# A Model of the Demand for Wheat Marketing Services in Production Areas

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## Introduction

The job of the country wheat elevator is that of efficiently moving wheat from the farmer to a terminal elevator or a miller. Behind this operation is a demand for the country elevator's services. Major factors affecting this demand are prices charged by it and competing firms, volume of wheat production in the area, distances between competing firms, and transportation rates. The purpose of this study was to determine how these factors affect the demand for elevator services.[1] The demand function for elevator services derived here furnishes the demand side of the analysis necessary for elevator firms to make scale-of-plant price decisions.

## Market Factor Characteristics

The construction of a model of the demand for wheat marketing services in production areas is presented in two parts.

The first part on market factor characteristics includes assumptions made, a description of truck transportation rates in production areas, the method of determining market areas in regions having a gridded highway system, and the method used for determining wheat supplies in a specific market area.

The second part on the determination of the derived demand presents the procedure used, the market area division and the schedules of demand, total revenue, and average marginal revenue.

### Assumptions

In the construction of the model of the demand for elevator services, several conditions were assumed. First, farmers respond to small differences in price. Second, the area within which demand is being determined is homogeneous. Third, the elevator services of various firms are similar. Fourth, the commercial rate for transporting wheat

[1]Services include merchandising and storing of wheat.

from the field to the country elevator was five cents per bushel for the first five miles or any part, and one cent for each additional mile.[2] Fifth, a farmer located between two elevators will sell his wheat where the positive difference between the price received and the cost of marketing is a maximum. The action of farmers located along a line between two elevators can be expanded into a market area demand schedule.

## Transportation Costs

The total transportation cost per bushel for transporting wheat various distances is a discontinuous function of the type shown in Figure 1.

The transportation costs used were based on existing trucking rates from farms to local elevators.

## Market Area

This cost of transportation per mile may be expressed as transportation cost per bushel by converting the axis labeled "miles" to "bushels",

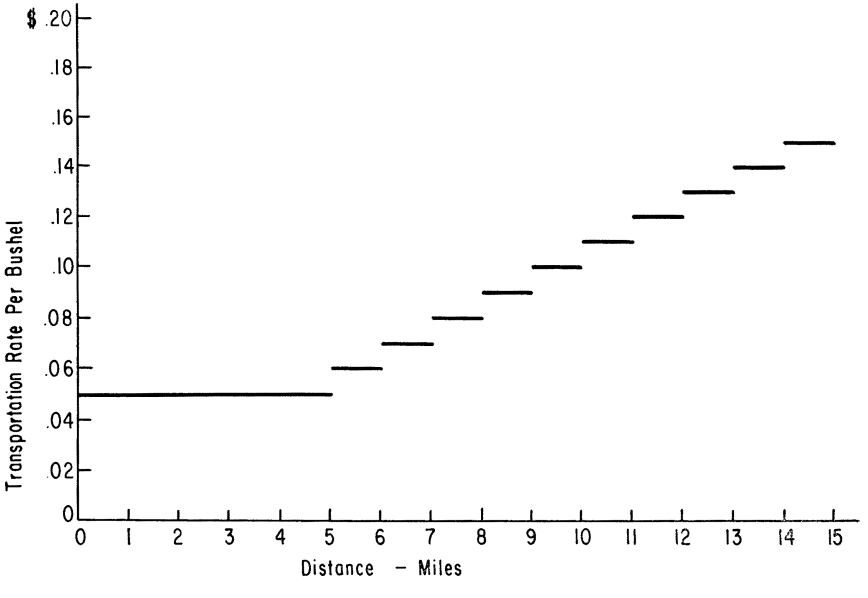


**Figure 1—Commercial Transportation Rates for Hauling Wheat Various Distances.**

[2]There is a tendency toward lower trucking rates.

after calculating the bushels of wheat produced within specified distances. This conversion is made by first determining the area inscribed by a given distance.

Because Oklahoma roads are built commonly on a rectangular grid system with section-line roads one mile apart and gridded north-south and east-west, the trucking transportation distance may not be calculated as a straight air-line distance. Consequently, the market area cannot be related to the transportation distance by the formula $\Pi r^2$ where r equals the radius. Rather, the market area must be related to actual highway distances as shown in Figure 2. The area was determined by the equation:

$$A=2D^2$$

where A is area in square miles and D is the distance in miles. For example, a farm located northeast of one elevator may be nearer by road distance to another elevator, yet farther in radial distance. The market area ADEF has the market at its center O. The highway distance is the same from the market to all points on ADEF, although airline routes differ. This is illustrated by the diagrammed routes 1, 2, and 3.

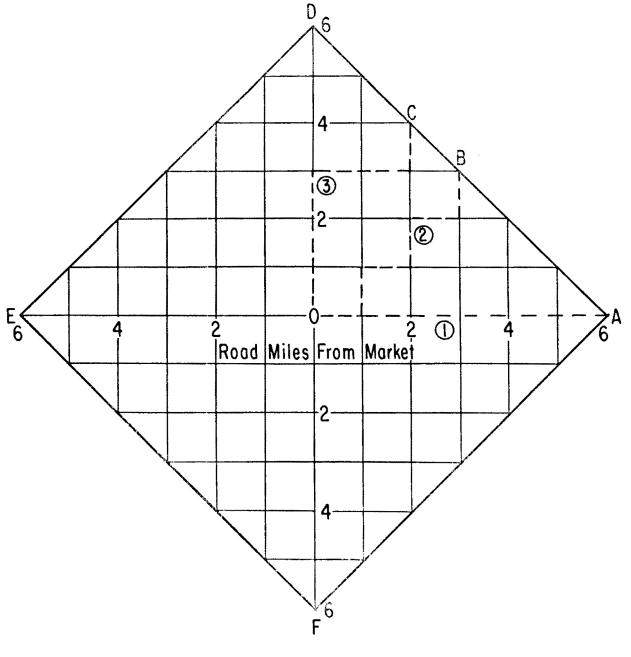


**Figure 2—A Market Area in a Region Served by a Grid System of Highways.**

As a result of this relationship, the area of the area ADEF equals four times the Δ ADO or two times $(OA)^2$. As OA equals the maximum highway distance, D, the total market area ADEF equals $2D^2$ where the units are similar, i.e., in miles and square miles.

With the area determined, assumptions were made that 80 percent of the area was cropped and 60 percent of the cropped acreage was in wheat. Thus, 48 percent of the total area, or 307 acres per square mile, was in wheat. It was further assumed that the maximum yield per acre was 15 bushels. With these assumptions, the quantities of wheat represented by various transportation distances were determined. The result is shown in Table I.

The information in Table I converted into cost of transportation for additional quantities of wheat is shown in Figure 3. The function is discontinuous; each successive incremental increase in transportation cost (distance) brings in a larger than proportional increase in quantity of wheat.

**Table I—The Market Area, and Quantity of Wheat Included as the Transportation Distance Increases**

| Transportation Distance (Miles) | Market Area* (Square Miles) | Quantity of Wheat** (Bushels) |
|---|---|---|
| 1 | 2 | 9,200 |
| 2 | 8 | 36,800 |
| 3 | 18 | 82,800 |
| 4 | 32 | 147,200 |
| 5 | 50 | 230,000 |
| 6 | 72 | 331,200 |
| 7 | 98 | 450,800 |
| 8 | 128 | 588,800 |
| 9 | 162 | 745,200 |
| 10 | 200 | 920,000 |
| 11 | 242 | 1,113,200 |
| 12 | 288 | 1,324,800 |
| 13 | 338 | 1,554,800 |
| 14 | 392 | 1,803,100 |
| 15 | 450 | 2,070,000 |

*It was assumed that 48 percent of the area is in wheat with a maximum yield of 15 bushels per acre.

**A rounded figure of 4,600 bushels per square mile was used for these computations.

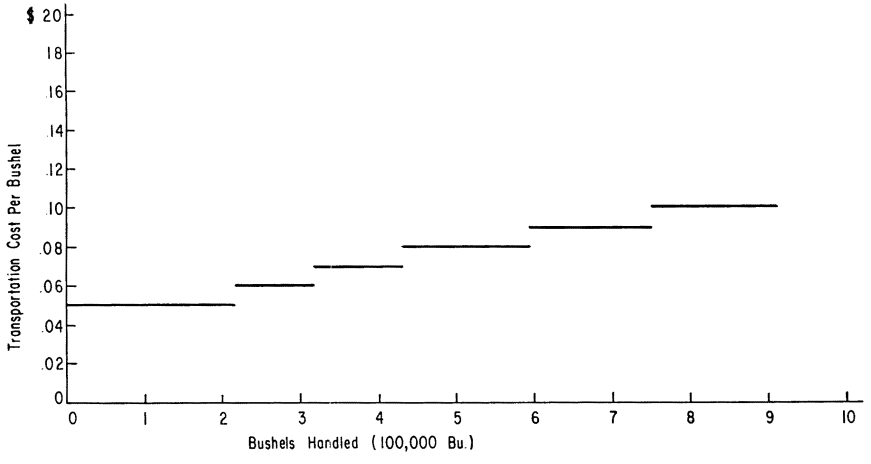


**Figure 3—Transportation Cost Per Bushel of Wheat as Quantity Increases with Greater Distances.**

## Determination of Derived Demand

### Method

A theoretical case of two elevators, A and B, located 20 miles apart and competing for the wheat produced by farmers located between them, was used to develop a demand schedule for elevator services faced by A when B maintains a constant price. The division of the wheat sales by farmers along the line between the two elevators must be investigated when A changes the price charged for elevator services. The price range over which the demand schedule is relevant starts at the upper limit with a price so high that no farmers patronize A and a lower limit where the prices charged by A and B are equal. At the lower limit of the relevant price range, the wheat sales by farmers are equally divided between A and B.

Any starting price may be charged by B. The analysis to determine the distance attracted by elevator A at various prices remains the same, as it is based on the difference in the total costs to wheat farmers.

It is also assumed that B can provide elevator services for any or all the farmers between A and B at five cents per bushel. So long as A does not price below five cents per bushel, B will not change price of five cents per bushel. Elevator B will begin cutting price if A prices its

services below five cents per bushel. A loss of customers would disrupt the economies of scale of B and cause more severe losses than retaliatory price cutting.

The actions of farmers between elevators A and B, as A varies the price charged for services, are shown in Table II. Column 1 shows the price charged for services by elevator A. Column 2 shows the cost of transportation for farmers in the marginal mile to deliver wheat to A. Column 3 is the sum of columns 1 and 2 and represents total merchandis-

**Table II—Marketing Costs per Bushel for Farmers at Various Locations Between Two Competing Elevators 20 Miles Apart**

| Elevator A Cost Per Bushel | | | Elevator B Cost Per Bushel | | | Distance Attracted by A |
|---|---|---|---|---|---|---|
| For Handling (Col 1) | For Trans. (Col. 2) | Total (Col. 3) | For Handling (Col. 4) | For Trans. (Col. 5) | Total (Col. 6) | (Col. 7) |
| $.05 | $.10 | $.15 | $.05 | $.10 | $.15 | 10 miles |
| .059 | .10 | .159 | .05 | .11 | .16 | 10 |
| .06 | .10 | .16 | .05 | .11 | .16 | Indifferent |
| .061 | .10 | .161 | .05 | .11 | .16 | 9 |
| .08 | .09 | .17 | .05 | .12 | .17 | Indifferent |
| .081 | .09 | .171 | .05 | .12 | .17 | 8 |
| .10 | .08 | .18 | .05 | .13 | .18 | Indifferent |
| .101 | .08 | .181 | .05 | .13 | .18 | 7 |
| .12 | .07 | .19 | .05 | .14 | .19 | Indifferent |
| .121 | .07 | .191 | .05 | .14 | .19 | 6 |
| .14 | .06 | .20 | .05 | .15 | .20 | Indifferent |
| .141 | .06 | .201 | .05 | .15 | .20 | 5 |
| .16 | .05 | .21 | .05 | .16 | .21 | Indifferent |
| .161 | .05 | .211 | .05 | .16 | .21 | 4 |
| .17 | .05 | .22 | .05 | .17 | .22 | Indifferent |
| .171 | .05 | .221 | .05 | .17 | .22 | 3 |
| .18 | .05 | .23 | .05 | .18 | .23 | Indifferent |
| .181 | .05 | .231 | .05 | .18 | .23 | 2 |
| .19 | .05 | .24 | .05 | .19 | .24 | Indifferent |
| .191 | .05 | .241 | .05 | .19 | .24 | 1 |
| .20 | .05 | .25 | .05 | .20 | .25 | Indifferent |

ing costs for farmers in the marginal mile to patronize elevator A. Columns 4, 5, and 6 represent for elevator B the counterparts of columns 1, 2, and 3 for elevator A. Column 7 indicates the distance along the line between elevators A and B which will include patrons of A at the various prices charged by A.

## Market Area Division

For investigating farmer actions, columns 3, 6, and 7 are the crucial columns. When the total cost in column 3 is greater than the total cost in column 6, no change occurs in the distance attracted by A (column 7). When the total cost to farmers for patronizing elevator A (column 3) becomes greater than the cost for patronizing elevator B (column 6), farmers in that mile switch from A to B.

When both elevators price services at five cents per bushel, the market area is divided evenly between them, ten miles going to each elevator. Elevator A can increase its cost to the farmer for handling to 5.9 cents without losing any patrons, as the total cost of $.159 is less than the $.16 of elevator B. If A increases the price for handling to six cents, farmers in the tenth mile from A and the eleventh mile from B may patronize either elevator at equal costs. Farmers closer than nine miles to A patronize A, and farmers closer than 10 miles to B patronize B. If A increases price infinitesimally above six cents, the division between A and B is nine miles from A and eleven miles from B. Crucial prices or margins for handling for elevator A are 6, 8, 10, 12, 14, 16, 17, 18, 19, and 20 cents. At these prices a small increase in price results in the division moving one mile nearer A. Pricing between the crucial prices is not important for the analysis; consequently, it was omitted from column 1 of Table II.

The analysis thus far has dealt with farmers along a line between two elevators. In developing Table II, an assumption was made that farmers react to a 0.1 cent change in price of services. Previous farmer preference studies indicate that farmers do not make adjustments to economic influences as rapidly as might be expected in a perfect-knowledge profit-maximization situation.[3] Prices paid for wheat are usually in whole-cent increments.

The demand schedules derived from the information in Table II are constructed to show how farmers would respond to one-cent changes

3Jerry G. West, "A Pilot Study of Farmers' Preferences for Marketing Services in Kingfisher County, Oklahoma," (Unpublished M.S. thesis, Oklahoma State University, 1955), p. 43.

**Table III—The Revenue Situation Faced by an Elevator Whose Competitors 20 Miles Away Charge $.05 for Performing Elevator Services**

| Handling Charge AR | Distance Mi. | Market Area Sq. Mi. | Total Quantity Bu. | Change in Quantity Bu. | Total Revenue TR | Change in Total Revenue | Average Marginal Revenue* |
|---|---|---|---|---|---|---|---|
| $.20 | 1 | 2 | 9,200 | 9,200 | $ 1,840 | $ 1,840 | $.20 |
| .19 | 2 | 8 | 36,800 | 27,600 | 7,000 | 5,160 | .187 |
| .18 | 3 | 18 | 82,800 | 46,000 | 14,900 | 7,900 | .172 |
| .17 | 4 | 32 | 147,200 | 64,600 | 25,000 | 10,100 | .156 |
| .16 | 5 | 50 | 230,000 | 82,800 | 36,800 | 11,800 | .143 |
| .14 | 6 | 72 | 331,200 | 101,200 | 46,400 | 9,600 | .095 |
| .12 | 7 | 98 | 450,800 | 119,600 | 54,100 | 7,700 | .064 |
| .10 | 8 | 128 | 588,800 | 138,000 | 58,900 | 4,800 | .034 |
| .08 | 9 | 162 | 745,200 | 156,400 | 59,600 | 700 | .004 |
| .06 | 10 | 200 | 920,000 | 174,800 | 55,200 | —4,400 | —.025 |

*Column 7 divided by Column 5.

in price (Tables III, IV, and V). The prices used in the demand schedule are from column 1 of Table II. The quantities in the demand schedule are determined by converting the distances in column 7 of Table II into bushels by the use of Table I.

## Demand, Total Revenue, and Average Marginal Revenue

The demand, total revenue, and average marginal revenue schedules shown in Table III are derived directly from the information in Table II, in which the charges made by elevator B were constant at $.05 while those at elevator A were allowed to vary from $.05 to $.20. The revenue schedules shown in Tables IV and V were derived in a similar manner except the price charged by B for the two situations was assumed to be 15 cents and —3 cents per bushel, respectively.

A diagrammatic solution to average and marginal revenue is used here. A different statistical solution exists for each case where a different price is assumed for elevator B. The three cases, developed in Tables III, IV, and V and shown diagrammatically in Figures 4, 5, and 6, are outlined here to show a method of demand analysis. The characteristic shape of the demand curve for elevator services, the discontinuous average revenue curve in Figures 3, 4, and 5, is caused by location differences and associated transportation costs.

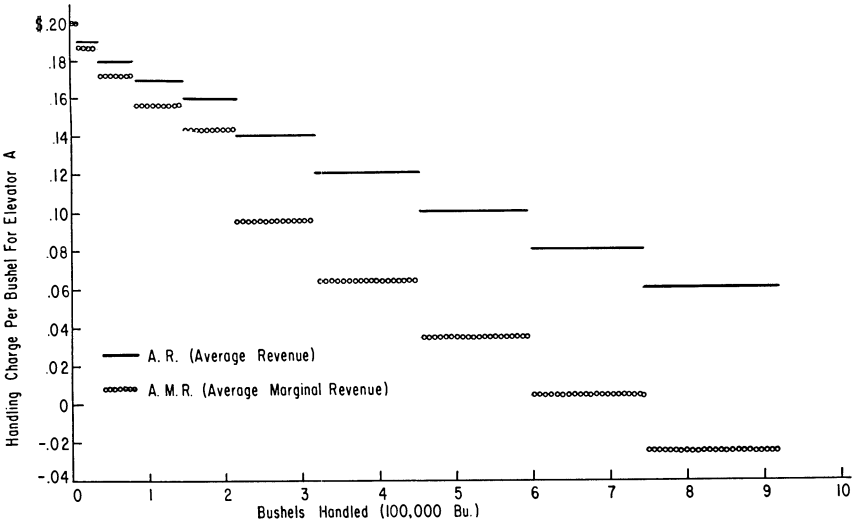


**Figure 4—A Firm's Demand Curve When Competitors are 20 Miles Away and Charge $.05 per Bushel for Elevator Services.**

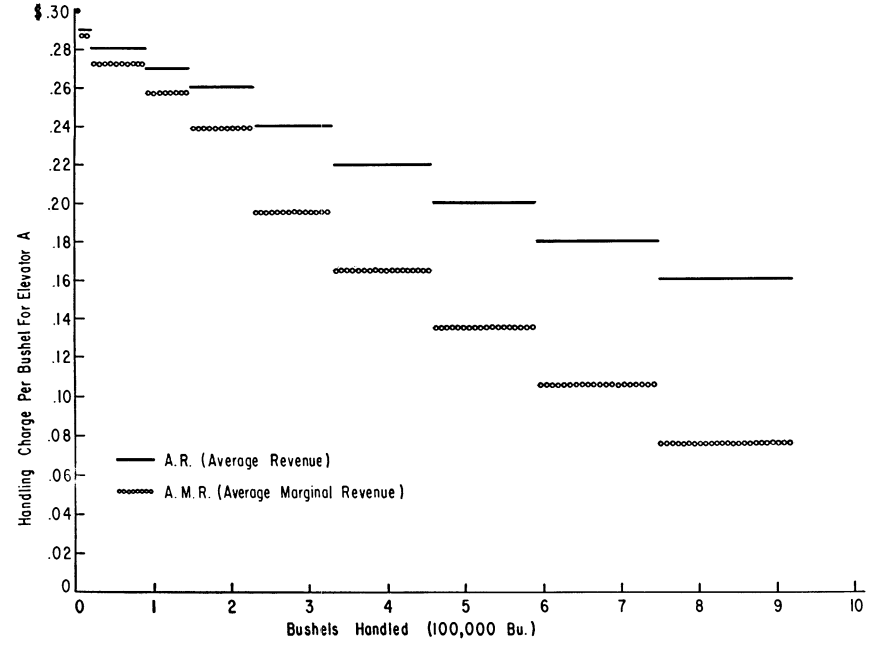


**Figure 5—A Firm's Demand Curve When Competitors are 20 Miles Away and Charge $.15 per Bushel for Elevator Services.**

**Table IV—The Revenue Situation Faced by an Elevator Whose Competitors 20 Miles Away Charge $.15 for Performing Elevator Services**

| Handling Charge AR | Distance Mi. | Market Area Sq. Mi. | Total Quantity Bu. | Change in Quantity Bu. | Total Revenue TR | Change in Total Revenue | Average Marginal Revenue* |
|---|---|---|---|---|---|---|---|
| $.30 | 1 | 2 | 9,200 | 9,200 | $ 2,760 | $ 2,760 | $.30 |
| .29 | 2 | 8 | 36,800 | 27,600 | 10,672 | 7,912 | .287 |
| .28 | 3 | 18 | 82,800 | 46,000 | 23,184 | 12,512 | .272 |
| .27 | 4 | 32 | 147,200 | 64,400 | 39,744 | 16,560 | .257 |
| .26 | 5 | 50 | 230,000 | 83,800 | 59,800 | 20,056 | .239 |
| .24 | 6 | 72 | 331,200 | 101,200 | 79,488 | 19,688 | .195 |
| .22 | 7 | 98 | 450,800 | 119,600 | 99,176 | 19,688 | .165 |
| .20 | 8 | 128 | 588,800 | 138,000 | 117,760 | 18,584 | .135 |
| .18 | 9 | 162 | 745,200 | 156,400 | 134,136 | 16,376 | .105 |
| .16 | 10 | 200 | 920,000 | 174,800 | 147,200 | 13,064 | .075 |

*Column 7 divided by Column 5.

At a price of 20 cents for the handling charge, almost all the wheat produced in the market area would be marketed through competing elevators pricing their handling services at five cents (Figure 4). An increase of one mile would result from each one-cent decrease in price up to a five-cent decrease. Beyond a five-cent decrease, a two-cent reduction in prices is required to increase the distance one mile.

The increase in area for each additional mile is greater than for the previous mile (Table I). Consequently, equal incremental price decreases bring forth increasing incremental quantity increases.[4]

When the area of the market approaches one half the distance between competing elevators, the competitive situation becomes oligopolistic. Further price decreases by a firm would attract business from the competing firm. The remainder of the demand curve would approach a vertical line.

If the price charged by A is below that charged by B, the resulting division of the market depends on B's actions. If B cuts price competitively, Schedule I of Table VI shows the results. If B does not counter with retaliatory price cutting, Schedule II is applicable.

4Results are similar in Figures 5 and 6 after allowances are made for differences in prices charged for elevator services.

**Table V—The Revenue Situation Faced by an Elevator Whose Competitors 20 Miles Away Charge $—.03 for Performing Elevator Services**

| Handling Charge AR | Distance Mi. | Market Area Sq. Mi. | Total Quantity Bu. | Change in Quantity Bu. | Total Revenue TR | Change in Total Revenue | Average Marginal Revenue* |
|---|---|---|---|---|---|---|---|
| $.12 | 1 | 2 | 9,200 | 9,200 | $ 1,104 | $ 1,104 | $.12 |
| .11 | 2 | 8 | 36,800 | 27,600 | 4,048 | 2,944 | .107 |
| .10 | 3 | 18 | 82,800 | 46,000 | 8,280 | 4,232 | .092 |
| .09 | 4 | 32 | 147,200 | 64,400 | 13,248 | 4,968 | .077 |
| .08 | 5 | 50 | 230,000 | 83,800 | 18,400 | 5,152 | .061 |
| .06 | 6 | 72 | 331,200 | 101,200 | 19,872 | 1,472 | .015 |
| .04 | 7 | 98 | 450,800 | 119,600 | 18,032 | —1,840 | —.015 |
| .02 | 8 | 128 | 588,800 | 138,000 | 11,776 | —6,256 | —.045 |
| .00 | 9 | 162 | 745,200 | 156,400 | 0 | —11,776 | —.075 |
| —.02 | 10 | 200 | 920,000 | 174,800 | 18,400 | —18,400 | —.105 |

*Column 7 divided by column 5.

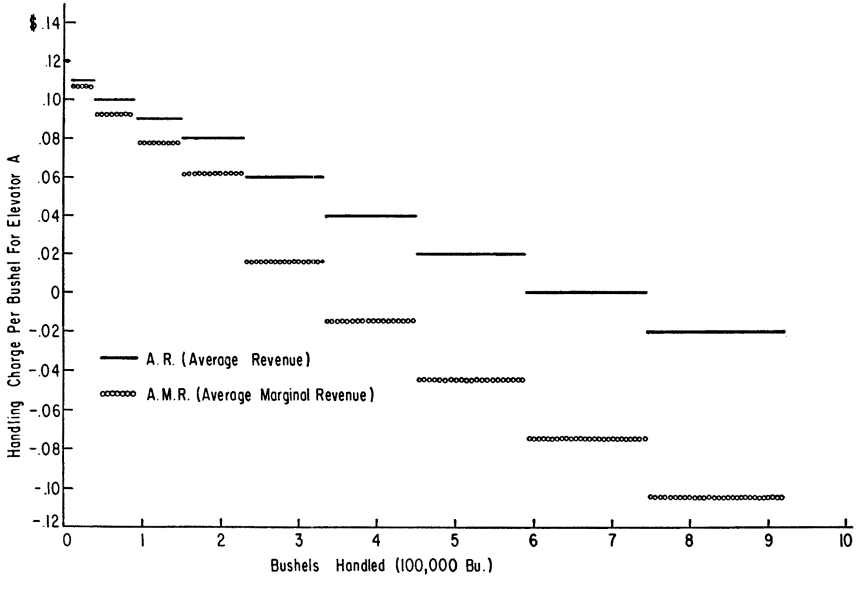


**Figure 6—A Firm's Demand Curve When Competitors are 20 Miles Away and Charge $—.03 per Bushel for Elevator Services.**

**Table VI—The Division of the Market Through the Range of Prices Below the Competitive Level**

| Elevator A Cost Per Bushel | | | Elevator B Cost Per Bushel | | | Distance Attracted by A |
|---|---|---|---|---|---|---|
| For Handling (Col. 1) | For Trans. (Col. 2) | Total (Col. 3) | For Handling (Col. 4) | For Trans. (Col. 5) | Total (Col. 6) | (Col. 7) |
| **Schedule I—With Retaliatory Price-Cutting.** | | | | | | |
| $.05 | $.10 | $.15 | $ 05 | $.10 | $.15 | 10 miles |
| .04 | .10 | .14 | .04 | .10 | .14 | 10 |
| .03 | .10 | .13 | .03 | .10 | .13 | 10 |
| .02 | .10 | .12 | .02 | .10 | .12 | 10 |
| .01 | .10 | .11 | .01 | .10 | .11 | 10 |
| .00 | .10 | .10 | .00 | .10 | .10 | 10 |
| **Schedule II—Without Retaliatory Price-Cutting.** | | | | | | |
| .05 | .10 | .15 | .05 | .10 | .15 | 10 |
| .04 | .11 | .15 | .05 | .10 | .15 | Indifferent |
| .039 | .11 | .149 | .05 | .10 | .15 | 11 |
| .02 | .12 | .14 | .05 | .09 | .14 | Indifferent |
| .019 | .12 | .139 | .05 | .09 | .14 | 12 |
| .00 | .13 | .13 | .05 | .08 | .13 | Indifferent |

If the competitor's price for handling wheat had originally been —3 cents (Table V and Figure 6) the market area would be evenly divided at a price of —3 cents — i.e., a bonus of three cents is paid. There would be no way of increasing this price and maintaining quantity received without agreement (tacit or otherwise) on the part of all concerned. An attempt on the part of one firm to increase price when other firms did not make similar price increases would result in the loss of a large quantity of business.

## Summary

A derived demand function for elevator services was determined, using location theory, transportation rates, yield estimates, and competitor price policy.

Farmer response to marketing costs along a line between two elevators was investigated to determine the market division. With the divi-

sion of the market for various prices charged for elevator services, the derived demand schedule consisted of the price of services and the quantities represented by the production of an area inscribed by the various distances.

Inasmuch as a division of market areas is affected by costs and prices of competing firms, prices above the competitive price can be charged if the firm is willing to sacrifice quantity handled. Prices below the competitive price will not attract larger quantities if the competing firms also cut price. In the major model analyzed, shown in Table III, an elevator, "A", competing with others 20 miles away and charging $.05 a bushel for elevator services, would be able to increase its volume from almost nothing to approximately 1,000,000 bushels by lessening the price charged for elevator services from $.20 to $.06 per bushel. This is a result of location advantage and suggests the advantages which come to an elevator from being able to reduce its operating costs appreciably.

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