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# Rail Line Abandonment: Impact on Grain Marketing and Transportation Costs in Western Ohio

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# Rail Line Abandonment: Impact on Grain Marketing and Transportation Costs in Western Ohio[1]

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## INTRODUCTION

Among the several transportation modes serving rural areas, railroads are the mainstay of the grain transportation system. In recent years, and presently, areas in the Midwest and Northeast are undergoing rail reorganization and abandonment in an effort to revitalize the economically ailing railroad system. Two major pieces of Federal legislation—the Rail Reorganization Act of 1973 (RRRA) and the Rail Revitalization and Regulatory Reform Act (RRRRA) of Feb. 5, 1976, were passed to begin the revitalization process. Under the RRRA of 1973, the U. S. Railway Association (USRA) was charged with the responsibility of initiating and implementing a system-wide plan that would restructure the railroad system located in 17 northeastern states and the District of Columbia. To this end a new government owned for profit organization, the Consolidated Rail Corporation (Conrail), was created and began operation on April 1, 1976, by taking over most of the activities performed by the defunct Penn Central railroad and seven smaller companies.[3]

Under the provisions of the RRRA and RRRRA, criteria were set whereby rail line segments would be judged as to their financial viability, and accordingly be designated as "potentially excess" or "viable". Using this criterion, 15,575 miles of track were designated as "potentially excess" (15). As part of the proposed plan, the USRA recommended to the U. S. Dept. of Transportation that approximately 6,000 miles of light density tracks in the Midwest and Northeast not be included in the Conrail System.[4] Light density tracks designated as potentially excess and not included in the Conrail System would be abandoned unless they were absorbed and subsidized by local and/or state governments with assistance provided by the Federal Government.[5]

In the midwestern states of Illinois, Indiana and Ohio alone, 7,500 miles, or approximately 30% of the rail lines existing in these three states were designated as excess. In Ohio, out of a total of about 8,206 miles of rail lines, 885.5 miles (11%) of light density tracks were designated as potentially excess (6).

Rail abandonment dates back to the 1920s, but never in its history has the U. S. railroad system experienced a selective reorganization with such a large number of miles of track considered for abandonment at any one time. Additionally, most of the lines considered for abandonment (especially in the Midwest) happen to be located in agriculture-based rural communities. Agribusiness firms such as grain elevators, fertilizer distributors, wholesalers, and grain millers are located in this region and rely primarily on low cost rail transportation.

Arguments have been made both for and against rail abandonment. Proponents of abandonment presented their argument to the Interstate Commerce Commission (ICC), indicating that it was necessary to abandon limited usage rail lines that do not carry enough goods to cover their costs, and continued operation of these lines is at the expense of the total rail system or subsidized by the profitable ones.[6]

Opponents of abandonment, such as shippers and communities that depend on railroads, argue that if certain lines are abandoned they, shippers, would incur losses in their business; and in instances where there are substantial investments in fixed plant and facilities, resorting to alternate modes such as trucks may not provide them with the necessary services. Even if they are willing to pay higher charges for motor transport, opponents of abandonment contend that existing highways and bridges in these rural areas cannot handle increased traffic and heavier loads (12).

[1]The work reported in this publication is part of the contribution of OARDC to NC-137, Evaluation of Alternative Rural Freight Transportation, Storage and Distribution Systems.

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[3]The other seven railroads are the Lehigh Valley, Lehigh and Hudson River, the Ann Arbor, the Reading, the Central of New Jersey, the Erie Lackawanna, and the Boston & Maine. The Pennsylvania and the New York Central railroads were merged in 1968 and went bankrupt 2 years later in June 1970.

[4]The legislation charged the USRA with the responsibility of developing a "Final System Plan" providing for the reorganization of rail services and the disposition of rail properties of the bankrupt railroads with financial obligations totaling not more than $1.65 billion to be used for making loans to assist in carrying out the Act.

[5]In the case of Ohio, those rail lines designated as potentially excess would not receive state or local government subsidy because of a provision in the state constitution that prohibits the use of tax monies to subsidize private firms. The brunt of the burden of upgrading and operating a rail line has to be borne by private groups with federal assistance, if they desire to have continued rail services.

[6]The Interstate Commerce Commission (ICC) is charged with the responsibility of reviewing abandonment applications and resolving abandonment cases.

Considering the extent of rail abandonment in Ohio (11% of all the miles of rail track in the state), very little research has been devoted towards evaluating the impact of rail abandonment as compared to other agricultural research that has direct bearing on the economic activities of rural areas.

## OBJECTIVES

The general objective of this study is to evaluate the impact of rail line abandonment on the net revenue of producers (farmers) as well as the resultant effects that rail abandonment may have on the number and location of grain storage and distribution firms in west-central Ohio. A capacitated network model of grain flow in and from west-central Ohio will be developed in order to determine these effects.

The next section of this paper describes the analytical model developed for this study as well as the data collected and the major characteristics of grain shippers and grain flows in west-central Ohio. The results of the model are presented next for a base solution and an abandonment solution. The conclusions and policy implications are presented in the final section.

## METHODOLOGY

### The Model

A multiperiod (four quarters) transshipment location-allocation model in a capacitated network form was used in this study. This is an application and extension of the model developed by Baumel *et al.* (2) which is a variation of the one developed by Ladd and Lifferth (5). The model uses an algorithm that systematically compares alternative rail-based grain distribution systems and selects the optimal 1) number, size, and location of grain elevators, and 2) flows of grain over space and time. Optimality is based upon the criterion of maximum joint net revenue for producers.

The grain model used in this study modifies and replaces the model developed by Baumel *et al.* In the Baumel version, a linear programming model was used to minimize the transportation cost incurred in filling the storage facilities of existing elevators at the beginning of the harvest quarter. This minimization solution was found separately from the grain model and the data output from the LP model was used as data input in the transshipment model. In this study, however, modifications were made such that the linear programming model was replaced by a specialized and more efficient network algorithm called the "out-of-kilter algorithm" (OKA) which was integrated into the grain model and run as a single interconnected unit. The solution of the two models would be identical.

The transshipment plant location model and the method of solution are based on the following model statement and assumptions. Three grains (corn, soybeans, and wheat) are shipped from origins located within a specified region. The supply of each grain at each origin is known for time t.[7] Each grain producer located in the selected region has the option of shipping his grain to either a country elevator or to a subterminal elevator. The country elevator can store and/or ship grain to a subterminal or to a terminal market. A subterminal can store and/or ship to a final destination. "Final destinations" and "terminal markets" are used synonymously and refer to either foreign export markets or domestic processing markets involving the physical transformation of grain.

A country elevator receives grain from producers. The grain may be stored or shipped immediately by semi-truck or rail in single car shipments to either a subterminal or to a final destination. Country elevators cannot utilize multiple-car rail shipments in excess of 10 cars because of rail or elevator load-out capacity constraints. Grain received by subterminals may be shipped to final destinations in multiple-car rail shipments (50 cars or more) or by semi-truck.

The predetermined supply of grain at each origin is first divided into two parts—harvest period supply and non-harvest period supply. The harvest period supply is that portion of the annual transportable surplus that was received by elevators during the harvest quarter. These amounts were determined from the elevator survey. The non-harvest period supply is therefore the remaining portion of the annual transportable surplus. Sufficient farm storage is available to store any grains produced but not marketed at harvest time. Using minimum transport cost criterion, the harvest period supply is shipped to elevator facilities until available storage is filled and the residual kept on farms for shipments later in the harvest quarter or in subsequent quarters. The non-harvest quantity of grains is distributed among the second, third, and fourth quarters on the basis of the average quarterly receiving rates of elevators obtained for the survey.

Quarterly demand prices for grain at each destination are obtained from historical data. As such, these prices reflect the changing supply-demand situation during the year. However, this model assumes this quarterly price pattern is given and will not be affected by the quantities marketed. In other words, each final destination is assumed to have a perfectly elastic demand at a given price in each time period.

[7]Time, which varies from $t = 1, 2, 3, 4$, denotes quarters.

Per unit transportation costs and variable handling costs are known and vary by commodity, time, and mode of shipment. The quarterly grain prices, net of transportation and variable handling costs, determine where a country elevator or subterminal will ship the grain.

Usable grain distribution facilities, including elevators, subterminals, and rail lines, are those which exist at the beginning of the planning horizon. Existing country elevators will continue in use and may be expanded into subterminals. Facilities that exist at the beginning of the planning horizon affect the optimal path of industry adjustment due to the nature of their "sunk" costs. Existing storage capacity at an elevator is defined as total storage capacity at the elevator minus that portion of storage capacity used for working space and back-to-farm shipments of grain.

The objective function of the model is net revenue to producers within a specified area under various rail line networks. Net revenue as defined here is the income received at final destination minus all handling costs other than previously sunk costs and minus all transportation costs from farm to final destination.[8]

The revenue to producers is maximized subject to the following constraints: a) Existing storage facilities of country elevators and subterminals are filled to capacity in the harvest quarter before storage capacity is allowed to expand at any elevator or subterminal. b) Processors of corn and soybeans in the study area receive grain equal to 90% of their estimated 1975 processing capacity before grain can be shipped out of the region to markets. c) The total supply of grain received at any one location in any one quarter equals the total supply shipped to that location from all sources in that same quarter. d) The total grain receipts of country elevators or subterminals from origins equal their net change in storage stocks plus total shipments to final destination.

### Data and Procedure

The region of analysis is Crop Reporting District IV (CRD IV) covering the counties of Auglaize, Champaign, Clark, Darke, Hardin, Logan, Mercer, Miami, and Shelby in west-central Ohio. The region contains seven rail line segments with a total of 54.5 miles of track deemed potentially excess and which face abandonment. Figure 1 shows the location of this region within Ohio, the rail line network of the region, and the seven rail line segments subject to abandonment. The following data were obtained for crop year 1975:

- Grain supply at origins requiring transportation to final destination
- Grain elevator type, location, and storage capacity
- Quarterly receipts and shipments of grain by elevators
- Demand prices for each grain at final destinations
- Grain processor demand requirements
- Grain handling costs
- Trucking rates and costs for each grain from origin to final destination
- Rail rates

***Farm Origins:*** The nine-county region was subdivided into squares of 3 miles by 3 miles. Each of these squares was designated as a farm origin, thus providing a total of 496 origins of supply. Mileage from each of the 496 origins to each of the elevator facilities located within the district was calculated using rectangular mileage coordinates.

***Grain Supplies at Origins:*** Estimates of the 1975 production of corn, soybeans, and wheat for the nine-county region were obtained from Ohio Agricultural Statistics (14). This grain production was then reduced by the amount utilized by livestock on farms in order to determine the transportable surplus of grain (4)[9] from each county which was then distributed to the farm origins. The total area in the nine-county region is not tillable because parts of the region are in lakes and population centers, as well as highway networks. Adjustments for these physical features of the land were made when the grain was

[8]A complete mathematical expression and specification of the model is found in Solomon (11).

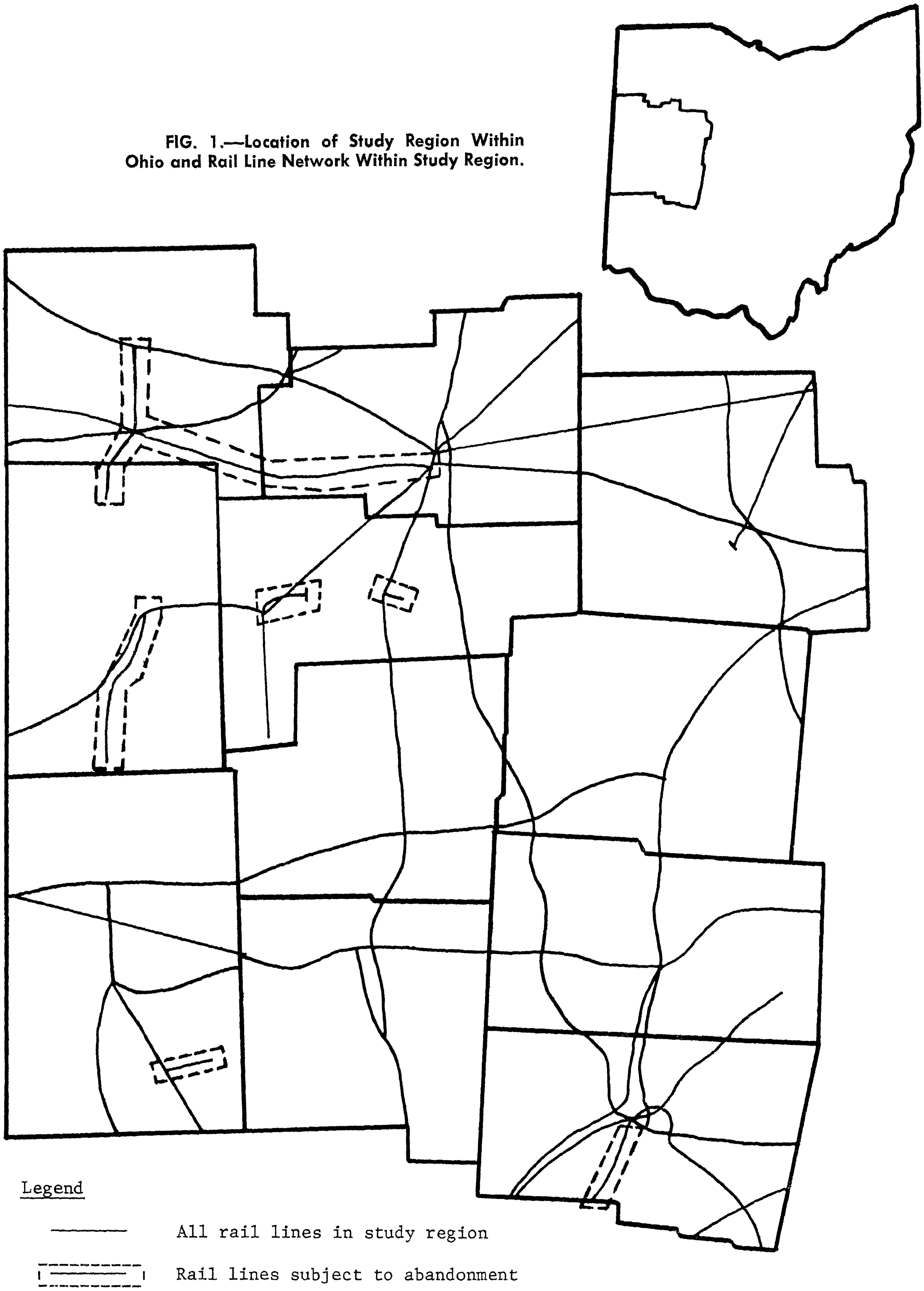
[9]Corn is the only grain used for livestock feed and therefore the district's production of soybeans and wheat are to be assumed as the transportable surpluses. Also, the production of grain in each county is assumed to be of a uniform density.

**TABLE 1.—Grain Production and Transportable Surplus for Crop Reporting District IV, Ohio, 1975.**

| County | Wheat Production | Soybean Production | Corn Production | Transportable Surplus of Corn* |
|---|---|---|---|---|
| | | (000 bu) | | |
| Auglaize | 1,607 | 2,218 | 6,605 | 5,152 |
| Champaign | 1,214 | 1,788 | 8,834 | 6,755 |
| Clark | 1,041 | 1,798 | 6,943 | 3,790 |
| Darke | 2,115 | 3,825 | 12,004 | 8,746 |
| Hardin | 2,283 | 3,273 | 6,930 | 5,343 |
| Logan | 1,008 | 1,769 | 6,110 | 4,780 |
| Mercer | 1,891 | 2,862 | 7,904 | 4,749 |
| Miami | 1,556 | 2,231 | 6,730 | 5,152 |
| Shelby | 1,598 | 2,206 | 6,057 | 3,926 |
| Total | 14,313 | 21,882 | 68,154 | 48,393 |

*Estimates from (4).
Source: (14).

FIG. 1.—Location of Study Region Within Ohio and Rail Line Network Within Study Region.



apportioned to the origins. Table 1 presents the transportable surplus of the three grains in the study area.

***Elevator Type, Location and Capacity:*** A list of elevator facilities, obtained from the directory of the Ohio Grain, Feed and Fertilizer Association, indicated that 135 grain elevators were identified within the district as commercial elevators that were associated with the handling of grain during the 1975 crop year. Fourteen of these elevators were excluded because they were found to be very small in their operations (4,000-10,000 bushels storage capacity) and also were not active in grain handling and merchandising. A survey of the managers of these 121 elevators yielded 97 usable interviews. Seven declined to participate and 17 were found to be involved only in the storage of feed grains for farmers and did not take part in the marketing of grain. The 97 completed interviews represent 93% of the commercial grain elevators and 98% of the storage capacity in the district.

There does not seem to be an agreed-upon classification of commercial elevator types in Ohio at the present time. In some instances, commercial elevators are classified as country elevators, subterminals (inland terminals), and terminal elevators. Because of the lack of unique features in the function performed by country and subterminal elevators, some elevators may be called, interchangeably, either a country or subterminal elevator.

For the purpose of this study two types, country elevators and subterminals, are established. The subterminal:

a) receives raw grain from farmers or other elevators and ships raw grain to final destination,
b) has storage capacity of at least 500,000 bushels,
c) has sufficient rail siding to allow the loading of a 50-car unit train within the time limits of the railroad.
d) has receiving capacity of at least 15,000 bushels per hour,
e) has drying capacity of at least 2,500 bushels per hour, and
f) has loadout capacity of at least 20,000 bushels per hour.

**TABLE 2.—Distribution of Elevators by Storage Size Class in Crop Reporting District IV, Ohio, 1975.**

| Elevator Storage Capacity (bu) | Number of Elevators | Percent of Total |
|---|---|---|
| 0- 49,000 | 20 | 21 |
| 50,000- 99,000 | 17 | 18 |
| 100,000-149,000 | 16 | 16 |
| 150,000-199,000 | 5 | 5 |
| 200,000-299,000 | 9 | 9 |
| 300,000-499,000 | 10 | 10 |
| 500,000 and above | 20 | 21 |
| Total | 97 | 100 |

Source: Elevator survey.

All elevators that fall short of the above requirements are classified as country elevators that receive raw grain from farmers and ship raw grain to other elevators or to final destinations. Country elevators may ship their grain by truck and/or by single rail cars. According to this classification, 90 elevators were grouped as country elevators and 7 as subterminals (Table 2).

The storage capacity of elevators is limited at a given period in time, and the three commodities compete for this limited space. A system of allocating the given storage capacity among the three commodities was devised. In the elevator survey, managers were asked what percent of their available storage space was occupied by each of the three commodities under consideration during the 1975 crop year. From the 97 responses, an annual average percentage storage space for each commodity was computed: 57% of the storage space was used for corn, 26% for soybeans, and 17% for wheat.

***Grain Receipts and Shipments:*** The crop year was divided into four quarters, the first quarter beginning at harvest. The crop year for corn and soybeans begins in October and ends in September; for wheat, the crop year starts in July and ends in June (Table 3).

The annual, as well as the monthly, grain receipts and shipments by each elevator were obtained in the field survey. The monthly grain receipts by

**TABLE 3.—A Quarterly Breakdown of the Crop Year for Corn, Soybeans and Wheat, Ohio, 1975.**

| Commodity | First Quarter | Second Quarter | Third Quarter | Fourth Quarter |
|---|---|---|---|---|
| Corn and Soybeans | Oct-Dec (75) | Jan-Mar (76) | Apr-June (76) | July-Sept (76) |
| Wheat | July-Aug (75) | Oct-Dec (75) | Jan-Mar (76) | Apr-June (76) |

Source: Calculated.

**TABLE 4.—Quarterly Averages of Grain Receiving and Shipping Rates by Elevator Facilities, Crop Year 1975.**

| Grain | 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter |
|---|---|---|---|---|
| | Receiving Rate (%) | | | |
| Corn | 69.08 | 8.25 | 8.62 | 14.05 |
| Soybeans | 74.98 | 8.33 | 7.60 | 9.09 |
| Wheat | 90.68 | 2.00 | 2.46 | 4.86 |
| | Shipping Rate (%) | | | |
| Corn | 46.33 | 20.27 | 19.45 | 13.95 |
| Soybeans | 50.52 | 15.01 | 21.45 | 13.02 |
| Wheat | 71.43 | 12.59 | 9.93 | 6.05 |

Source: Elevator survey.

elevators were grouped into quarterly receipts, and each quarterly receipt was expressed as a percent of the annual grain receipt by each elevator. The quarterly percentages were then summed over all elevators and a single average quarterly receipt was obtained for all elevators (Table 4). These quarterly averages were assumed to represent the quarterly receiving pattern of the 97 elevators included in the survey. For corn and soybeans, it was found that nearly three-fourths of the grain was received during the harvest quarter, whereas for wheat nine-tenths of the grain was received during the harvest quarter. The remainder of the grain was received evenly over the last three quarters.

On the shipping side, information was obtained on the monthly shipment of grain, the mode of transport, and the destination to which each elevator shipped its grains. Quarterly average shipping rates were computed following a procedure similar to that of receiving rates (Table 4). The quarterly shipping patterns indicated that about half of the corn and soybeans and more than two-thirds of the wheat shipments were made during the harvest quarter and the remainder was shipped more or less uniformly over the remaining three quarters.

***Grain Market Prices:*** The availability of market price information dictated the final number of markets to be used in the analysis. Nine markets for corn and soybeans and ten markets for wheat were identified and price data were collected. An examination of the data obtained in the survey showed that these markets received approximately 85% of the corn and wheat, and 75% of the soybeans shipped out of the district (Table 5).

Spatial and temporal price differences in grain prices at final destinations determine the volume and direction of grain flows to each market. The supply of grain is determined at harvest, but all that is harvested is not consumed during that season. The demand for grain is spread throughout the year. As a result, whatever is not demanded at harvest is stored for later seasons. Price differences, therefore, reflect the cost of storage, damages, shrinkage and risk, thus accounting for temporal variations. Prices differ from one market to another, not only due to distance factors, but also due to factors such as weather conditions, export market interactions, bottlenecks in the transportation system, or other unpredictable phenomena such as dock strikes. These external factors occurring outside of the producing region result in variations in prices offered by each market.

Price data were obtained from an ongoing research project directed by Dr. John Sharp in the Dept. of Agricultural Economics and Rural Sociology, The Ohio State University and Ohio Agricultural Research and Development Center, and from daily published bid cards furnished by Continental Grain Co. These prices were aggregated and monthly average prices were calculated. The monthly average prices were pooled to obtain quarterly average prices for each of the markets under consideration (Tables 6, 7 and 8).

**TABLE 5.—Percent of Grain Receipts at Selected Markets from Crop Reporting District IV, Ohio, 1975.**

| Market | Corn | Soybeans | Wheat |
|---|---|---|---|
| | | Percent Received | |
| Dayton | 10.0 | 3.0 | 3.0 |
| Sidney | 7.0 | 2.5 | 5.3 |
| Fostoria | 9.5 | 9.0 | 6.0 |
| Toledo | 14.0 | 17.5 | 38.0 |
| Marion | 2.5 | 4.5 | 4.5 |
| Cincinnati | 3.0 | 11.5 | 5.0 |
| Columbus | 2.0 | 1.5 | 3.0 |
| Baltimore | 17.5 | | 8.0 |
| Norfolk | 21.0 | 16.0 | 12.0 |
| New England | | 10.0 | 5.0 |
| Others | 13.5 | 24.5 | 10.2 |
| Total | 100.0 | 100.0 | 100.0 |

Source: Elevator survey.

***Grain Processor Demand Requirements:*** Estimates of grain demanded by processors were obtained from the SM-42 study (1) which divided Ohio into two grain marketing areas identified as areas 25 and 45. Since the present study area (CRD IV) is within area 25, the 1975 processors' demand requirements for corn, soybeans, and wheat from area 25 were obtained. The total processors' demand requirements for area 25 were then divided by the total grain production of that area in order to arrive at the share of grain produced going to processors. This is performed separately for each of the three grains. These ratios were then multiplied by the grain production of CRD IV, thus providing an estimate of the bushels of grain from CRD IV going to meet the demand requirements of local processors. One fourth of this total was allocated to each quarter year.

***Grain Handling Costs:*** Grain handling activities are composed of grain receiving, loading out, drying, and storage. In these four activities all the costs of blending, sampling, loading the grain in the various modes of transport, drying, conditioning and storage are incurred.

Data used for estimating grain handling costs for the two types of elevators used in this study were obtained from the USDA publication, Feed Situation Report 252 (8). These cost figures include all variable expenditures associated with normal operations of an elevator such as labor, administrative overhead, power and light, repairs and maintenance, interest on working capital, and other miscellaneous expenditures (Table 9).

The estimated variable handling costs were updated to 1975 and projected on the basis of cost increases as well as expected changes in the volume of grain from the survey year 1971-72 (Table 10).

**TABLE 6.—Average Delivered Corn Prices at Selected Ohio and Eastern U. S. Markets by Quarter, October 1975 to September 1976.**

| Markets | Quarter | | | |
|---|---|---|---|---|
| | Oct.-Dec. | Jan.-Mar. | Apr.-June | July-Sept. |
| | ($/bu) | | | |
| Sidney | 2.500 | 2.500 | 2.810 | 2.800 |
| Dayton | 2.400 | 2.400 | 2.750 | 2.700 |
| Fostoria | 2.522 | 2.523 | 2.789 | 2.761 |
| Toledo | 2.728 | 2.728 | 2.937 | 2.903 |
| Marion | 2.470 | 2.503 | 2.740 | 2.720 |
| Cincinnati | 2.520 | 2.633 | 2.820 | 2.810 |
| Columbus | 2.480 | 2.600 | 2.780 | 2.773 |
| Baltimore | 2.783 | 2.839 | 2.961 | 2.936 |
| Norfolk | 2.753 | 2.800 | 2.900 | 2.853 |

Source: Continental Grain Company, Columbus, Ohio, overnight bid cards; and Sharp (1978).

**TABLE 7.—Average Delivered Soybean Prices at Selected Ohio and Eastern U. S. Markets by Quarter, Oct. 1975 to Sept. 1976.**

| Markets | Quarter | | | |
|---|---|---|---|---|
| | Oct.-Dec. | Jan.-Mar. | Apr.-June | July-Sept. |
| | ($/bu) | | | |
| Sidney | 4.541 | 4.589 | 5.390 | 6.475 |
| Dayton | 4.560 | 4.626 | 5.000 | 6.513 |
| Fostoria | 4.618 | 4.589 | 5.385 | 6.348 |
| Toledo | 4.555 | 4.508 | 5.278 | 6.446 |
| Marion | 4.431 | 4.482 | 5.209 | 6.382 |
| Cincinnati | 4.568 | 4.681 | 5.310 | 6.557 |
| Columbus | 4.657 | 4.586 | 5.997 | 6.482 |
| New England | 4.930 | 4.896 | 5.569 | 6.570 |
| Norfolk | 4.715 | 4.666 | 5.669 | 6.226 |

Source: Continental Grain Company, Columbus, Ohio, overnight bid cards; and Sharp (1978).

**TABLE 8.—Average Delivered Wheat Prices at Selected Ohio and Eastern U. S. Markets by Quarter, July 1975 to June 1976.**

| Markets | Quarter | | | |
|---|---|---|---|---|
| | July-Sept. | Oct.-Dec. | Jan.-Mar. | Apr.-June |
| | ($/bu) | | | |
| Sidney | 3.533 | 3.309 | 3.475 | 3.243 |
| Dayton | 3.582 | 3.262 | 3.465 | 3.246 |
| Fostoria | 3.703 | 3.418 | 3.419 | 3.286 |
| Toledo | 3.526 | 3.315 | 3.425 | 3.195 |
| Marion | 3.457 | 3.251 | 3.419 | 3.228 |
| Cincinnati | 3.616 | 3.273 | 4.565 | 3.272 |
| Columbus | 3.594 | 3.335 | 3.528 | 3.293 |
| New England | 3.728 | 3.586 | 3.648 | 3.340 |
| Baltimore | 3.460 | 3.310 | 3.420 | 3.310 |
| Norfolk | 3.542 | 3.399 | 3.393 | 3.126 |

Source: Continental Grain Company, Columbus, Ohio, overnight bid cards; and Sharp (1978).

**TABLE 9.—Estimated Variable Cost of Receiving, Loading-out, and Storage of Grain at Country and Subterminal Elevators, Ohio, 1975.**

| Cost Item | Country Elevator | Subterminal Elevator |
|---|---|---|
| | (¢/bu) | |
| Direct Labor | 3.32 | 2.81 |
| Administrative Overhead | 2.28 | 1.63 |
| Power and Heat | 0.31 | 0.29 |
| Repairs and Maintenance | 1.07 | 0.52 |
| Interest on Working Capital | 0.24 | 0.13 |
| Insurance on Grain | 0.62 | 0.28 |
| Fumigation | 0.15 | 0.22 |
| Taxes on Grain | 0.15 | 0.11 |
| Miscellaneous | 0.79 | 0.80 |
| Total Variable Cost | 8.93 | 6.79 |

Source: (8).

**TABLE 10.—Increases in Operating Costs Used to Project Elevator Variable Handling Costs, Ohio, 1975.**

| Cost Item | Increases 1971-72 to 1974-75 |
|---|---|
| **Fixed Cost** | **Percent** |
| Building and Equipment Depreciation | 22 |
| Building and Equipment Insurance | 22 |
| Building and Equipment Taxes | 22 |
| Building and Equipment Interest on Invested Capital* | 22 |
| **Variable Cost** | |
| Direct Labor | 19 |
| Administrative Overhead | 19 |
| Electricity, Heat, etc. | 20 |
| Building and Equipment Repair | 22 |
| Insurance on Grain | 49 |
| All Other Items | 11 |

*Interest on invested capital was calculated at 8.0% of one-half of the replacement value of buildings and equipment.

Source: (8).

**TABLE 11.—Estimated Intrastate Rail Rates, Tariff E772, Ohio, 1975.**

| Mileage | Single Car Rate | Three Car Rate |
|---|---|---|
| | $/bu | |
| 0-120 | 0.202 | 0.185 |
| 121-130 | 0.209 | 0.190 |
| 131-150 | 0.219 | 0.199 |
| 151-170 | 0.232 | N.A. |

Source: (3).

**TABLE 12.—Interstate Rail Rates from Fort Wayne to Selected Eastern U. S. Markets, 1975.**

| Fort Wayne to: | Grain Type | Rate 1 Car | 3 Car |
|---|---|---|---|
| | | Dollars per Bushel | |
| New England | Wheat | 0.576 | |
| | Soybeans | 0.576 | |
| | Corn | 0.392 | 0.330 |
| Pennsylvania and New York | Wheat | 0.396 | |
| | Soybeans | 0.396 | |
| | Corn | 0.229 | 0.201 |
| Virginia | Wheat | 0.428 | |
| | Soybeans | 0.428 | |
| | Corn | 0.308 | 0.263 |
| Carolinas and Georgia | Wheat | 0.466 | |
| | Soybeans | 0.466 | |
| | Corn | 0.380 | |
| Baltimore | Wheat | 0.235 | 0.173 |
| | Soybeans | 0.235 | 0.173 |
| | Corn | 0.235 | 0.173 |
| Norfolk | Wheat | 0.235 | 0.173 |
| | Soybeans | 0.235 | 0.173 |
| | Corn | 0.235 | 0.173 |

Source: (3).

*Grain Trucking Rates:* Interstate truck rates for moving raw agricultural products are not regulated by the Interstate Commerce Commission (ICC). In general, truck rates vary according to the extent of competition, availability of equipment, economic conditions, and geographic areas.

Truck rates specific to the study area were gathered during the elevator survey. Elevator managers provided information on the mode of transport and the cost of shipping grain by destinations. The number of miles between the particular elevator and the stated destinations was calculated from a highway map.

A total of 75 usable observations was taken from the survey and, using the transportation cost and the distance (miles), a linear trucking cost function was fit. The estimated trucking cost function from elevator to market was:

$$C = 0.0457 + 0.000710\ M$$
$$R^2 = .85$$

where:

C = transport cost, $/bu

M = one-way distance, miles

Grains are transported from farms to elevators in tractor wagons, goose neck trailers, single axle trucks, and semi-trucks. Trucking cost functions for transporting grain from farms to elevators were also estimated using data from Worley (17). This cost function represents a weighted average cost of hauling grain in the various types of vehicles.

The estimated transport cost function from farms to elevators was:

$$C = 0.03995 + 0.001461\ M$$
$$R^2 = .97$$

***Rail Rates:*** The main source of data for rail rates was a compilation of rail, barge, and truck rates published by the Tennessee Valley Authority (1). In order to make the information obtained from this source usable in this study, rail rates were computed for three types of rail shipments: intrastate, interstate, and unit train shipments (Tables 11, 12, and 13).

Point-to-point rail rates were available from three major points in Ohio and from Fort Wayne,

**TABLE 13.—Export Grain Unit Train Rates from Ohio, 1975.**

| Origin | Export Destination | $/bu | Cars/Unit | Trips/yr |
|---|---|---|---|---|
| Columbus | Baltimore, Md. | 0.145 | 100 | 5 |
| or | or | 0.140 | 100 | 20 |
| Cincinnati | Norfolk, Va. | 0.137 | 100 | 30 |
| | | 0.134 | 100 | 35 |
| | | 0.132 | 100 | 45 |

Source: (4).

Ind., for 1975. Fort Wayne was selected as the origin point for CRD IV because it is the closest to the region and because elevators in the region are charged the prevailing rate at this point.

Intrastate rail rates are scheduled following the E772 mileage tariff for single and multiple car movements (17). Since multiple car rates were not available for soybeans and wheat, available rates for corn were used for all three commodities.

A unit train is defined as a group of rail cars of sufficient number to move from origin to destination and back as a through train. Although the number of cars required to qualify as a unit train varies among individual railroads depending on power and profile of track, it is generally assumed that 50 cars would satisfy the minimum number in Ohio. Additionally, in order for a particular elevator to qualify for unit train rates, it must ship at least five trains per year to a given destination. Export grain unit train rates hold for only one grain per train.

At the time of this study there were 27 unit train facilities operating in Ohio, but only 7 of them were in the study region (Table 14). Besides annual tonnage requirements as qualifications for unit train rates, there are additional physical characteristics that an elevator should have in order to efficiently ship grain in unit trains. First, an elevator should be located in a strategic location where there is sufficient grain to be shipped in order to meet its minimum tonnage requirement. Second, the elevator should have sufficient handling capacity. For example, an elevator that intends to handle a 50-car unit train should have sufficient rail siding to avoid switching; it must have a receiving capacity of 15,000 bu/hr, drying capacity of 2,500 bu/hr, and loadout capacity of 20,000 bu/hr. For an elevator intending to handle an 85-car unit train facility, it should have a receiving capacity of 25,000 bu/hr, drying capacity of 5,000 bu/hr, loadout capacity of 30,000 bu/hr, and sufficient rail siding (2). Discussions with elevator managers that handle unit trains in the study area indicate that, as a rule of thumb, the minimum storage requirement to load out multiple-car shipments was 500,000 bushels for a 50-car unit, and 1,000,000 bushels for an 85-car unit. Five of the seven subterminal elevators included in this study shipped their grains by unit trains in 1975.

## RESULTS:

## GRAIN FLOWS FOR ALTERNATIVE SCENARIOS

Optimal solutions from two alternative simulations are analyzed here. The first simulation provides optimal solutions that depict pre-abandonment baseline conditions. The second simulation provides optimal solutions under conditions of rail abandonment. It may be recalled that in the Baumel model each final destination is assumed to have a perfectly elastic demand and with that the capacity to take unlimited amounts. This assumption allows a market that offers the highest net price to receive all of the grain shipments from the district. The possibility of having perfectly elastic demands at certain markets without imposing any restrictions on the maximum volume of grain that could be shipped to any one market is therefore a questionable assumption.

In the present model, three kinds of restrictions are imposed which modify this assumption. First, the five subterminal elevators that were allowed to ship grain to specified markets using unit trains are prohibited from making grain shipments by truck to nearby in-state markets, but are allowed to make grain shipments by single rail cars to in-state markets or by single rail cars and/or unit trains to Baltimore and Norfolk. The remaining two subterminals (subterminals four and five) are allowed to use truck and single rail cars for making grain shipments to in-state markets. Second, country elevators are prohibited

**TABLE 14.—Location, Name, and Storage Capacity for Unit Train Facilities in Ohio, 1977.**

| Location | Name of Firm | Capacity (000 bu) |
|---|---|---|
| Alger* | Alger Feed and Grain Co. | 800 |
| Arcanum* | Continental Grain Co. | 775 |
| Belleview | Central Soya | 5,630 |
| Cincinnati | Central Soya | 4,136 |
| | Queen City Grain | 1,229 |
| | Early and Daniel | 3,023 |
| Columbus | Landmark | 5,600 |
| | Continental Grain Co. | 2,900 |
| | International Multi Foods | 1,250 |
| Coshocton | The Coshocton Grain Co. | 783 |
| Fostoria | The Ohio Farmers Grain | 5,423 |
| Harpster | Pillsbury Company | 387 |
| Huron | Pillsbury Company | 1,700 |
| Jeffersonville | Landmark | 1,157 |
| Kenton* | Landmark | 1,050 |
| Lilly Chapel | Pillsbury Company | 800 |
| Lima | Cargill | 2,150 |
| Mansfield | Early and Daniel | 1,400 |
| Marion | Central Soya | 5,100 |
| Mechanicsburg* | The Ohio Grain Company | 2,014 |
| Montpelier | Landmark | 750 |
| Sidney* | Landmark | 1,430 |
| South Charleston* | Landmark | 1,300 |
| Toledo | The Andersons | 18,950 |
| | Mid States Terminals | 4,700 |
| | Cargill | 4,600 |
| Troy* | Early and Daniel | 1,909 |

*Unit train facilities located in the study area.

Source: Grain Facilities in the U. S. Specializing in Originating Grain for Export and Soybean Processing Plants, by John W. Sharp (unpublished).

**TABLE 15.—Quarterly Flow of Corn, Soybeans, and Wheat Through Subterminals, Baseline Solution, Ohio, Oct. 1975 to Sept. 1976.**

| Quarter | Corn | Soybeans | Wheat | Quarterly Total |
|---|---|---|---|---|
| | 000 bushels received<br>% of annual total received | | | |
| First | 11,227 | 5,472 | 887 | 17,586 |
| (Oct.-Dec.) | 37.6 | 18.3 | 3.0 | 58.9 |
| Second | 3,151 | 1,104 | 1,037 | 5,292 |
| (Jan.-Mar.) | 10.5 | 3.7 | 3.5 | 17.7 |
| Third | 1,309 | 1,038 | 258 | 2,605 |
| (Apr.-June) | 4.4 | 3.5 | 0.8 | 8.7 |
| Fourth | 1,847 | 376 | 2,156 | 4,379 |
| (July-Sept.) | 6.2 | 1.3 | 7.2 | 14.7 |
| Annual Total | 17,534 | 7,990 | 4,338 | 29,862 |
| | 58.7 | 26.8 | 14.5 | 100.0 |

Source: Model results.

from making grain shipments to the East Coast using unit trains. The cost of transporting grain by trucks is an increasing function of distance. By prohibiting country elevators from shipping their grains to the East Coast using unit trains (lower cost and independent of distance), and allowing them to use single rail cars and/or trucks for grain shipments, there is a limit to how far they can ship their grains efficiently in order to maximize their revenue. Third, every country elevator and subterminal is not allowed the option of making grain shipments to each of the candidate markets. Country elevators and subterminals are allowed to make grain shipments only to those destinations to which they reported shipping grains in the elevator survey during the 1975 crop year. The prohibition of certain shipments of grain to some of the destinations using these three restrictions is expected to make some of the destination demands less "elastic".

**Baseline Solution**

The transshipment-location-allocation model was built to handle only one commodity at a time, and as such it was not possible to simulate grain flows from farms to consumption points for all three grains simultaneously. Therefore, optimal solution results were aggregated over all three grains outside of the model.

Commodity flows from farms to elevators suggested by the optimal solution of the grain model may not necessarily be in conformity with the real world situation. In the real world, some farmers may show loyalty to particular elevators. Optimal flows eliminate these loyalties by assuming that grains will flow from farm to an elevator that offers the highest net price for the commodity. Attempting to describe the path of grain flows from farms through the 97 storage facilities to final markets would be too unwieldy. Therefore, the analysis of grain flows over space and time will focus upon the seven subterminal elevators identified in the district.

***Quarterly Flows of Grain:*** Approximately two-thirds of the corn and soybeans and one-half of the wheat is marketed during the harvest quarter (Table 15). Harvest quarter marketings of corn and soybeans account for 56% of total grain receipts during the year. This volume taxes the capacity of the country elevators and subterminals to handle grain and therefore is associated with relatively small receipts of wheat. Even during the July-September quarter, the harvest quarter for wheat, wheat receipts are slightly less than one-half of total grain receipts. Consequently, any viable subterminal elevator will handle primarily soybeans and corn.

***Subterminal Elevators:*** During the baseline year (1975), the seven subterminal elevators received an aggregate of 29,862,000 bushels of grain (corn, soybeans and wheat), which is 35.4% of the 1975

**TABLE 16.—Aggregate Annual Subterminal Grain Receipts Computed from Optimal Baseline Solutions of Corn, Soybean, and Wheat Models, Ohio, Oct. 1975 to Sept. 1976.**

| Subterminal Number | Corn | Soybeans | Wheat | Total Volume | Total (Percent) |
|---|---|---|---|---|---|
| | (000) bushels | | | | |
| 1 | 2,847 | 2,755 | 916 | 6,518 | 21.83 |
| 2 | 1,994 | 1,221 | 744 | 3,959 | 13.26 |
| 3 | 861 | 393 | 1,208 | 2,462 | 8.24 |
| 4 | 1,086 | 349 | 189 | 1,624 | 5.44 |
| 5 | 690 | 2,063 | 450 | 3,203 | 10.73 |
| 6 | 1,439 | 655 | 401 | 2,495 | 8.36 |
| 7 | 8,617 | 554 | 430 | 9,601 | 32.15 |
| Total | 17,534 | 7,990 | 4,338 | 29,862 | 100.00 |

Source: Model results.

grain surplus in the district. The remainder was shipped through country elevators to final destination without going through subterminals. This grain receipt by subterminal is made up of 58.7% corn, 26.8% soybeans, and 14.5% wheat. The distribution of grain receipts by the seven subterminals is not uniform (Table 16). Two of the subterminals, one and seven, received nearly 54% of the total subterminal grain receipts. The remaining 46% is distributed among the remaining five subterminals. The volume of grain received by subterminal seven (largest) is nearly six times the amount received by subterminal four (smallest). Subterminal seven received 49% of the corn from the district; however, subterminal seven ranks only fifth in its soybean and wheat receipts.

For subterminals one and two, receipts of corn and soybeans are equally important. Others tend to specialize in one grain. Total grain receipts of subterminal four are 1,624,000 bushels or 5.4% of the total grain receipts by subterminals. These model results suggest that subterminal four cannot compete with the other subterminals, and therefore is not a viable subterminal. However, certain factors have to be taken into consideration. First, subterminal four was prohibited the services of unit trains in the baseline model and was allowed to use only truck and single car rail transportation. Second, the model considers the district as a closed system and, as such, all the grain that flows to the 97 elevator facilities is from only the 496 origins of supply enclosed within the district. Subterminal four is located within the district but very close to origins of supply outside of the district boundary. In the real world, such rigid and distinct boundaries are non-existent. It is therefore possible for subterminal four to receive grains from outlying areas and still show minimal amounts of grain receipts from within the district. It is difficult to make definitive statements about the viability of subterminal four on the basis of the results of the baseline solution.

Adjustments have been made when aggregating grain receipts to reflect the different harvest quarters for wheat (July-September) and corn and soybeans (October-December).

The distribution of aggregate grain receipts among the seven subterminals is very uneven between quarters and for different grains (Table 17 and Figures 2, 3, and 4). Subterminals one and seven absorb more than 50% of all grain during the first and second quarters. During the third and fourth quarters, grain receipts are more evenly distributed among the seven subterminals.

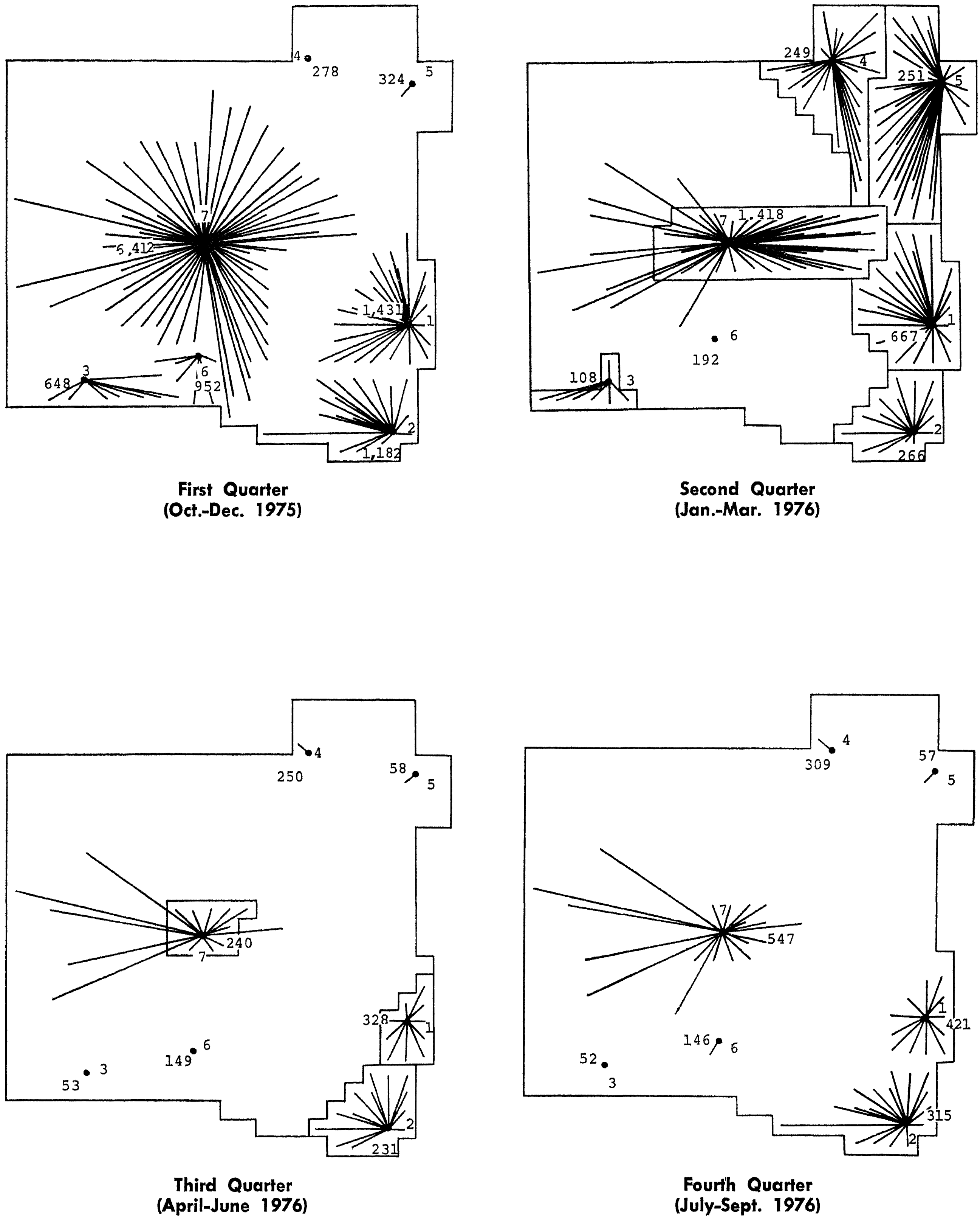
A comparison of the quarterly receipts for each grain for each subterminal further points out the uneven distribution of grain receipts, even for quarters three and four. The grain receiving and handling capacity of each subterminal is fixed and within that fixed capacity different subterminals concentrate on different grains during any given quarter. Subterminal seven, a dominant one, concentrates on corn during the corn harvest quarter. Subterminal five receives soybeans, while subterminal one receives substantial amounts of both corn and soybeans. As expected, very little wheat is marketed during this quarter since the capacities of the subterminal are reserved for receiving corn and soybeans during the harvest quarter.

Receipts of grain at all subterminals drop sharply from October-December to January-March (Table 15). This occurred even though some subterminals (*e.g.,* subterminal five) greatly increased wheat receipts on a percentage basis. As noted previously, during the July-September quarter, relatively small amounts of grain are received by the subterminals. Even though this is the harvest quarter for wheat,

**TABLE 17.—Aggregate Grain Receipts by Subterminals from Farms and Country Elevators by Quarter, Computed from Baseline Optimal Solutions, Ohio, Oct. 1975 to Sept. 1976.**

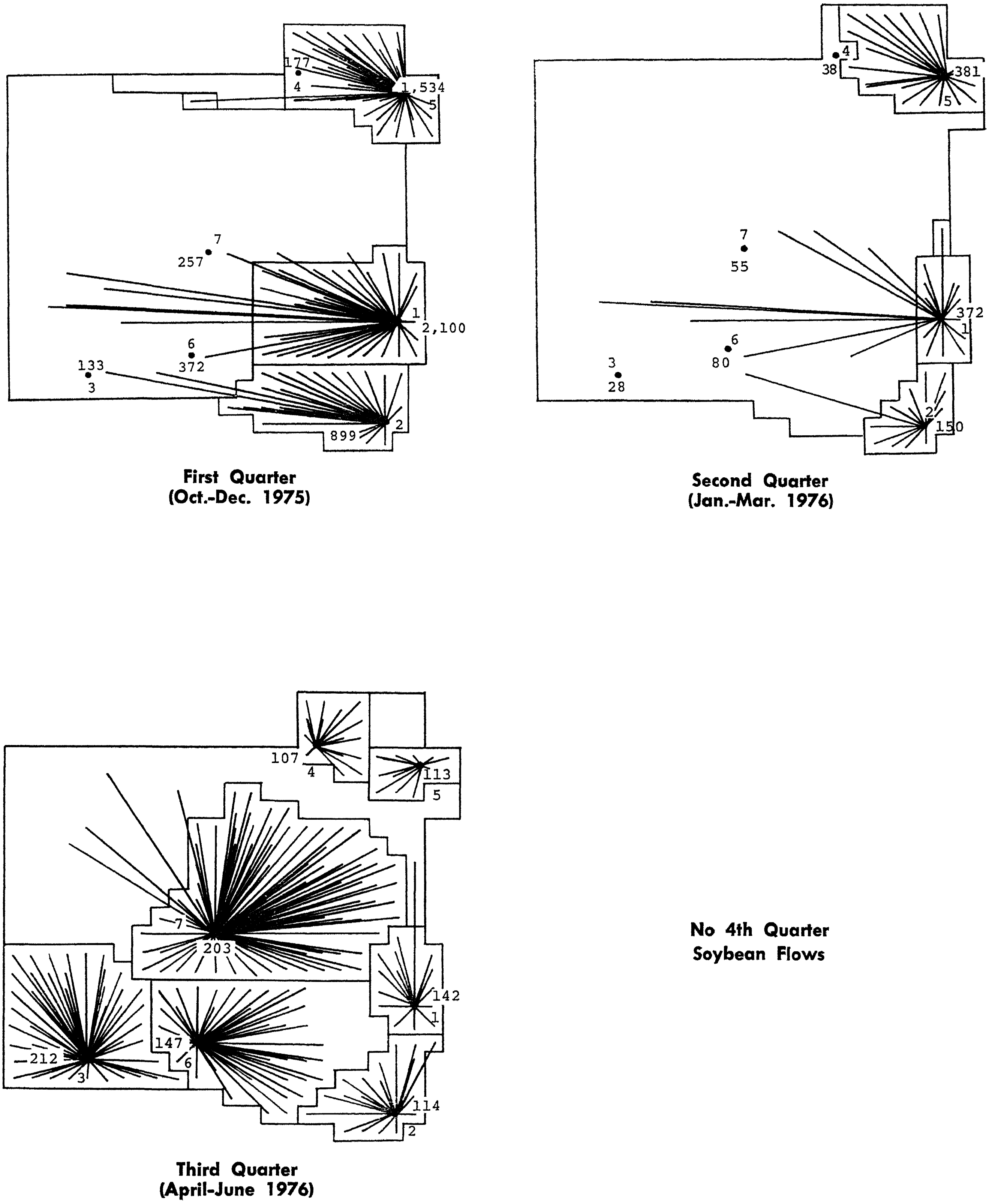
| Subterminal Number | Oct.-Dec. 1st Quarter Receipts (000) bu | % | Jan.-Mar. 2nd Quarter Receipts (000) bu | % | Apr.-June 3rd Quarter Receipts (000) bu | % | July-Sept. 4th Quarter Receipts (000) bu | % | Annual Total (000) bu | % |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3,879 | 22.1 | 1,278 | 24.1 | 496 | 19.0 | 865 | 19.8 | 6,518 | 21.8 |
| 2 | 2,193 | 12.5 | 511 | 9.7 | 432 | 16.6 | 823 | 18.8 | 3,959 | 13.3 |
| 3 | 1,066 | 6.1 | 338 | 6.4 | 328 | 12.6 | 730 | 16.7 | 2,462 | 8.2 |
| 4 | 480 | 2.7 | 308 | 5.8 | 371 | 14.2 | 465 | 10.6 | 1,624 | 5.4 |
| 5 | 1,887 | 10.7 | 885 | 16.7 | 188 | 7.2 | 243 | 5.5 | 3,203 | 10.7 |
| 6 | 1,374 | 7.8 | 330 | 6.2 | 328 | 12.5 | 466 | 10.6 | 2,495 | 8.4 |
| 7 | 6,707 | 38.1 | 1,642 | 31.1 | 465 | 17.9 | 787 | 18.0 | 9,601 | 32.2 |
| Total | 17,586 | 100.0 | 5,292 | 100.0 | 2,605 | 100.0 | 4,379 | 100.0 | 29,862 | 100.0 |

Source: Model results.



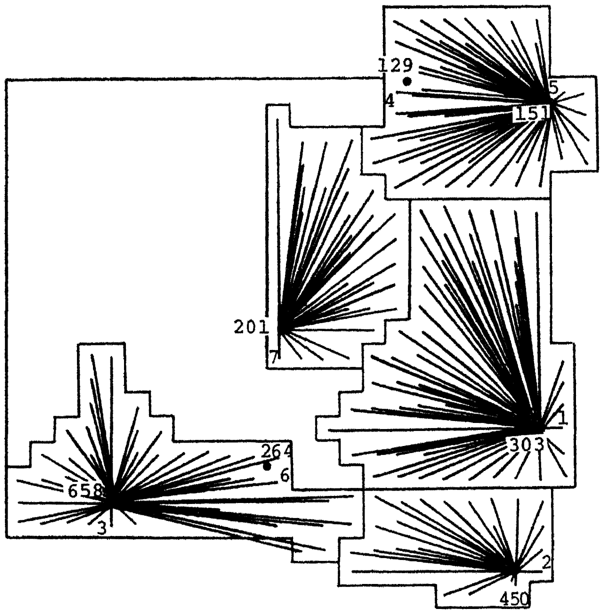

Note: Numbers 1 through 7 are subterminal identifications; other numbers indicate quarterly grain volume.

**FIG. 2.—Estimated 1975 Corn Flows from Farms and Country Elevators to Subterminal Elevators by Quarter Under Baseline Optimal Solution.**

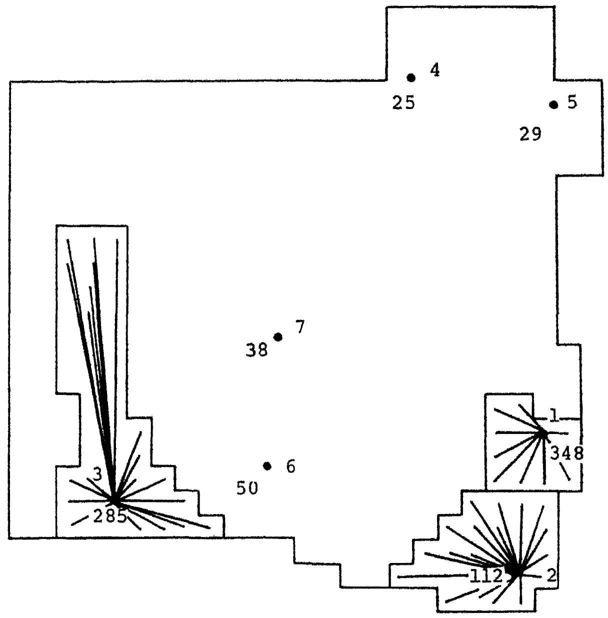



Note: Numbers 1 through 7 are subterminal identifications; other numbers indicate quarterly grain volume.

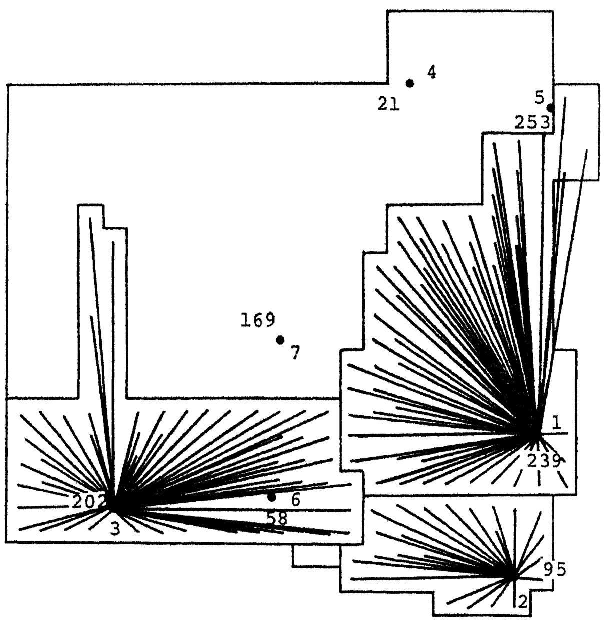
**FIG. 3.—Estimated 1975 Soybean Flows from Farms and Country Elevators to Subterminal Elevators by Quarter Under Baseline Optimal Solution.**



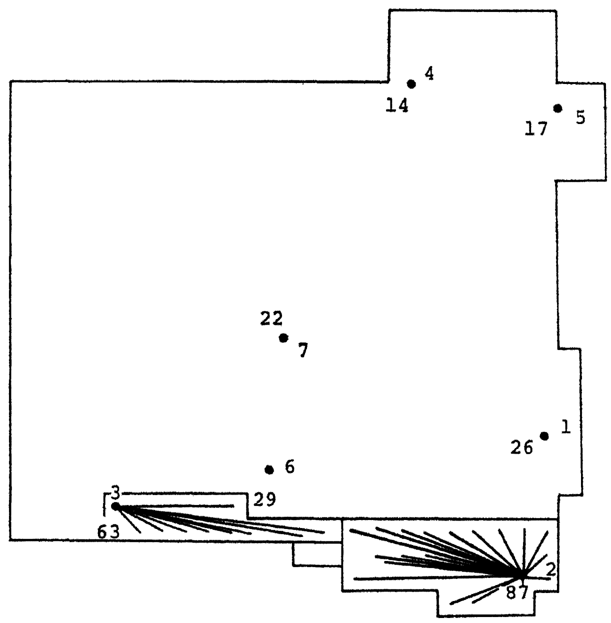

**First Quarter**
**(July-Aug. 1975)**




**Second Quarter**
**(Oct.-Dec. 1975)**




**Third Quarter**
**(Jan.-Mar. 1976)**




**Fourth Quarter**
**(April-June 1976)**

Note: Numbers 1 through 7 are subterminal identifications; other numbers indicate quarterly grain volume.

**FIG. 4.—Estimated 1975 Wheat Flows from Farms and Country Elevators to Subterminal Elevators by Quarter Under Baseline Optimal Solution.**

subterminals one and seven receive more corn than wheat.

Subterminal four receives only 5.4% of the total grain flowing through the system (Table 17). During the heaviest marketing quarters (one and two), it receives only small amounts. Since more than 75% of subterminal grain receipts occur during these two quarters, a subterminal not competitive during this time is not expected to be a viable subterminal. As previously noted, this low volume of grain moving through subterminal four is affected by the structure of the model. It is near the boundary of the closed region and was not allowed to use unit trains.

***Markets:*** A total of 84,303,000 bushels of surplus grain was shipped from the district to consumption points in 1975. Net revenue from the sale of this grain to the district's producers was $278,399,-000.

The out-of-state markets (Baltimore, New England, and Norfolk) receive a total of 49% of the district's grain surplus (Table 18). The base year (1975) survey indicated that the district shipped no corn to New England and no soybeans to Baltimore. Consequently, these shipments were prohibited in the baseline model. Amounts of corn shipped to the East Coast markets under the baseline model were similar to those indicated by the base year survey. Optimally 49% went to these markets, whereas the survey data indicated 45% (Table 6). For soybeans the proportions going to the East Coast markets were substantially different between baseline model and survey estimates. The estimates were 64% for baseline model and 34% for survey. For wheat the estimates were 25% and 19% for baseline and base year survey estimates, respectively. Toledo is the other large export point. For corn, baseline model estimates of proportions going to Toledo were much greater than base year survey estimates (41% and 16%, respectively). For soybeans (1% and 23%) and wheat (9% and 42%), the reverse was true. The larger differences for in-state shipments are likely attributable to the greater sensitivity of baseline model results to small product price changes within the state and lesser sensitivity to small price changes between Ohio and East Coast markets.

Baltimore is the most important out-of-state market, with almost all receipts being corn; it is equal in importance to Toledo. New England receives large amounts of soybeans and Norfolk receives only small amounts of grain. This pattern of receipts to out-of-state markets is primarily a function of the prices received for the grains in those markets (Tables 6-8). Norfolk's price for corn is 3 to 8 cents less than that of Baltimore, while except for the April-June quarter its soybean price is at least 22 cents less than the New England price. Among the three out-of-state markets, New England's wheat price always exceeds that of the other two and by amounts ranging from 3 to 25 cents. The difference in transportation cost from any subterminal elevator in the district to any selected out-of-state market is less than the differences in commodity prices in these markets. Consequently, each grain is shipped to that market which offers the highest delivered price.

Among in-state markets Toledo is the largest receiver of the district's grain surplus, accounting for 25.1% of the total. Toledo is an export point located strategically, such that grain shipments could be made efficiently by truck and/or rail. In-state markets such as Sidney, Fostoria, and Marion show small amounts of grain receipts. The actual amount of grain receipts of these markets would include some that goes to the processor segment. Since Sidney, Fostoria, and Marion have soybean processors, some of the grain that flows to these consumption points is included in the processors' markets (15.53%) be-

**TABLE 18.—Aggregate Grain Shipments to Specified Markets, from the Baseline Optimal Solutions, Ohio, Oct. 1975 to Sept. 1976.**

| Markets | Corn | Soybeans | Wheat | Total | Percent |
|---|---|---|---|---|---|
| | | | (000) bushels | | |
| Processor | 4,546 | 6,287 | 2,276 | 13,109 | 15.53 |
| Sidney | 64 | 275 | 205 | 544 | 0.64 |
| Fostoria | 26 | — | 6,126 | 6,152 | 7.29 |
| Toledo | 19,586 | 268 | 1,328 | 21,182 | 25.10 |
| Marion | 11 | 15 | 5 | 31 | 0.04 |
| Cincinnati | 55 | 754 | 419 | 1,228 | 1.45 |
| Columbus | 101 | 404 | 419 | 984 | 1.17 |
| Baltimore | 21,104 | — | 2 | 21,106 | 25.01 |
| New England | — | 12,759 | 3,552 | 16,311 | 19.33 |
| Norfolk | 2,583 | 1,173 | — | 3,756 | 4.45 |
| Total | 48,136 | 21,935 | 14,332 | 84,303 | 100.00 |

Source: Model results.

**TABLE 19.—Corn, Soybean, and Wheat Receipts of the 16 Country Elevator Facilities Located Along the Abandoned Rail Lines Under the Baseline and Abandonment Optimal Solutions, Ohio, Oct. 1975 to Sept. 1976.**

| Elevator No. | Corn Solutions Baseline | Corn Solutions Abandonment | Corn Percent Change | Soybeans Solutions Baseline | Soybeans Solutions Abandonment | Soybeans Percent Change | Wheat Solutions Baseline | Wheat Solutions Abandonment | Wheat Percent Change | Total Grain Receipts Baseline | Total Grain Receipts Abandonment | Total Percent Change |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (000 bu) | | | (000 bu) | | | (000 bu) | | | (000 bu) | | |
| 1 | 1,069 | 1,087 | 2 | 14 | 14 | 0 | 43 | 11 | (75) | 1,126 | 1,112 | (1.24) |
| 2 | 880 | 741 | (16) | 421 | 431 | 2 | 208 | 208 | 0 | 1,509 | 1,380 | (8.55) |
| 3* | 404 | 51 | (95) | 9 | 9 | 0 | 5 | 5 | 0 | 418 | 35 | (91.63) |
| 4 | 261 | 261 | 0 | 113 | 113 | 0 | 61 | 61 | 0 | 435 | 435 | 0 |
| 5* | 768 | 54 | (93) | 1,130 | 23 | (98) | 13 | 13 | 0 | 1,911 | 90 | (95.29) |
| 6 | 24 | 24 | 0 | 10 | 10 | 0 | 6 | 24 | 296 | 40 | 58 | 45 |
| 7* | 611 | 195 | (68) | 2,107 | 85 | (96) | 453 | 385 | (15) | 3,171 | 665 | (79.03) |
| 8 | 27 | 27 | 0 | 12 | 12 | 0 | 382 | 382 | 0 | 421 | 420 | (0.24) |
| 9* | 24 | 24 | 0 | 420 | 10 | (98) | 285 | 307 | 8 | 729 | 341 | (53.22) |
| 10* | 83 | 83 | 0 | 1,255 | 30 | (98) | 45 | 17 | (62) | 1,383 | 130 | (90.60) |
| 11* | 102 | 19 | (81) | 7 | 7 | 0 | 4 | 4 | 0 | 113 | 30 | (73.45) |
| 12 | 60 | 60 | 0 | 36 | 36 | 0 | 24 | 24 | 0 | 120 | 120 | 0 |
| 13* | 800 | 21 | (97) | 2,205 | 13 | (99) | 8 | 8 | 0 | 3,013 | 42 | (98.61) |
| 14* | 889 | 67 | (92) | 134 | 134 | 0 | 76 | 5 | (93) | 1,099 | 206 | (81.26) |
| 15 | 428 | 428 | 0 | 257 | 257 | 0 | 186 | 207 | 10 | 871 | 893 | 2.53 |
| 16 | 23 | 23 | 0 | 10 | 10 | 0 | 7 | 7 | 0 | 40 | 40 | 0 |

*Country elevators that have lost more than 50% of their grain receipts due to rail abandonment.
Source: Model results.

cause of the processors' demand requirements that have been exogenously imposed in the model. Thus, the amounts shown for these markets include only what is transshipped to another location.

**Abandonment Solution**

There are seven rail line segments with a total of 54.5 miles of track deemed potentially excess and which face abandonment. Along these rail lines, there are 16 grain elevators that depend on rail transportation for moving their grains to market. Rather than a line-by-line abandonment, a total abandonment was selected because of the limited number of elevators that are located on, and directly linked to, each of the rail line segments. Comparisons of the baseline solution with the abandonment solution for these 16 elevators show that some elevators [3, 5, 7, 9, 10, 11, 13, 14] receive less grain and another [6] more grain under abandonment (Table 19). Country and subterminal elevator facilities that handled grain in the baseline solution also handled grain in the abandonment solution. From this it may seem that rail line abandonment did not affect the number of elevator facilities in the district. But the flow of grains to 8 of the 16 country elevators located along the abandoned rail lines has been reduced by more than 50% under the abandonment solution.

In the corn model, five country elevator facilities were found to be adversely affected by rail abandonment. Four of the five elevators showed a loss of more than 50% of their annual corn receipts under the abandonment solution. The fifth elevator indicated a loss of 16% of its annual corn receipts. The highest proportion of the loss in corn receipts occurred after the harvest quarter.

For soybeans, the abandonment solution showed six elevator facilities with grain receipts different from that of the soybean baseline solution. One elevator showed a small increase (2%) in soybean receipts, with the remaining five elevators showing losses ranging from 96% to 99%. Three of the elevators that had reductions in their soybean receipts also had decreased corn receipts.

The wheat abandonment solution shows seven elevators affected, three increasing and four decreasing. Those elevators that benefited from abandonment showed increases in their wheat receipts ranging from 8% to 296% (the actual volume of the latter rose from 6,000 bushels to 24,000 bushels). Those that had decreases showed losses ranging from 15% to 93%. All of these elevators had grain receipts below 500,000 bushels under the baseline solution.

As shown in the last column of Table 20, eight country elevators have lost more than 50% of their total grain receipts due to rail abandonment. Even though these elevator facilities handle some grain, the reduction in the volume is so substantial that they may not be able to viably exist at these locations. These affected elevators received almost all of their grain receipts during the harvest quarter when the demand for storage space is very acute. The economic viability of a plant such as an elevator is highly dependent upon the volume of grain received as well as the frequency of inventory turnover. It is unlikely that the eight elevators which receive grain only during the harvest quarter will remain viable in the competitive environment of the grain industry. Considering the magnitude and frequency of grain flows to these elevators, it can be concluded that rail abandonment has had an adverse impact and resulted in the reduction of eight elevator facilities in the district.

***Subterminal Elevators:*** The baseline solution and the abandonment solution show slight differences in subterminal corn receipts (Table 20). Relative shares by subterminal elevators did not change significantly under the rail abandonment solution, but the overall volume as well as the percentage shares of grains moving to subterminal elevators have increased. Under the baseline solution, subterminal elevators received 17.5 million bushels of corn, approximately

**TABLE 20.—Aggregate Annual Subterminal Grain Receipts Computed from Optimal Solutions of the Baseline and Abandonment Models, Ohio, Oct. 1975 to Sept. 1976.**

| Subterminal No. | Corn | | Soybeans | | Wheat | | Total | | Percent Change |
|---|---|---|---|---|---|---|---|---|---|
| | Baseline | Abandonment | Baseline | Abandonment | Baseline | Abandonment | Baseline | Abandonment | |
| 1 | 2,847 | 2,862 | 2,755 | 4,265 | 916 | 988 | 6,518 | 8,115 | 24.50 |
| 2 | 1,994 | 2,691 | 1,221 | 1,233 | 744 | 783 | 3,959 | 4,707 | 18.84 |
| 3 | 861 | 1,317 | 393 | 397 | 1,208 | 1,296 | 2,462 | 3,010 | 22.26 |
| 4 | 1,086 | 2,077 | 349 | 451 | 189 | 189 | 1,624 | 2,717 | 67.30 |
| 5 | 690 | 706 | 2,063 | 4,115 | 450 | 449 | 3,203 | 5,270 | 64.50 |
| 6 | 1,439 | 1,438 | 655 | 606 | 401 | 401 | 2,495 | 2,445 | (2.00) |
| 7 | 8,617 | 10,079 | 554 | 531 | 430 | 431 | 9,601 | 11,041 | 15.00 |
| Total | 17,534 | 21,170 | 7,990 | 11,591 | 4,338 | 4,537 | 29,862 | 37,305 | 24.92 |

Source: Model results.

36% of the district's surplus. Under the rail abandonment solution, their receipts increased to 21.2 million bushels or 44%. Soybean receipts increased from 8 million bushels (36% of surplus) to 11.6 million bushels (53%). Wheat receipts increased from 4.3 million bushels (30%) to 4.5 million bushels (32%).

Comparison of the baseline solution and the abandonment solution indicates that rail abandonment has led to increases in the absolute share of subterminal elevators' grain receipts and decreases in country elevator grain receipts. This indicates that rail abandonment has led to a restructuring of the flow of commodities: the decreases in grain receipts realized by country elevators have been re-directed toward subterminal elevators, thus boosting their overall share.

***Markets:*** Under the abandonment model, the net revenue to the district's producers from the sale of the three commodities was $277,884,000, a reduction of $515,000 (0.18%) from the $278,399,000 of the baseline solution. This reduction is insignificant.[10]

Market shares of the district's grain surplus under the abandonment solution are substantially different from the solution of the baseline model (Table 21). Toledo's corn receipts increased from 19,586,000 bushels (40.69%) to 24,464,000 bushels (44.59%). On the other hand, Baltimore's corn receipts declined from 21,104,000 bushels (43.84%) to 18,537,000 bushels (38.51%) under the rail abandonment solution when compared to the baseline solution.

[10]The term "significant" as used in the context of this study is to imply "economic significance" where the criterion for the critical value of significance is a change that is greater than 1 percentage point above or below the baseline value.

The abandonment of those seven rail line segments is a reduction in the availability of certain transportation services in the total transportation system of the district. With these rail lines abandoned, some elevators have to find other modes of transport such as trucks to ship their grains. Since cost of truck transportation is an increasing function of distance, it is not an efficient mode of transport on long hauls. This would lead elevators to make their grain shipments to nearby truck-based markets where truck transportation is efficient.

It was discussed earlier that grain flows from origins of supply to the particular elevator that offers the highest net price. In the baseline model, those elevators that were located near rail line segments subject to abandonment had the option to ship their grains to market both by rail and truck. Under this given condition, some of these elevators did ship their grains to Baltimore because the Baltimore market offered the best net price to the particular elevators. However, under the abandonment model, these same elevators are denied the services of rail transportation because the rail lines are abandoned. The only alternative mode of transport available to them is truck transportation. Since the Toledo market is near enough to compete in truck transportation, it receives some of the rerouted grain by truck from the affected elevators. Baltimore, on the other hand, has lost some of the grain shipments from the affected elevators, thus showing a total reduction in its corn receipts under the abandonment optimal solution.

**TABLE 21.—Aggregate Grain Shipments to Specified Markets, Computed from Optimal Solutions of the Baseline and Abandonment Models, Ohio, Oct. 1975 to Sept. 1976.**

| Market | Corn | | Soybeans | | Wheat | | Total | | Percent Change |
|---|---|---|---|---|---|---|---|---|---|
| | Baseline | Abandonment | Baseline | Abandonment | Baseline | Abandonment | Baseline | Abandonment | |
| | | | | | (000 Bushels) | | | | |
| Processor | 4,546 | 4,602 | 6,287 | 6,279 | 2,276 | 2,266 | 13,109 | 11,147 | (14.97) |
| Sidney | 64 | 66 | 275 | 304 | 205 | 205 | 544 | 575 | 5.70 |
| Fostoria | 26 | 85 | — | 1 | 6,126 | 6,149 | 6,152 | 6,235 | 1.35 |
| Toledo | 19,586 | 24,464 | 268 | 275 | 1,328 | 1,290 | 21,182 | 26,029 | 22.88 |
| Marion | 11 | 16 | 15 | 15 | 5 | 6 | 31 | 37 | 19.35 |
| Cincinnati | 55 | 233 | 754 | 1,107 | 419 | 436 | 1,228 | 1,776 | 44.66 |
| Columbus | 101 | 161 | 404 | 104 | 419 | 418 | 924 | 683 | (26.08) |
| Baltimore | 21,104 | 18,537 | — | — | 2 | 2 | 21,106 | 18,539 | (12.16) |
| New England | — | — | 12,759 | 12,669 | 3,552 | 3,560 | 16,311 | 16,229 | (0.5) |
| Norfolk | 2,583 | 2,973 | 1,173 | 1,184 | — | 0 | 3,756 | 4,157 | 10.68 |
| Total | 48,136 | 48,136 | 21,935 | 21,938 | 14,332 | 14,333 | 84,343 | 85,407 | 1.26 |

Source: Model results.

## CONCLUSIONS AND IMPLICATIONS

During the crop year 1975, approximately 48 million bushels of corn, 22 million bushels of soybeans, and 14 million bushels of wheat were shipped from CRD IV to various markets. Optimal solutions of both simulations (baseline and post-abandonment) indicated that five markets absorbed more than 90% of the district's grain surplus. Although the relative importance of the five markets varied among the two simulation results, local processors, Toledo, and Fostoria within the state, and Baltimore and New England in the East, dominated the market. The Toledo market was the highest receiver of corn from the district, whereas Fostoria was the leading in-state market for the district's wheat surplus. Except for local processors, in-state markets were not dominant in soybean receipts. Among the out-of-state markets, the Baltimore market was the biggest receiver of the district's corn surplus. New England was the leading receiver of soybeans and wheat from the district. Nearly 50% of the corn, 65% of the soybeans, and 33% of the wheat was shipped out of the district by rail. All of the corn, 98% of the soybeans, and 90% of the wheat that was moved by rail was delivered to out-of-state markets. The net revenue to producers from the sale of this grain was $278,399,000 in the baseline solution.

The principal conclusion of the present study is that rail line abandonment has a small adverse impact on the annual net revenue to producers from the sale of corn, soybeans and wheat in CRD IV. Even though the loss in net revenue due to rail line abandonment is not significant (two-tenths of 1 percent) substantial changes in grain shipping patterns among the 97 elevators did occur. Out of the 16 country elevators that are located along the 7 abandoned rail lines, 8 suffer dramatic reductions (more than 50%) of their annual grain receipts. Furthermore, these elevators received almost all of their grain during the harvest quarter and little during the latter three quarters of the crop year. Since the economic viability of a grain elevator is highly dependent upon the volume of grain received as well as the frequency of inventory turnover, it is unlikely that these eight country elevators can remain viable in the competitive environment of the grain handling industry. Considering the magnitude and frequency of flow to these elevators, it is concluded that rail abandonment had an adverse impact and could result in the loss of eight country elevator facilities in CRD IV.

Thus, rail abandonment has a considerable impact upon those elevator facilities located along the abandoned rail lines. Elevators that lost their rail services can expect to receive approximately 50% less grain. Because of the reductions in profit margins caused by the increased per bushel cost of truck transportation, and cost per bushel of grain caused by reduction in inventory turnover, these elevators may not be able to receive reasonable returns on investment. Unless these elevators diversify their commercial activities to other products and services such as seed, feed, fertilizer, etc. to mitigate the loss in revenue due to reduced grain receipts, it is unlikely that these elevators can remain viable in the competitive environment of the grain industry in the long run.

Because of the lower rail rates for trainload grain shipments, the subterminal elevators with sufficient facilities to handle unit trains and who retain rail service will increase their grain receipts. Not all the seven subterminals located in CRD IV benefit equally from rail line abandonment, since their location with respect to the abandoned lines and other elevators plays an important role in their ability to increase grain receipts.

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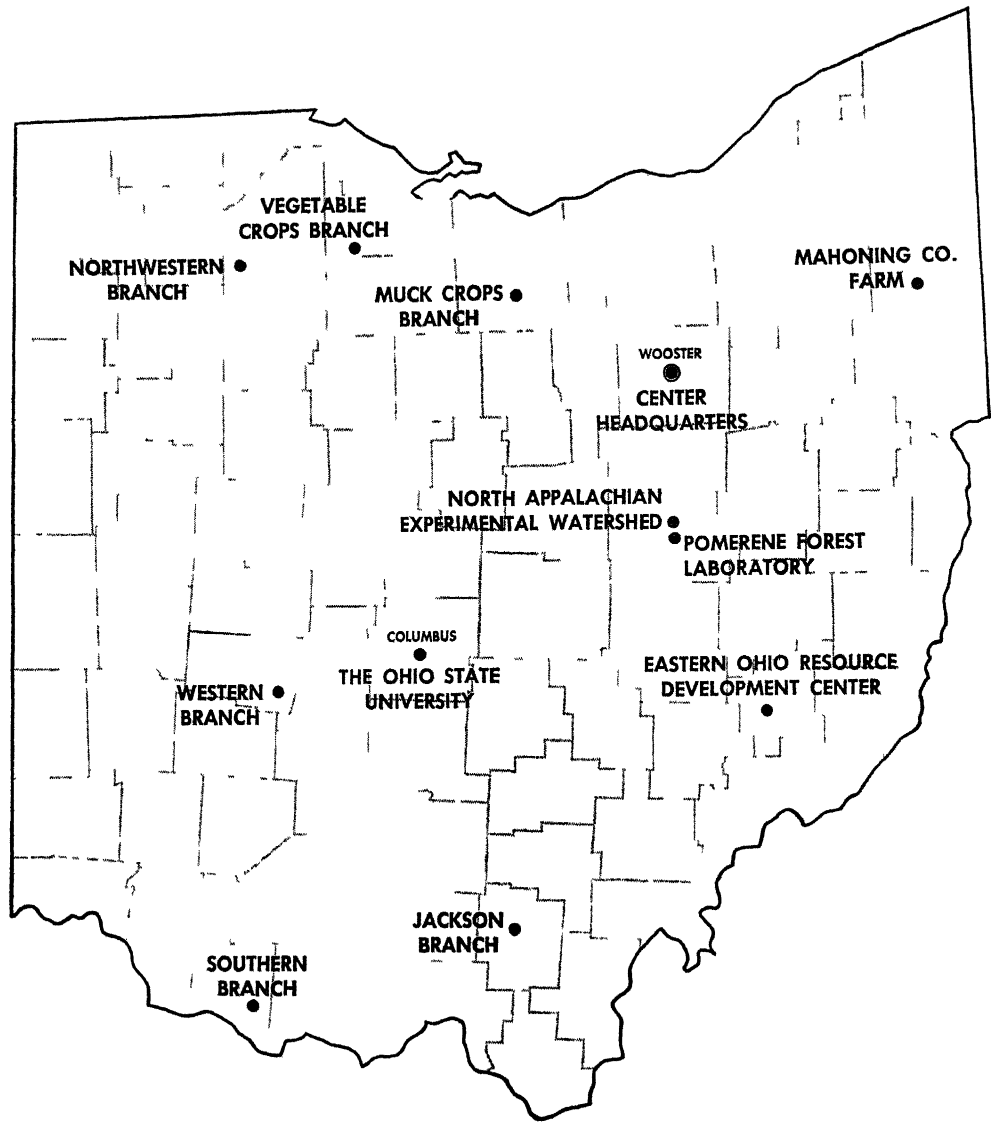


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