SUBTERMINAL PROCESSING COSTS

### The Subterminal Concept

In distinguishing a subterminal or "country terminal" from other grain-handling facilities, the former was defined for the purposes of this study as:

> ...those using official weights and grades, primarily engaged in merchandising raw grain, and receiving most of their grain from country elevators.[1]

Thus the assumption was made that the place of the subterminal within the grain merchandising industry in North Dakota would be one of expeditious processing and merchandising of grain and facilitating movement of grain commodities from country elevator to major terminals located outside North Dakota.

Generalized data representing subterminal merchandising costs, construction costs, and turn-over rates were supplied in part through the cooperation of five major grain merchandising firms in Minneapolis and St. Paul, Minnesota.[2] Evaluation of information from those firms

---

[1]United States Department of Agriculture, Agricultural Marketing Service, Transportation and Facilities Research Division, Grain Transportation in the North Central Region: An Economic Analysis, Marketing Research Report No. 490, Washington, D. C., 1961, pp. 6-9.

[2]Personal interviews with marketing and transportation personnel of Archer-Daniels-Midland; Bunge, Inc.; Cargill, Inc.; Farmers Union Grain Terminal Association; and Peavey, Inc., Minneapolis and St. Paul, Minnesota, January 29-30, 1968.

and marketing volume potentials from existing production data led to the selection of two hypothetical plant sizes.

## Selection of Firm Size

The first subterminal size utilized was a 1.5 million bushel capacity facility. From that plant, 16 different combinations of amortized facility life and initial investment or construction costs of various increments from $2.50 to $3.10 per bushel of capacity were utilized for both 30-year and 40-year investment amortization (Table 1).

Results of the interviews provided information indicating that the minimum $2.50 cost would have provided an adequate facility. The maximum $3.10 per bushel construction cost would have been sufficient to provide a 1.5 million bushel capacity subterminal at a location in North Dakota which would be equipped with sufficient technology to prevent any "bottlenecks" in grain handling; either receiving, processing, or shipping.

The second subterminal plant size utilized was a 3.0 million bushel capacity facility. Sixteen combinations of amortized facility life and initial investment or construction cost were developed from this size plant also.

Construction costs of various increments from $2.60 to $3.00 per bushel of capacity were utilized for this larger plant size in both the 30-year and 40-year investment amortization schedules. As with the smaller size plant, the construction price range for the 3.0 million bushel capacity plant was indicated to be adequate to prevent occurrence of any receiving, processing, or shipping "bottlenecks."

## Processing Cost Analysis

A subterminal processing cost curve representing turn-over rate volumes from one to ten times total capacity was then calculated to develop the amortization schedule.

To further simplify the evaluation process, the highest construction costs used for both the 1.5 million and 3.0 million bushel facilities; and inherent processing costs relating to volume handled (variable costs) were selected for use as the two specific models utilized in this study.

## Highest Cost Subterminal Models

Model I in Figure 1 is the highest cost 1.5 million bushel facility, and Model II in Figure 1 is the highest cost 3.0 million

TABLE 1. CONSTRUCTION COST AND VARIABLE COST AMORTIZATION FOR 1.5 MILLION AND 3 MILLION BUSHEL SUBTERMINAL FOR 30- AND 40-YEAR PLANT DEPRECIATION SCHEDULES

| Construction Cost Per Bushel[a] | Total Construction Cost | 30-Year Annual Fixed Cost | 40-Year Annual Fixed Cost | Annual Variable Cost | 30-Year Life Annual Total Cost | 40-Year Life Annual Total Cost |
|---|---|---|---|---|---|---|
| | million | | | | | |
| | | | 1.5 MILLION BUSHEL CAPACITY | | | |
| $2.50 | $3.750 | $125,000 | $ 93,750 | $100,000 | $225,000 | $193,750 |
| 2.60 | 3.900 | 130,000 | 97,500 | 100,000 | 230,000 | 197,500 |
| 2.70 | 4.050 | 135,000 | 101,250 | 100,000 | 235,000 | 201,250 |
| 2.75 | 4.125 | 137,500 | 103,125 | 100,000 | 237,500 | 203,125 |
| 2.80 | 4.200 | 140,000 | 105,000 | 100,000 | 240,000 | 205,000 |
| 2.90 | 4.350 | 145,000 | 108,750 | 100,000 | 245,000 | 208,750 |
| 3.00 | 4.500 | 150,000 | 112,500 | 100,000 | 250,000 | 212,500 |
| 3.10 | 4.650 | 155,000 | 116,250 | 100,000 | 255,000 | 216,250 |
| | | | 3 MILLION BUSHEL CAPACITY | | | |
| $2.10 | $6.300 | $210,000 | $157,500 | $150,000 | $360,000 | $307,500 |
| 2.20 | 6.600 | 220,000 | 165,000 | 150,000 | 370,000 | 315,000 |
| 2.30 | 6.900 | 230,000 | 172,500 | 150,000 | 380,000 | 322,500 |
| 2.40 | 7.200 | 240,000 | 180,000 | 150,000 | 390,000 | 330,000 |
| 2.50 | 7.500 | 250,000 | 187,500 | 150,000 | 400,000 | 337,500 |
| 2.60 | 7.800 | 260,000 | 195,000 | 150,000 | 410,000 | 345,000 |
| 2.70 | 8.100 | 270,000 | 202,500 | 150,000 | 420,000 | 352,500 |
| 2.80 | 8.400 | 280,000 | 210,000 | 150,000 | 430,000 | 360,000 |
| 2.90 | 8.700 | 290,000 | 217,500 | 150,000 | 440,000 | 367,500 |
| 3.00 | 9.000 | 300,000 | 225,000 | 150,000 | 450,000 | 375,000 |

[a]Includes cost of land.

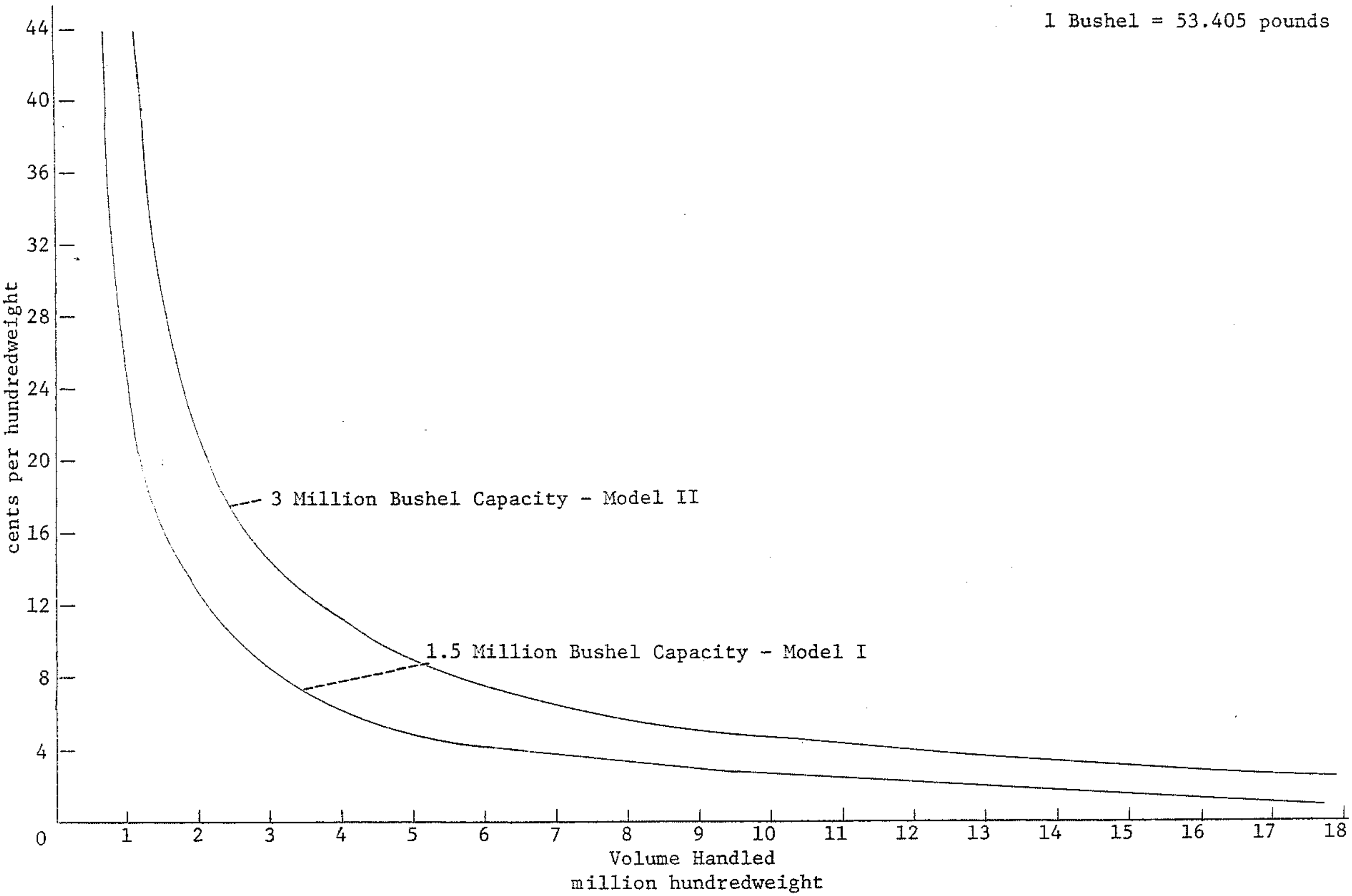


Figure 1. Average Total Cost Curves for 1.5 Million Bushel Capacity and 3 Million Bushel Capacity Terminals at $3.10 and $3.00 Per Bushel Investment Costs, Respectively (30-Year Depreciation) for Volume Handled Per Year

bushel facility. Therefore, the high processing cost curve of the 1.5 million bushel plants will be reflected in Model I; and the high processing cost curve of the 3.0 million bushel plants will be reflected in Model II.

Presentation of the most costly barrier to operation of either size firm was the single criterion selected for determination of cost curves to represent Model I and Model II. The justification here being that the greatest interest was in the determination of freight rate reductions necessary to allow sufficient use of higher cost, modern technology was necessary to insure the rapid handling necessary to minimize loading delays. The transportation mode considered was multiple-car shipments in large volume covered hopper cars.

All firms were assumed to be in a relative homogeneous economic environment, thus eliminating cost differences commonly associated with variation in locations. Each firm operated under average conditions with respect to costs per unit of volume handled (wages, taxes, utilities, land costs, etc.).

Each firm operated 300 days per year and 8 hours per day. During peak periods of receiving or loading, operation might have been extended to 16 or 24 hours per day. Each firm was designed primarily as a merchandising facility and not for a storage function due to the volumes necessary for loading 86 or 115 covered hopper cars in a unit-train or rent-a-train.

## ESTIMATING GRAIN ASSEMBLY COSTS

Determination of an assembly cost for transporting commercial grains from point of production to country elevator necessitated specification of farm truck and tractor-trailer (semi-truck) transport costs as well as specification of marketed density for the particular area of assembly operations.

### Producer to Country Elevator

An average assembly cost of 5 cents per bushel from point of production to the country elevator was determined as a satisfactory farm truck cost for the study (Table 2).

Average running-mile costs selected for semi-trucks amounted to 25 cents loaded or unloaded or a total of 50 cents per round trip mile.

TABLE 2. AVERAGE HAULING CHARGES FOR NORTH DAKOTA FARM TRUCKS BY COMMODITY, BASE MILEAGE, AND EXTRA MILEAGE

| Operation | Base Rates Per Bushel | Base Mileage | Extra Charges Per Mile Per Bushel Above Base Charge |
|---|---|---|---|
| | cents | | cents |
| Wheat | 4.6 | 10.1 | 0.7 |
| Barley | 4.3 | 10.1 | 0.7 |
| Oats | 4.1 | 10.2 | 0.6 |
| Rye | 4.6 | 8.6 | 0.7 |
| Flax | 4.6 | 10.1 | 0.7 |

SOURCE: United States Department of Agriculture, North Dakota Crop and Livestock Reporting Service, Custom Farm Rates for Harvest Operations and Miscellaneous Activities on North Dakota Farms, Fargo, January, 1966, p. 3.

## Assembly to the Subterminals

Three potential modes of assembly to the subterminal were included in the analysis.

As much as 20 percent of the marketed commodities would bypass the country elevator completely and would be assembled by farm truck direct from farm storage to the subterminal.[3]

Country elevator to subterminal assembly would include motor carriers and/or rail. The first would constitute the major portion of the shipments due to flexibility of operation on the improved secondary and primary road system, inherent short-haul cost advantages, and scheduling simplications.[4]

[3] United States Department of Agriculture, Agricultural Marketing Service, Transportation and Facilities Research Division, *op. cit.*, pp. 6-9.

[4] Casavant, Kenneth L., and David C. Nelson, *An Economic Analysis of the Costs of Operating Grain Trucking Firms in North Dakota*, Agricultural Economics Report No. 54, Department of Agricultural Economics, North Dakota State University, Fargo, July, 1967.

## Assumptions of Country Elevator Operations

Velde reported that an average country elevator in North Dakota merchandised grain for 7.9 cents per bushel[5] and that the 797 elevators, then in operation within the State, had evolved to an average capacity of 154,000 bushels.[6] For the purposes of this study, those figures were rounded to 8 cents per bushel and 150,000 bushels, respectively.

Turn-over rates of the North Dakota elevators ranged from .94 to 2.85 times the total licensed storage capacity of an individual plant, for an average ratio of 2.14 times.[7]

Due to past structural characteristics of the country elevator system of price competition by that industry, other assumptions employed were:

1. A portion of the industry was operating at less than optimum size.[8]

2. Merchandising costs ranged from 3.0 to 15.1 cents per bushel with 8.0 cents per bushel selected as the maximum allowable for optimum or near optimum efficiency.[9]

3. Elevator storage capacity per elevator in 1968 ranged from 1,508,000 down to 10,000 bushels in North Dakota.[10]

4. Larger elevators tended to operate on a relatively larger margin, thus helping smaller, less efficient plants to stay in operation.[11]

---

[5] Velde, Paul D., The Organization of Country Markets for Grain in North Dakota, Unpublished Master of Science Thesis, Department of Agricultural Economics, North Dakota State University, Fargo, August, 1964, p. 38.

[6] Ibid., pp. 12-13.

[7] Ibid., p. 100.

[8] Ibid., p. 98.

[9] Ibid.

[10] Farmers Grain Dealers Association of North Dakota, 1968 Directory of Licensed and Bonded Country Elevators in North Dakota, Fargo, 1968.

[11] Velde, op. cit., p. 47.

5. The industry maintained an excess capacity of storage space as a percent of annual volume.[12]

6. Elevators which were less than average size were assumed, in the long run, not to have the advantages of larger elevators and, therefore, would have had difficulty attempting to compete for sales to a subterminal facility.

7. Without a subterminal facility locating within the State, the past trend of demise of the number of country elevators within the State would continue under the existing system structure.

## Average Marketed Density of Commodities

The composition of the grain volume which would have been handled by a subterminal in North Dakota was assumed to be durum wheat, hard red spring wheat, oats, barley, rye, and flax. Average grain volumes produced for the years involved were employed in the study with allowances made for quantities of each commodity produced but not marketed during an average marketing year.[13] This adjustment resulted in net percentages marketed or sold, a factor which would affect the commodity flow through the subterminal facility.

By applying the marketing factor to the total production figures for each commodity for the selected years, weight per average bushel of all commodities included in the study was calculated to be 53.405 pounds (Table 3).

Marketed densities were developed to indicate the volume of grain marketed per square mile for the state of North Dakota by specific areas (Table 4).

---

[12] Ibid., p. 98.

[13] Anderson, Donald E., and Egediusen, Stephen, The Feasibility of Establishing a Terminal Cash Grain Market in North Dakota, Agricultural Economics Report No. 51, Department of Agricultural Economics, North Dakota State University, Fargo, October, 1966, p. 28.

TABLE 3. TOTAL PRODUCTION VOLUME, MARKETING FACTOR, VOLUME AND AVERAGE WEIGHT OF MARKETED BUSHEL, DURUM, HARD SPRING WHEAT, OATS, BARLEY, RYE, AND FLAX IN NORTH DAKOTA, 1961-1965

| Commodity[a] | Bushels Produced | Marketing Factor | Bushels Marketed | Pounds Per Bushel | Pounds Marketed |
|---|---|---|---|---|---|
| | 000 bu. | percent | 000 bu. | | 000 lb. |
| Durum | 47,658.4 | .960 | 45,752.064 | 60 | 2,745,123.840 |
| Other Spring Wheat | 88,048.0 | .960 | 84,526.080 | 60 | 5,071,564.800 |
| Barley | 86,395.0 | .726 | 62,722.770 | 48 | 3,010,692.960 |
| Oats | 78,234.0 | .348 | 27,225.432 | 32 | 871,213.824 |
| Rye | 9,944.6 | .955 | 9,497.093 | 56 | 531,837.208 |
| Flax | 15,444.0 | .949 | 14,656.356 | 56 | 820,755.936 |

[a]Average weight per bushel of all commodities equals 53.405.

SOURCE: United States Department of Agriculture, Statistical Reporting Service, North Dakota Crop and Livestock Statistics Annual Summary for 1966, Agricultural Statistics No. 17, Fargo, May, 1967, p. 81.

## Methodology of Assembly Cost Development

A technique capable of providing optimum volumes and marketing radii was found to be necessary. An adaptation of an existing model was developed by Cobia and found workable for milk.[14] This method, given the density of marketed grains and the cost of transportation or assembly, was utilized to develop assembly cost functions and operating radii for the subterminal models.

[14]Cobia, David W., Determination of the Optimum Size Fluid Milk Processing Plant and Sales Area, Unpublished Master of Science Thesis, Agricultural Economics Department, Purdue University, Lafayette, Indiana, June, 1963, pp. 24-25.

TABLE 4. AVERAGE ANNUAL MARKETED NORTH DAKOTA DENSITIES FOR WHEAT, BARLEY, FLAX, OATS, AND RYE, 1961-1965

| City | County | Square Miles | Total Marketing Pounds | | Hundredweight Per Square Mile |
|---|---|---|---|---|---|
| Williston | Divide | 1,303 | 247,397,000 | | |
| | Williams | 2,032 | 352,356,000 | | |
| | McKenzie | 2,721 | 176,919,000 | | |
| | | 6,056 | 776,672,000 | = | 1,282.5 |
| Minot | Bottineau | 1,699 | 477,161,000 | | |
| | Renville | 901 | 256,674,000 | | |
| | Ward | 2,048 | 509,474,000 | | |
| | Mountrail | 1,817 | 331,915,000 | | |
| | McLean | 2,090 | 474,736,000 | | |
| | McHenry | 1,890 | 282,609,000 | | |
| | | 10,445 | 2,330,569,000 | = | 2,231.3 |
| Devils Lake | Cavalier | 1,513 | 552,523,000 | | |
| | Towner | 861 | 371,132,000 | | |
| | Pierce | 1,053 | 246,389,000 | | |
| | Benson | 1,412 | 335,142,000 | | |
| | Ramsey | 1,214 | 412,875,000 | | |
| | Walsh | 1,287 | 442,920,000 | | |
| | Nelson | 997 | 294,930,000 | | |
| | Wells | 1,300 | 346,560,000 | | |
| | Eddy | 643 | 97,732,000 | | |
| | Griggs | 714 | 173,462,000 | | |
| | | 10,994 | 3,273,665,000 | = | 2,977.7 |
| Grand Forks | Walsh | 1,287 | 442,920,000 | | |
| | Nelson | 997 | 294,930,000 | | |
| | Grand Forks | 1,438 | 468,152,000 | | |
| | Steele | 710 | 260,778,000 | | |
| | Traill | 861 | 322,283,000 | | |
| | | 5,293 | 1,789,063,000 | = | 3,380.6 |
| Fargo | Traill | 861 | 322,283,000 | | |
| | Cass | 1,749 | 572,038,000 | | |
| | Ransom | 863 | 120,908,000 | | |
| | Richland | 1,450 | 243,438,000 | | |
| | | 4,923 | 1,258,667,000 | = | 2,556.7 |
| Jamestown | Foster | 648 | 172,162,000 | | |
| | Griggs | 714 | 173,462,000 | | |
| | Barnes | 1,478 | 413,701,000 | | |
| | Stutsman | 2,256 | 394,309,000 | | |
| | Kidder | 1,377 | 99,088,000 | | |
| | Logan | 1,003 | 116,750,000 | | |
| | LaMoure | 1,137 | 232,540,000 | | |
| | | 8,613 | 1,602,012,000 | = | 1,860.0 |

-continued-

TABLE 4. AVERAGE ANNUAL MARKETED NORTH DAKOTA DENSITIES FOR WHEAT, BARLEY, FLAX, OATS, AND RYE, 1961-1965 - continued

| City | County | Square Miles | Total Marketing Pounds | | Hundredweight Per Square Miles |
|---|---|---|---|---|---|
| Bismarck-Mandan | Sheridan | 995 | 165,920,000 | | |
| | Mercer | 1,041 | 109,729,000 | | |
| | Oliver | 720 | 64,961,000 | | |
| | Burleigh | 1,648 | 157,439,000 | | |
| | Kidder | 1,377 | 99,088,000 | | |
| | Morton | 1,933 | 179,984,000 | | |
| | Grant | 1,664 | 137,504,000 | | |
| | Sioux | 1,124 | 42,192,000 | | |
| | Emmons | 1,546 | 175,283,000 | | |
| | | 12,048 | 1,132,100,000 | = | 939.7 |
| Dickinson | Dunn | 1,996 | 145,055,000 | | |
| | Billings | 1,139 | 34,920,000 | | |
| | Golden Valley | 1,014 | 85,837,000 | | |
| | Slope | 1,226 | 94,163,000 | | |
| | Hettinger | 1,135 | 225,840,000 | | |
| | Stark | 1,318 | 184,815,000 | | |
| | Mercer | 1,041 | 109,729,000 | | |
| | | 8,869 | 880,359,000 | = | 992.6 |

Supposing that a high-volume or subterminal merchandising facility were to be constructed, the problem would be to select the correct plant size and location and the operating perimeters for specified marketing densities. In developing the assembly cost functions, the following assumptions were made based on information collected from personal interviews with the personnel of five major grain merchandising firms in Minneapolis and St. Paul, Minnesota:[15]

1. The entire production area should be well represented by the average marketing density used.

2. Grain volume handled would be made up of durum wheat, hard red spring wheat, barley, oats, rye, and flax.

3. Average grain marketed for the production years 1961-1965 would be the annual operating volume available on the market.

---

[15] Stated by marketing and transportation personnel of Archer-Daniels-Midland; Bunge, Inc.; Cargill, Inc.; Farmers Union Grain Terminal Association, and Peavey, Inc., in personal interviews, op. cit., January 29-30, 1968.

4. Variations in grade and weight of commodities would be acceptable to the subterminal to facilitate blending operations for profit maximizing.

The actual model utilized for assembly cost formulation was:

Given R

$$\text{Assembly cost (average per hundredweight)} = 4/3C\sqrt{\frac{V}{\pi D}}$$

Where:
- $\pi$ = 3.1416
- D = Marketed density per square mile
- R = Radius of assembly area
- C = Variable contract cost, cents per hundredweight per running-mile
- V = Volume in hundredweight (density X square miles)

## Average Length of Haul

The average distance of each load hauled from a country elevator pick-up point and delivered to the subterminal would be two-thirds the radius of the assembly area. This distance was then doubled to account for the empty back-haul distance, resulting in a variable cost (AVAC) per hundredweight per running-mile.

For the purposes of the analysis, the hypothesis was made that there would be no excessive lumpiness of marketed commodities over the given assembly area and that degree of lumpiness occurring would be self-averaging.[16]

Other studies concluded that the square grid road system would have negated the two-thirds radius consideration of average length of haul. The formulation resulted in the utilization of the full R or radius value for the average length of haul. For this study, the former method was selected due to the more direct highway routing system available from country elevator locations to potential subterminal sites.

## Semi-Trailer Assembly Cost

Basic data from the Casavant and Nelson truck cost study was adjusted to compensate for changes in equipment design for semi-trailers. The net load for an average semi-trailer was considered to be 45,000 pounds or 450 hundredweights per trip.[17]

---

[16] Olson, F. L., "Location Theory as Applied to Milk Processing Plants," Journal of Farm Economics, Vol. XLI, December, 1959, p. 1547.

[17] Interview with I. E. Solberg, Executive Director, North Dakota Motor Carriers Association, Bismarck, January, 1968.

Total assembly cost varied from 35.47 cents per mile on the highest cost average sized firm to 17.39 cents per mile as the lowest average total cost average sized firm in the Casavant study.[18] The average North Dakota firm had an annual average total cost of 23.42 cents per running-mile.

Variable assembly cost for the same firms was 15.80 and 14.19 cents per running-mile. The average North Dakota firm had an annual average variable cost of 13.07 cents per mile.

Fixed assembly costs for those same firms were 19.67 and 3.20 cents per running-mile. The average North Dakota firm had an annual average fixed cost of 10.35 cents per mile.[19]

For purposes of this study, all assembly costs were treated as being contracted with an independent commercial grain hauler with the subterminal firm owning none of the equipment involved in actual transport of the grain commodities.[20] Therefore, all assembly costs to the subterminal were treated as variable in nature.

Average variable assembly costs of the synthesized model trucking firm was derived from averages of North Dakota three tractor-four trailer trucking firms operating at 50 percent of possible capacity in all total operating cost categories as defined by Casavant and Nelson.[21]

It was assumed that the model firm would have operated 300 days out of each year and hauled an average of 3 loads per day per tractor or a total of 2,700 loads per year for the entire firm. The average load per trailer was assumed at about 843 bushels. The capacity of the trailer considered was 45,000 pounds or 450 hundredweights.

For the synthesized model firm treating total running-mile cost as a variable contract cost per running-mile, the cost figure was adjusted upward to 25 cents per running-mile. This was done to compensate for the cost of improved technology and inflationary trends within the industry.

Divided by the 450 hundredweight capacity, the 25 cents per running-mile cost equals .0555 cents per hundredweight of capacity per running-mile. In other words, both the loaded run from the country elevator to the subterminal and the empty back-haul were charged that amount.

---

[18] Casavant and Nelson, *op. cit.*, pp. 34-37.

[19] *Ibid.*

[20] Cargill, Inc., was in the trucking business for a period of time, for example, and then sold out turning to contract transport of commodities where necessary by truck.

[21] Casavant and Nelson, *op. cit.*, p. 41.

## Graphical Assembly Cost Analysis

Each curve in Figure 2 is cost per hundredweight of assembling North Dakota average marketings of durum, hard red spring wheat, barley, oats, flax, and rye from the country elevator to the subterminal and utilizing the synthesized model trucking firm costs. Distances on the curves represent radii required at the specific curve density of marketed commodities per square mile to assemble the volume represented on the horizontal axis.

To determine assembly cost to the subterminal, management would have to consider three factors:

1. Density of marketings.

2. Distance from subterminal necessary to procure the desired volume of commodities.

3. Actual share of the market the firm would be able to capture.

For example, if the subterminal management desired to process 7 million hundredweights (13,107,386.9 bushels) and knew that the density of marketed commodities for the area of operation was 1,000 hundredweights per square mile, capturing 25 percent of the available marketing would result in an assembly cost of 6.99 cents per hundredweight; and the operating radius would be 94 miles from the subterminal. Thus, subterminal management would use the 250 hundredweight curve as a planning tool; since 250 is 25 percent of the 1,000 hundredweights per square mile marketed density available to all merchandising firms operating within that area.

Figure 2 represents only one set of many possible assembly cost functions. Any firm which utilized the costs represented would have had several options:

1. The subterminal management could select an operating volume desired on the horizontal axis, moved vertically to the desired density curve and operating radius, and then moved horizontally to the left hand vertical axis for the total assembly cost per hundredweight information.

2. A firm knowing a certain operating radius to be used could select a density curve representing the marketed density the firm assumed possible to capture of total available marketings and then move out that density curve to the appropriate radius. Drawing a vertical line downward to the horizontal axis would have given the possible volume of operation. Drawing a horizontal line back to the vertical or cost axis from the correct radius position on the density curve would give the average total assembly cost per hundredweight of commodity.

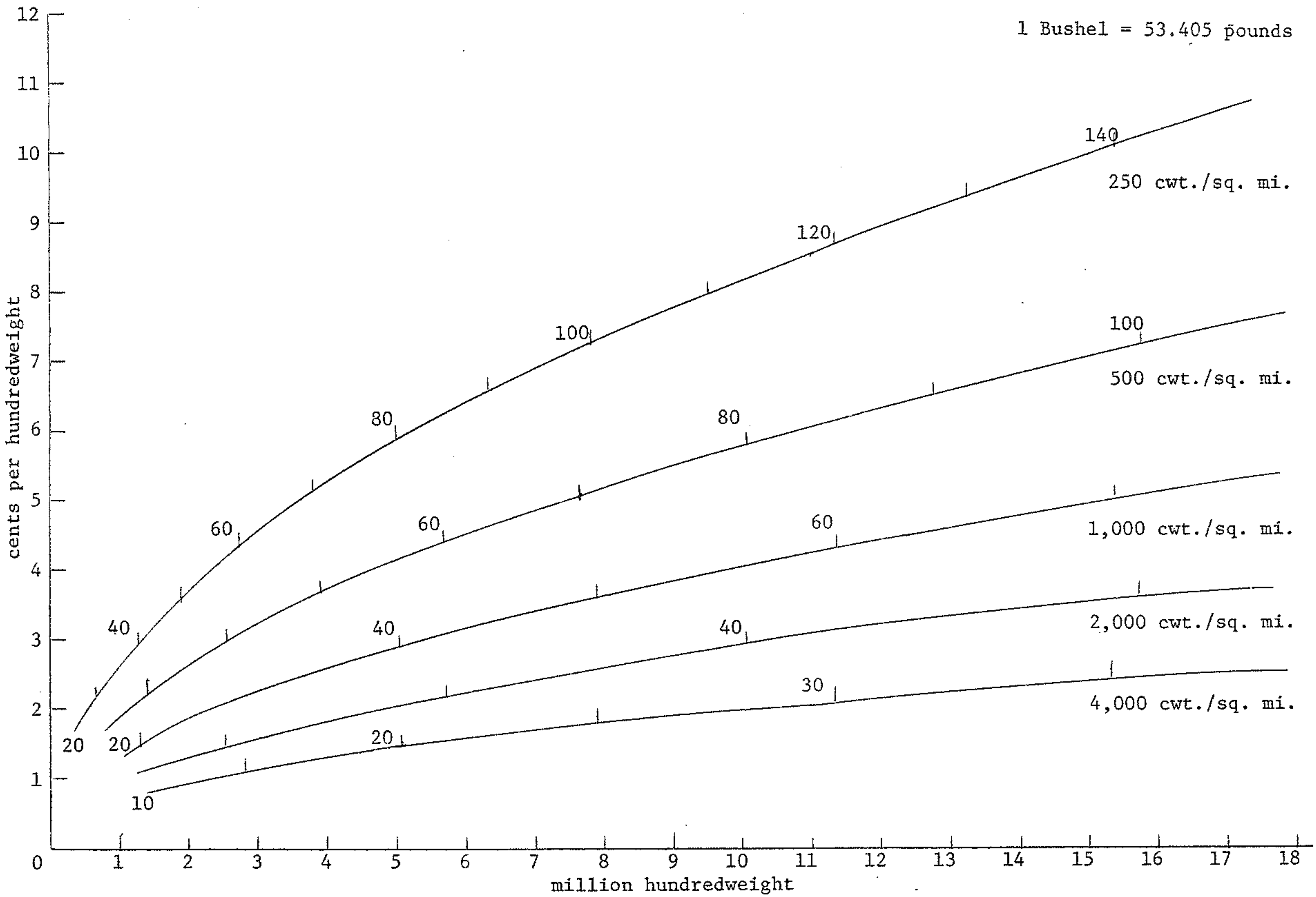


Figure 2. Costs of Assembly by Motor Carrier (3 Tractor-4 Trailer Firm) for Various Levels of Marketing Density and Varying Distance from the Terminal

3. Management of a firm could select a particular average total assembly cost which they desired to operate at and draw a horizontal line to intercept any selected density curve representing the captured share of marketed volume, revealing the operating radius. Then, draw a vertical line downward to the horizontal or volume axis to determine the volume which could be assembled at that cost per hundredweight, captured density, and radius.

At this point, the commodity is assembled to the subterminal and is ready for any processing necessary and outbound distribution.

## OPTIMUM COST-VOLUME ANALYSIS

The major premise of this study is to determine overall usefulness or cost advantages of special railroad tariffs for high-volume shipments in multiple-car, unit-train, or rent-a-train units. Any such advantage or cost reduction must at least compensate for potential increases in costs due to the facilities and volumes demanded by such technology.

Determination of a least cost volume is the major consideration in depicting the cost structure evolving from each aggregated case in section.

### Cost Aggregation

The process of cost aggregating is necessary to determine the feasibility of seriously contemplating the establishment of subterminals at any country points. The initial step is to merely sum the assembly and processing costs in a vertical fashion to determine the optimum or least cost (low point per hundredweight or bushel handled). This is represented on Figure 3 at the lowest point on curve $C_1$. Any variety of optimum volumes can be determined depending on the nature of the control variables; i.e., levels of investment in the subterminal, capacity of the subterminal, method of depreciation of the subterminal, density of marketings in area where the subterminal is located, and organization of the commercial assembly trucking industry. Graphically the process is depicted on the next page (Figure 3).

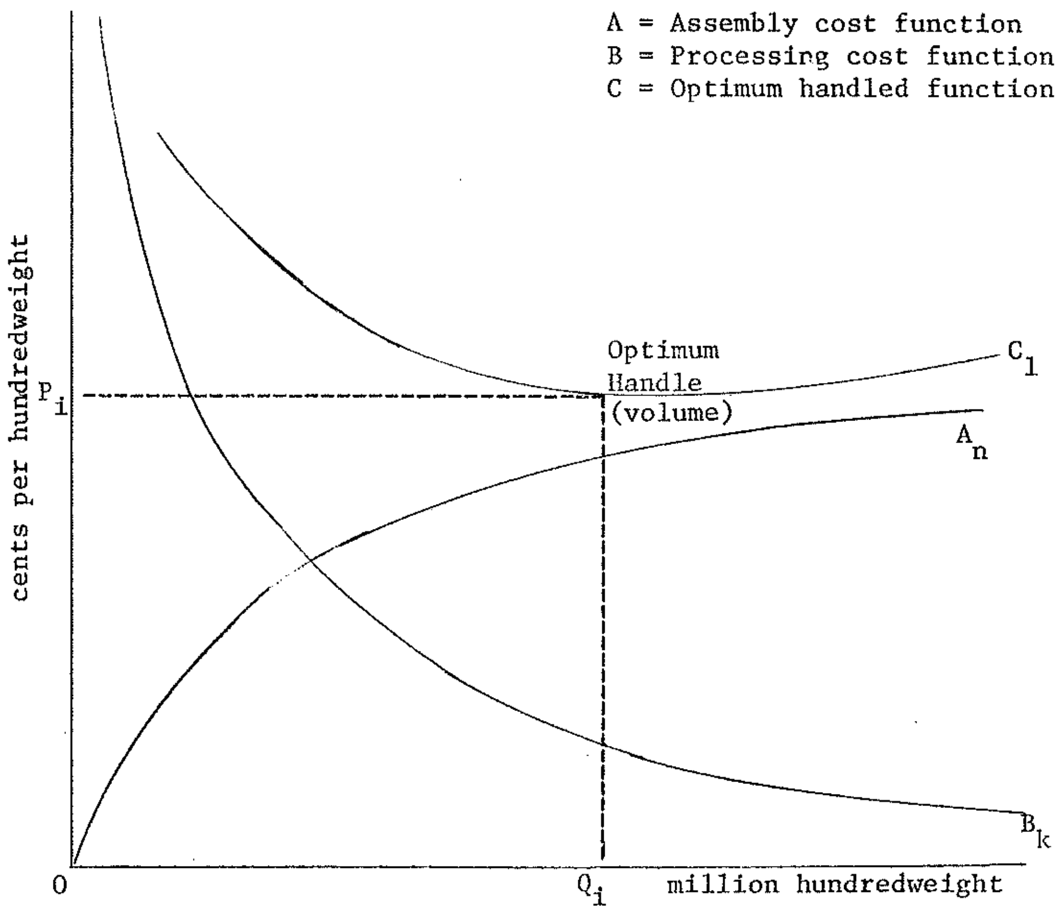


Figure 3. Theoretical Optimum Aggregate Least Cost Solution

Examination of the above graph places the optimum handle ($Q_i$) at the lowest possible cost ($P_i$) which is determined from the optimum handle curve ($C_1$) which is derived from $C_1 = A_n + B_k$, where $C_1$ is one of any number of possibilities, since curve A can possess values 1...n, and curve B can possess values 1...k. The subdesignate "n" is an indicator of the density per square mile values, while the subdesignate "k" is an indicator of the level of processing investment costs at specific choices of depreciation schedules.

Each of the five marketed density assembly cost curves has been mated with each of two synthesized model subterminal firms for development of the least cost curves presented in graphic form in this section (Figures 4 and 5).

This process was accomplished by the vertical summation of costs for each level of volume handled in the synthesized models. In each case, however, the resultant curve represents costs other than production (on farm) and distribution. Production costs and assembly costs from point of production (farm) to the country elevator are absorbed by the producer in making a sale-no sale decision and, therefore, are not entered into the optimizing of a least cost solution.

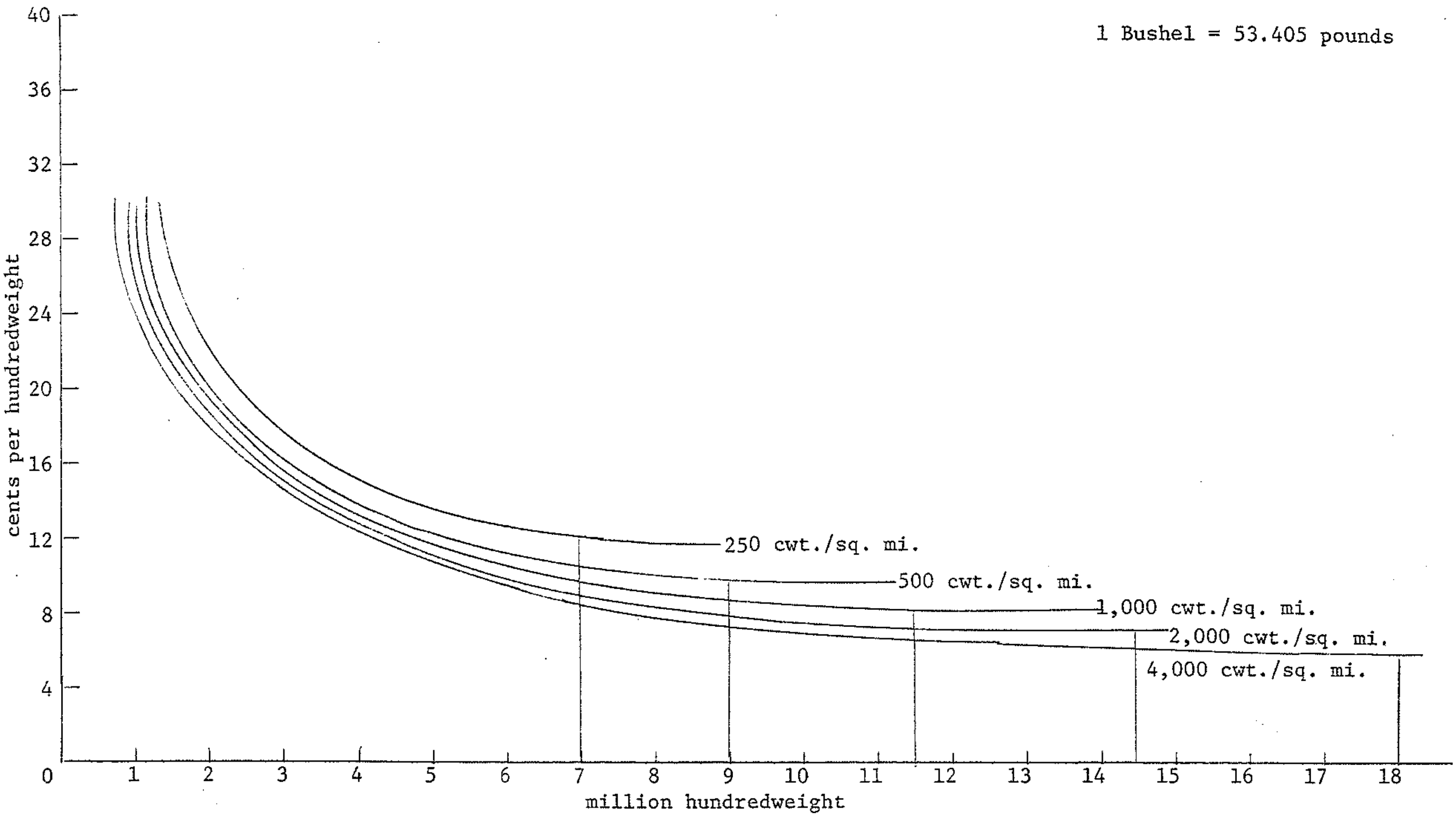


Figure 4. Optimum Aggregate Least Cost Solutions for Five Densities of Handled Volume Per Square Mile for Synthesized Subterminal Model I (1.5 Million Bushel Capacity and High Construction Cost)

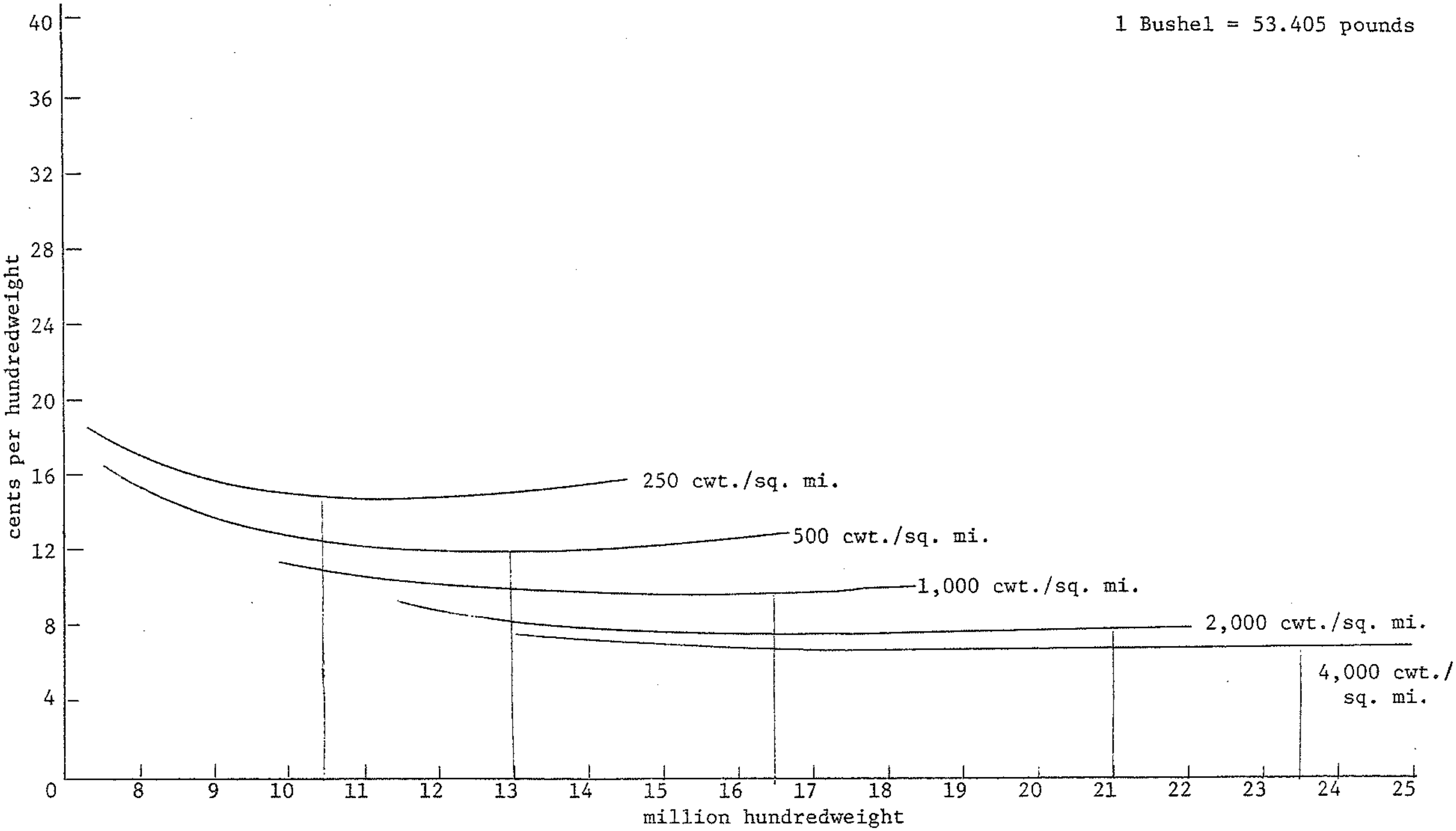


Figure 5. Optimum Aggregate Least Cost Solutions for Five Densities of Handled Volume Per Square Mile for Synthesized Subterminal Model II (3 Million Bushel Capacity and High Construction Cost)

A constant margin of 8 cents per average weight bushel or 14.979 cents per hundredweight is assumed to be paid to the country elevator selling the commodity to the subterminal. The 14.979 cents margin should be added to the aggregated cost in Table 5 for each optimum case development.

## DISTRIBUTION COSTS

Determination of a specific supply area and location for a subterminal involves analysis of the cost of transporting the assembled and processed commodities to a major terminal market.

The relevance of distribution transport rates for large volume shipments cannot be determined until applied to one or more of the optimum volumes. This is so since merely decreasing the distribution rates may not offset the costs involved in providing the technology necessary to meet the volume demands of the large volume transportation method involved.

The Illinois Central unit-train or rent-a-train rates were selected for the distribution cost analysis of this study. As no multiple-car, unit-train, or rent-a-train rate was available for transport of grain commodities from North Dakota at the time of the study, the assumption was made that the rates selected represented rates sufficient to cover costs of a railroad operating in environment much like the Illinois Central. It was assumed that existing multiple-car rates on grains elsewhere and on other commodities would have been applicable to the to the transportation of grain from North Dakota.

### The Illinois Central Rent-a-Train Tariff

During the spring of 1968, Cargill, Inc., announced the construction of a large grain-handling facility in Illinois to be served by a rent-a-train. Cargill officials said the company would lease a 115 car train and operate it between the new facility and a company gulf terminal at Baton Rouge, Louisiana.[22]

The Illinois Central rate provides for 86 covered hopper cars of 100 tons net capacity each at a cost of $1 million per year plus 1.5 mills per ton-mile and a minimum charge of $5 per train-mile loaded or empty. Additional covered hopper cars up to 29 in number will be furnished and moved for $201,181 per year plus the 1.5 mills per ton-mile. A minimum average speed of 25 miles per hour is guaranteed by the Illinois Central Railroad Company.[23]

---

[22] Youngblood, Dick, The Minneapolis Tribune, Sunday, March 3, 1968, Minneapolis, Minnesota, p. 5c.

[23] Illinois Central Railroad Company Freight Tariff 19597, C. A. Pace, Assistant Freight Tariff Manager, Chicago, October 26, 1967, pp. 1-4.

TABLE 5. ESTIMATED COSTS AT OPTIMUM VOLUMES FOR a 1.5 AND 3 MILLION BUSHEL CAPACITY SUBTERMINAL AT FIVE LEVELS OF DENSITY PER SQUARE MILE MARKETINGS, 1969

| Density Per Square Mile | Optimum Volumes Handled (Million Hundredweight) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1.5 Million Bushel Capacity | | | | | 3 Million Bushel Capacity | | | | |
| | 7 | 9 | 11.5 | 14.5 | 18 | 10.5 | 13 | 16.5 | 21 | 23.5 |
| hundredweight | cents per hundredweight | | | | | | | | | |
| 250 | 12.6 | -- | -- | -- | -- | 14.8 | -- | -- | -- | -- |
| | (97)[a] | -- | -- | -- | -- | (117) | -- | -- | -- | -- |
| 500 | -- | 10.4 | -- | -- | -- | -- | 12.2 | -- | -- | -- |
| | -- | (75) | -- | -- | -- | -- | (91) | -- | -- | -- |
| 1,000 | -- | -- | 8.7 | -- | -- | -- | -- | 10.1 | -- | -- |
| | -- | -- | (61) | -- | -- | -- | -- | (73) | -- | -- |
| 2,000 | -- | -- | -- | 7.3 | -- | -- | -- | -- | 8.4 | -- |
| | -- | -- | -- | (48) | -- | -- | -- | -- | (57) | -- |
| 4,000 | -- | -- | -- | -- | 6.2 | -- | -- | -- | -- | 7.1 |
| | -- | -- | -- | -- | (38) | -- | -- | -- | -- | (42) |

[a]Figures in parentheses represent the estimated mileage distance in radius from the subterminal that would be necessary to capture the indicated volume at each level of density.

Operating either train between Fargo and Minneapolis, Minnesota, 300 days per year at 25 miles per hour results in 105.6 trips per year. This is 68.2 hours per round trip, allowing 24 hours per trip at Fargo for loading and 24 hours per trip at Minneapolis for unloading (Table 6).

A similar cost breakdown for movement of grain commodities from Fargo to New Orleans, Louisiana, results in 66.3 trips per year possible at 108.6 hours per round trip.

Likewise, a cost breakdown is made for shipments from Fargo to Portland, Oregon, with 86 and 115 car rent-a-trains and the Illinois Central rate--resulting in 40.7 trips possible per year at 112.0 hours per round trip.

A physical limitation exists in respect to possible volume for one train due to the number of round trips within the operating year. Therefore, the assumption is made that additional shipments are predictable by projecting the curves to greater volumes. The projections are accomplished by extending the calculations to larger volumes at the same fixed cost and 1.5 mills per ton-mile variable cost.

### Optimum Aggregate Cost Analyses

Distribution cost by the unit-train or rent-a-train developed for each of three markets and is then aggregated to the cost structure of each optimum base developed (Table 5 and Figures 4 and 5).

To determine the applicable rate where the entire volume is moved to a selected destination, management must know what the optimum handle of the subterminal should be based on processing and assembly costs. If that optimum volume were 7 million hundredweights, the entire volume could be moved to Portland and New Orleans from Fargo in trainload units at a rate somewhere between 30-33 cents per hundredweight. This rate represents a considerable savings over the existing 83 cents per hundredweight to West Coast and Gulf Coast ports.

## COUNTRY ELEVATOR DEMISE

Since the synthesized models developed in this study included the North Dakota country elevator as a necessary part of operational planning, certain elevators operating efficiently would continue to exist. Less efficient elevators, however, would tend to be eliminated even more rapidly than the current trend.

This might best be explained by pointing out that if the total operating capacity at individual turnover rates per elevator was sufficient to handle the annual volume, new subterminal plants being located within any area would "capture" part of this overall volume.

TABLE 6. TOTAL ANNUAL VOLUME, NUMBER OF TRIPS REQUIRED, AND COST PER HUNDREDWEIGHT FOR 86 AND 115 COVERED HOPPER CAR (200,000 POUND CAPACITY EACH) RENT-A-TRAINS, BASED UPON ILLINOIS CENTRAL FREIGHT TARIFF 19597. POINT OF ORIGIN - FARGO, NORTH DAKOTA. DESTINATIONS - MINNEAPOLIS, MINNESOTA; NEW ORLEANS, LOUISIANA; AND PORTLAND, OREGON

| Million Hundredweights Shipped | Number of Trips | 86 Car ($1,000,000 Fixed Cost) 252 Miles Minneapolis | 86 Car 1,515 Miles New Orleans | 86 Car 1,601 Miles Portland | Number of Trips | 115 Car ($1,201,181 Fixed Cost) 252 Miles Minneapolis | 115 Car 1,515 Miles New Orleans | 115 Car 1,601 Miles Portland |
|---|---|---|---|---|---|---|---|---|
| | | cents per hundredweight | | | | cents per hundredweight | | |
| 6.0 | 34.9 | 19.18 | 32.43 | 32.32 | 26.0 | 22.36 | 34.67 | 35.50 |
| 6.5 | 37.8 | 17.90 | 31.15 | 32.04 | 28.3 | 20.82 | 33.13 | 33.96 |
| 7.0 | 40.7 | 16.80 | 30.05 | 30.94 | 30.4 | 19.50 | 31.81 | 32.64 |
| 7.5 | 43.6 | 15.85 | 29.09 | 29.99 | 32.6 | 18.35 | 30.67 | 31.50 |
| 8.0 | 46.5 | 15.01 | 28.26 | 29.16 | 34.8 | 17.35 | 29.67 | 30.50 |
| 8.5 | 49.4 | 14.28 | 27.53 | 28.42 | 36.9 | 16.47 | 28.78 | 29.61 |
| 9.0 | 52.3 | 13.62 | 26.87 | 27.77 | 39.1 | 15.68 | 28.00 | 28.83 |
| 9.5 | 55.2 | 13.04 | 26.29 | 27.18 | 41.3 | 14.98 | 27.29 | 28.13 |
| 10.0 | 58.1 | 12.51 | 25.76 | 26.66 | 43.5 | 14.35 | 26.66 | 27.49 |
| 10.5 | 61.0 | 12.04 | 25.29 | 26.18 | 45.7 | 13.78 | 26.09 | 26.92 |
| 11.0 | 63.9 | 11.60 | 24.85 | 25.75 | 47.8 | 13.26 | 25.57 | 26.40 |
| 11.5 | 66.9 | 11.21 | 24.46 | 25.35 | 50.0 | 12.78 | 25.10 | 25.93 |
| 12.0 | 69.8 | 10.85 | 24.09 | 24.99 | 52.2 | 12.35 | 24.66 | 25.49 |
| 13.0 | 75.6 | 10.21 | 23.45 | 24.35 | 56.5 | 11.58 | 23.89 | 24.72 |
| 14.0 | 81.4 | 9.66 | 22.90 | 23.80 | 60.9 | 10.92 | 23.23 | 24.06 |
| 15.0 | 87.2 | 9.18 | 22.43 | 23.32 | 65.2 | 10.34 | 22.66 | 23.49 |
| 16.0 | 93.0 | 8.76 | 22.01 | 22.91 | 69.6 | 9.84 | 22.16 | 22.99 |
| 17.0 | 98.8 | 8.40 | 21.64 | 22.54 | 73.9 | 9.40 | 21.72 | 22.55 |
| 18.0 | 104.7 | 8.07 | 21.32 | 22.21 | 78.3 | 9.01 | 21.32 | 22.16 |
| 19.0 | 110.5 | 7.78 | 21.02 | 21.92 | 82.6 | 8.66 | 20.97 | 21.80 |
| 20.0 | 116.3 | 7.51 | 20.76 | 21.66 | 86.9 | 8.34 | 20.66 | 21.47 |
| 21.0 | 122.1 | 7.25 | 20.53 | 21.42 | 91.3 | 8.06 | 20.38 | 21.14 |
| 22.0 | 127.9 | 7.00 | 20.33 | 21.23 | 95.6 | 7.80 | 20.12 | 20.83 |
| 23.0 | 133.7 | 6.78 | 20.16 | 21.08 | 99.9 | 7.56 | 19.88 | 20.54 |
| 24.0 | 139.5 | 6.57 | 20.02 | 20.93 | 104.2 | 7.34 | 19.65 | 20.27 |

For example, assume that the management for Model I determined their firm could capture only 500 hundredweights per square mile or less than 25 percent of the average available marketings of the five commodities for the Devils Lake, North Dakota, marketing area.

The optimum least cost solution for that size firm is 9 million hundredweights per year from a radius of 75 miles out from Devils Lake. The total volume available to country elevators within that operating radius would then be reduced. The amount of this reduction within the subterminal operating radius would equal the annual volume of the new subterminal plant or 9 million hundredweights per year. This, in essence, indicates that some elevators within that competitive operating radius would be eliminated.

The determination of the sequence of elimination of these country elevators may be estimated by first determining the average annual turnover volume from historic data for elevators in that area. Then, subtract annual elevator volumes beginning with the lowest average annual volume until the total of those elevators eliminated equals the annual volume handled by the subterminal plant.

Such procedure is best described as one of by-pass wherein the flow of commodities would by-pass the less efficient elevators. Examples of such operating or marketing areas are shown in Table 7.

TABLE 7. ESTIMATED DEMISE OF COUNTRY ELEVATORS IN DEVILS LAKE, NORTH DAKOTA MARKETING AREA FOR SUBTERMINAL HANDLING OPTIMUM VOLUME OF 9 MILLION HUNDREDWEIGHTS ANNUALLY CAPTURING 500 HUNDREDWEIGHTS PER SQUARE MILE

| Method of Estimating Demise | Number of Country Elevators Exiting |
|---|---|
| 1. By-pass due to efficiency factor | 79 |
| 2. 150,000 bushel capacity | 95 |
| 3. Proximity to subterminal by-pass | 22 |

By this means of estimation for the previously selected Devils Lake area, 79 country elevators would tend to exit considering the 2.14 average annual turnover.[24] The result for the Devils Lake area is that all elevators below 135,000 bushel capacity would exit by this means.

[24] Velde, op. cit., p. 43.

Another means of estimation is based on the supposition that any less efficient elevator (i.e., those having per bushel operating costs of more than 8 cents per bushel) would eventually be eliminated from the commodity market within the State. These less efficient elevators were indicated to be those of 150,000 bushels or less capacity.[25]

This system is implemented by merely identifying all elevators of less than 150,000 bushel storage capacity within the subterminal assembly area. For the demonstration area selected in the first method, this method of country elevator demise determination indicates that 95 country elevators would be eliminated from the Devils Lake subterminal location with a subterminal facility capturing 500 hundredweights or less than 25 percent of the 2977.7 hundredweights per square mile marketed density annually available.

Another method of indicating demise of country elevators would refer to elevator location in comparison with the subterminal location. For example, a country elevator of 50,000 bushel capacity and 67,000 bushels per year average volume located one mile from a new subterminal plant would be considered less likely to continue in existence than the same country elevator located at the periphery of the subterminal operating radius. This could be expected on the basis of another aspect of the by-pass principle wherein producers within the immediate vicinity of the subterminal would tend to desire delivering directly to the subterminal for additional price margins rather than to the adjacent small country elevator for less per bushel. Operation of this by-pass procedure, however, would depend upon the kind of small truck handling and other operational capabilities of the subterminal plant. The assumption is made here that any small truck or farm truck would be accepted which arrived with commodities for sale. This is necessary to simplify the analysis for projective purposes.

This demise estimation method may be implemented by first determining the annual volume to be handled by the subterminal facility and then selecting the required number of country elevator plants by annual volume handled to total the same amount as the expected subterminal volume. As stated, this would begin with those country elevators adjacent to the subterminal facility and move outward toward the perimeter of the assembly area in a spiral fashion until the subterminal volume was matched. Twenty-two firms would exit from the area in this method.

The additional suggestion is made here that in reality the actual resultant data from construction and operation of a subterminal-type facility at a given location might result in a combination of these three methods of country elevator demise determination presented here.

The examples presented a modest approach, since the possibility exists that the same firm could capture a greater market share.

---

[25] Ibid., p. 98.

Assuming the same high cost, a 1.5 million bushel capacity terminal could capture 2,000 hundredweights per square mile or nearly two-thirds of the available average marketings.

In such a case, the radius of assembly would be reduced to 45 miles; and volume would increase to 11.5 hundredweights per year. Each demise method described would then cause the same number of elevators to exit from operation in the market.