EFFECTS OF SEASONAL RAILROAD RATES FOR WHEAT UPON WHEAT STORAGE AND TRANSPORTATION MARKETS IN OKLAHOMA

By

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PREFACE

This study evaluates the effects of seasonal railroad rates on Oklahoma's wheat storage and transportation market. The primary objective is to determine whether seasonal ratemaking in this market can achieve the objectives intended in the Railroad Revitalization and Regulatory Reform Act of 1976. A transportation decision model based on relative rates is developed and used to examine wheat shipper responses to seasonal rates.

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THE RESEARCH PROBLEM

Introduction

The Railroad Revitalization and Regulatory Reform Act of 1976 (RRRRA) was passed to fulfill two broad goals (23). The first was to alleviate several very serious short-run problems of the railroad industry by providing federal assistance to those railroads experiencing severe financial and operational difficulties. The second goal was to promote the long-run financial viability of the entire railroad industry by instituting reforms within the railroad regulatory system. These reforms represent a shift in public policy towards greater reliance upon economic forces within transportation markets.

Regulation of railroad rates and ratemaking is an important area in which changes have been made. These changes affect the standards by which rates are regulated and the procedures by which these standards are implemented in the regulatory process.[1] The rate modernization reforms of the RRRRA cover a broad range of topics including minimum and

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[1] A good example of the dual nature of the rate regulatory reforms is that of the changes in the regulation of maximum railroad rates (23, pp. 35-36). The RRRRA not only introduces a new standard to be used by the ICC for identifying those proposed rates which may exceed a just or reasonable maximum; it also changes the procedures used by the ICC to apply this standard. The new standard is the market dominance criterion; the Commission has 90 days after starting a rate investigation in which to apply this criterion and to make its ruling on the rate(s) in question.

maximum rates, separate pricing for distinct rail services, and demand-sensitive rates.

Prior to the Act, the regulation of railroad rates had become so restrictive that railroads were not able to make adequate responses to rapidly changing conditions in transportation markets. Regulatory procedures made ratemaking an expensive and time-consuming process. The rate standards used by the Interstate Commerce Commission prevented railroads from freely setting their rates according to market conditions. Competitive forces and rising input costs rapidly changed both demand and supply conditions. By the time rate changes were approved, market forces would often have made the new rates inappropriate.

Inability of rail carriers to lower rates in a timely fashion resulted in traffic diversion to other modes even when railroads had a cost advantage over those modes for the traffic. Inability to raise rates promptly when market forces would normally have dictated such increases resulted in lost opportunities to increase railroad revenues and hampered attempts to attract resources into the railroad industry. The rate modernization sections of the RRRRA were written to correct these situations.

The rate sections provide for new regulatory standards and procedures giving railroads greater freedom from regulatory constraints in their ratemaking. These provisions place a greater reliance upon market forces to regulate traditional ratemaking activities; in addition, they encourage experimentation with new types of ratemaking which may be appropriate in some markets served by railroads. Demand-sensitive ratemaking is an example of a new type of ratemaking encouraged in the RRRRA.

Demand-sensitive ratemaking is discussed in Section 202(d) of the 1976 Act; this amendment to the Interstate Commerce Act instructs the ICC to establish rules and procedures by which railroad rates may be based upon seasonal, regional, or peak-period demand for rail service (23, p. 36). The Commission was given one year to set forth the necessary rules and procedures. In addition, it must submit annual reports to Congress on the implementation of demand-sensitive rates, including recommendations on additional legislation needed to facilitate such ratemaking.

Since no definition of "demand-sensitive rates" is given in the Act, it is difficult to know precisely what type of ratemaking is encouraged. Section 202(d) does state that the ICC's standards and procedures should be designed to:

> ...(a) provide sufficient incentive to shippers to reduce peak-period shipments, through rescheduling and advance planning; (b) generate additional revenues for the railroads; and (c) improve (i) the utilization of the national supply of freight cars, (ii) the movement of goods by rail, (iii) levels of employment by railroads, and (iv) the financial stability of markets served by railroads (23, p. 36).

The first two objectives appear to be the most important ones. The ability to establish demand-sensitive rates will allow the railroads to "adjust rates in response to market demands and thus even traffic flows and reduce car shortages, while providing revenues to the railroads more reflective of the demand for their services" (24, p. 55). Ratemaking which increases railroad revenues and smooths fluctuations in railroad demand over the year is the type of ratemaking encouraged in this section of the Act.

The fluctuation in shipper demand for rail service that results in uneven traffic flows over the year is a source of problems for railroads.

As common carriers, they are required to provide service to all shippers at the published rates. When changes in the level of shipper demand take place fairly slowly and consistently over time, the necessary adjustments in rail capacity can be made by investing or disinvesting in rolling stock and permanent plant. For some classes of railroad traffic, shipper demand fluctuates too rapidly for such adjustments. Maintaining sufficient capacity to meet the heaviest demand results in excess rail capacity when the level of demand declines. Maintaining less capacity than is required to meet the heaviest demand results in car shortages during peak periods.

Car orders are quickly filled when demand for freight cars is low relative to supply. As demand increases, delays are experienced in receiving the requested number of cars; as the railroad network's capacity is approached transit times of individual shipments are also lengthened. Rail service quality is lowered by such delays even though shippers continue to pay the same rates as they did when demand was lower and service quality higher.

In the past, car service orders were required to allocate railroad cars among shippers during periods of car shortages. A pricing mechanism would accomplish this allocation in an unregulated competitive market. The price level would depend upon the level of demand relative to the supply capacity; rates would be low when demand is low and would increase as the rising demand nears capacity. The lack of such a pricing mechanism in railroad ratemaking necessitates car service orders. Demand-sensitive ratemaking introduces a pricing mechanism for allocating cars among shippers to lessen the need for car service orders.[2]

It is not clear that the absence of demand-sensitive ratemaking in the past is the result of either restrictive regulation by the ICC or a reluctance of railroad management to initiate such ratemaking. Public regulation of other industries such as telecommunications and electricity generation allows the use of peak-load pricing. And the ICC has allowed railroads to use two-tier pricing schemes in a limited number of situations in order to meet seasonal barge competition. The purpose of Section 202(d) of the RRRRA is to remove any regulatory impediments to peak-period, seasonal, and regional ratemaking which may presently exist, and to encourage railroad management to use these types of ratemaking in the future.

The success of Section 202(d) depends upon two factors. First, railroad management will attempt to use demand-sensitive ratemaking only if it results in a net gain compared to traditional ratemaking. Do demand-sensitive rates have an advantage, in terms of cost and effectiveness, over car service orders for allocating cars to shippers? Will such rates increase revenues; if so, with accompanying cost changes, will these rates yield higher profits? Answers to these questions must be positive before railroads attempt to establish demand-sensitive rates. Second, success at removing regulatory obstacles will depend upon the ICC's interpretation of the section's provisions, not only in

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[2]A situation analogous to the fixity of railroad rates is that of the fixity of per diem rates which govern the allocation of freight cars among railroad carriers. Felton (6, p. 272) suggests that seasonally variable per diem rates may be appropriate along with seasonally variable freight rates.

the standards and procedures established by the Commission but also in its rulings on demand-sensitive rates proposals.

The Interstate Commerce Commission (9) initiated proceedings for the purpose of establishing the necessary rules and procedures for demand-sensitive ratemaking. A proposed set of regulations was issued on July 7, 1976 (9). After receiving and considering the statements of various railroads, shippers, and other interested parties made in response to this proposed set, the Commission (10) adopted a final set of regulations made effective on January 28, 1977. These regulations are reproduced in Appendix A. The Commission stated that the regulations can and will be modified if actual experience with demand-sensitive rates indicates the need for such changes.

The regulations cover two areas. First, they provide for the procedures by which the rates may be filed. The types of information which may be included, such as railroad costs, revenues, and traffic volumes, and the reporting methods are outlined. Second, the regulations provide a definition of demand-sensitive rates and indicate some of the standards which will guide the Commission when it considers the rate proposals.

The definition and the standards are not precise. This is necessary since there is no past experience from which to draw upon when forming the regulations. It is also desirable since the Commission needs flexibility if it is to promote experimentation and utilization of demand-sensitive rates. However, this introduces uncertainty into the process of ratemaking - uncertainty as to what exactly demand-sensitive rates are or should be and uncertainty as to how they can be made operational. Added to this are the unanswered questions of their effects on railroads and shippers and of whether the objectives set forth in Section 202(d) of the RRRRA can be achieved.

Problematic Situation

The wheat industry provides a large volume of railroad traffic to which seasonal and peak-period rates can be applied.[3] Wheat demand for rail service does exhibit a strong seasonal pattern. Figure 1 shows the monthly shipping pattern of eight wheat elevators for three crop years and is indicative of the seasonal pattern of railroad demand. The seasonal high occurs in the harvest period as the new crop is moved into storage at terminal facilities or to final markets. Railroad demand is also subject to large fluctuations throughout the year which are caused by wheat movements to export markets.

Although the level of wheat railroad demand does move up and down throughout the year, railroad rates on wheat have remained constant over the year and unresponsive to these changes. Seasonal rates can be established by wheat-carrying railroads to handle the high seasonal demand

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[3]Upon issuing the proposed set of regulations of June 7, 1976, the ICC requested that the railroads and other interested parties make available their comments on those regulations. One specific question asked by the Commission was whether there were commodities that should be made exempt from demand-sensitive ratemaking. Many responses to this question requested that grain be exempt primarily on the grounds that grain shippers are forced by physical reasons alone, not economic ones, to ship when they do. Since it was contended that these shippers cannot make any response to the economic incentives created by demand-sensitive rates, the raising of rail rates during times of high railroad demand can only be detremental to grain shippers. The Commission rejected this argument because it felt that: 1) the evidence indicated that, to some degree, grain shippers can respond to the economic incentives created by demand-sensitive rates; and 2) demand-sensitive rates can be established by lowering railroad rates below present levels when demand is low rather than by raising the rates above present levels when railroad demand is high. All grain traffic, including that of wheat, may be subject to demand-sensitive pricing.

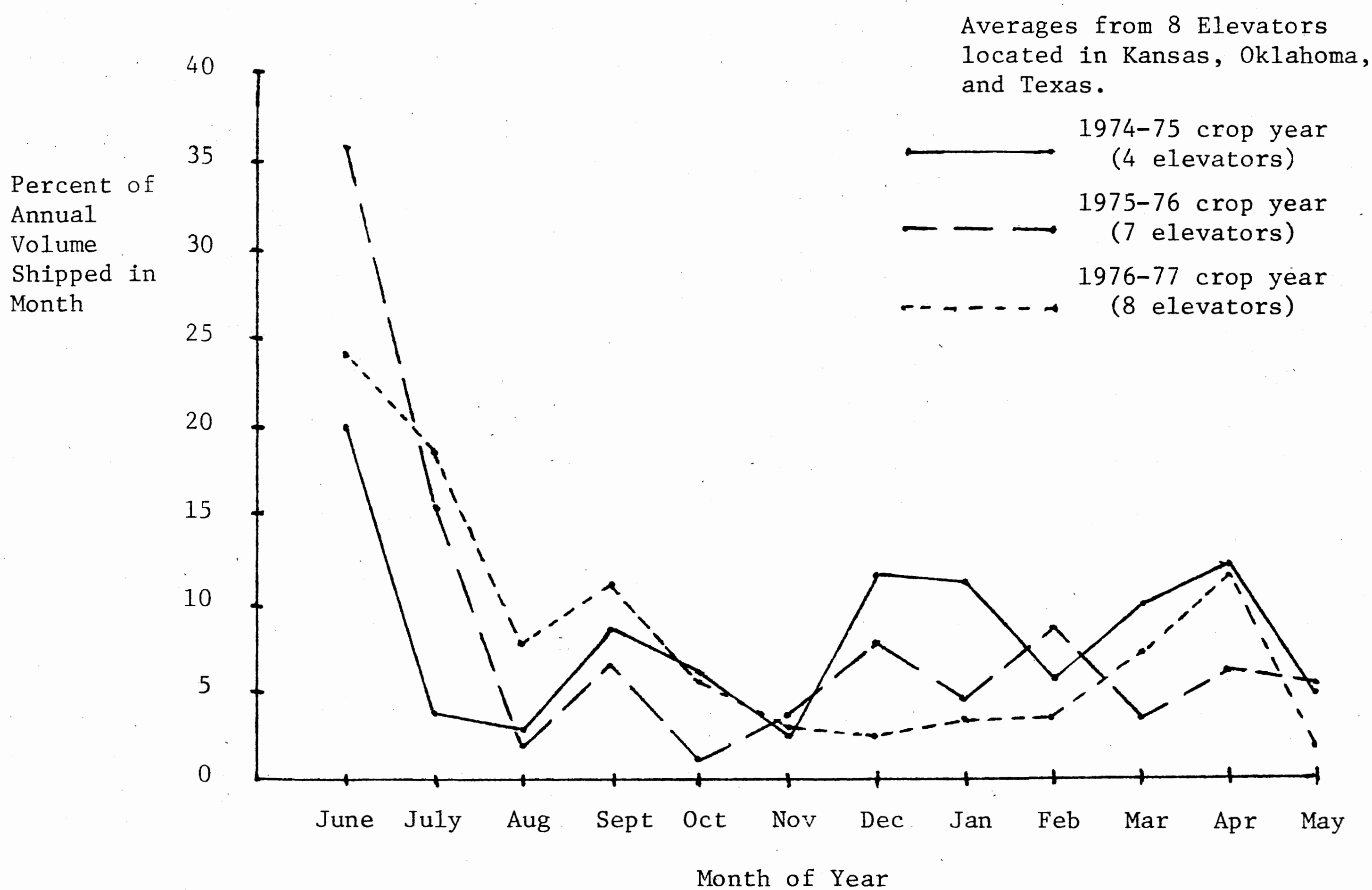

Figure 1. Monthly Wheat Shipments From 8 Country Elevators

during the harvest period. The railroad demand fluctuations caused by large export sales can be handled by peak-period ratemaking. Such actions will make railroad rates on wheat responsive to the changes in the demand for wheat rail service which occur during the year.

The large quantities of wheat which move out of country elevators during the harvest period have created the seasonal pattern of wheat rail demand. Some of this wheat is that which has been sold by producers during harvest. When wheat is delivered to an elevator and is sold by a producer, the elevator has the choice of either retaining ownership of the wheat for some time or selling the wheat immediately. Some country elevators do retain ownership of the wheat for extended periods of time, thus taking a position in the cash wheat market or a position in the wheat futures market (by hedging the grain).[4] However, the management policy at a majority of country elevators is to sell and ship out producer-sold wheat as soon as they receive ownership of it. Producer-sold wheat moving from these elevators forms part of the total wheat volume moving from country elevators during harvest.

Inland terminal elevators receive much of the producer-sold wheat shipped from country elevators during harvest. Though country elevators and producers may ship directly to final markets, the inland terminals are typically used since they have distinct marketing and merchandizing

[4]Two disadvantages of retaining ownership are 1) the substantial amount of time and expertise needed to manage the elevator's market position, and 2) storage revenues lost by storing elevator-owned rather than producer-owned wheat.

advantages.[5] Because of these advantages and the presence of rail transit privileges, large quantites of producer-sold wheat move from country elevators to inland terminals during harvest. From there the wheat is moved to final markets as it is sold to export and domestic mill buyers.

Producer-sold wheat makes up only a part of the total wheat traffic moving during harvest. Wheat not sold during harvest must be stored, either for sale in the future or use as feed or seed. On-farm storage and country elevator storage facilities represent two primary sources of capacity for storing this wheat. However their combined capacities in many areas are less than the amount needed at harvest, which is the volume of the new crop plus carryover stocks less harvest sales. Inland terminal elevators located close to these production areas act as residual suppliers of storage capacity since wheat can be quickly moved there when farm and country elevator capacities are filled during harvest. Movements of wheat into storage at inland terminals and the movements associated with harvest sales combine each year to raise the level of wheat transportation demand during the harvest period over the average level of demand during the rest of the year.

Seasonal railroad rates on wheat will mean that any given railroad movement (origin to destination) will have a higher rate if it takes place during harvest than if it takes place some time after harvest. Seasonal rates are dependent upon the recurrent seasonal pattern of railroad demand. Hence the rate level depends upon only the time period

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[5]The marketing advantages include the availability of inspection and grading personnel and the ability to put together large volume shipments with certain grade requirements.

in which the movement takes place. Once seasonal rates are established, wheat shippers will know in advance exactly when during the year the higher rates will apply and when the lower rates will apply.[6]

This contrasts with the establishment of peak-period rates on wheat. Given the lack of sufficient storage capacity at the export ports, wheat for export sales must be stored inland and moved to the ports only when the sales take place. These sales do not take place evenly throughout the year but tend to bunch together at different times, forming no particular pattern from year to year. Seasonal rates alone will leave railroad rates unresponsive to the railroad demand fluctuations caused by large export sales. The peak-period rate which would apply to a shipment would depend upon the level of railroad demand, and not upon the season of the year, when that shipment takes place. Though peak-period rates will introduce the rate responsiveness necessary when export-related fluctuations are large, shippers will not know in advance when railroad rates will be high and when they will be low.

The demand-sensitive regulations contain no guidelines on how the rate levels for either seasonal or peak-period rates are to be changed in practice. Presumably, a seasonal rate tariff would have to include all relevant rate levels and the specific time periods within the year when each will apply. Peak-period rate tariffs would indicate the railroad demand measure to be used, the rate level corresponding to each level of this measure, and an indication of how often rates will be adjusted. Regardless of which type of ratemaking is used, the

[6]This assumes that the railroad will not cancel the demand rate in the middle of the study period. See Sections (e)7 and (h) in Appendix A for the regulations covering cancellations of demand-sensitive rates.

establishment of demand-sensitive railroad rates on wheat will result in a higher average rate level during the harvest period relative to that during the rest of the year.

The inclusion of the term "regional demand for rail service" in Section 202(d) may affect the establishment of demand-sensitive rates on wheat. The timing of harvest varies among the wheat-producing regions. Seasonal rates could be established in each region separately based on that region's seasonal pattern of demand. Alternatively, seasonal rates could be established for all regions together based on their overall seasonal pattern of demand. Similar comments apply to the establishment of peak-period rates on wheat. This is another aspect of the uncertainty arising out of the imprecise nature of the ICC's regulations on demand-sensitive rates.

The rail transit privilege was mentioned previously as an important factor influencing the movement of wheat from country elevators to inland terminals. A transit arrangement is the privilege granted to a shipper by a railroad of stopping a shipment at some point (or points) en route to allow some function to be performed on that shipment before reshipping on to the final destination. Rather than pay two separate rates, one for the origin to stopover haul and one for the stopover to final destination haul, the shipper effectively pays only the through rate applicable from origin direct to final destination.[7]

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[7]For wheat transit arrangements, shippers pay the domestic rate from origin to stopover when the first haul takes place. The through rate is set at this time. When the second haul from stopover to final destination takes place, the shipper pays the balance of the through rate minus the short haul domestic rate.

Typically the through rate is less than the sum of the rates on the two separate hauls. Thus the rail transit privilege results in lower rates for those shippers who must ship to a stopover point before shipping on to a final destination. For the reasons of marketing advantages and storage availability mentioned previously, many country elevator shippers must ship to inland terminal elevators located at stopover points; these shippers enjoy the lower rail rates resulting from transit arrangements. The presence of export rates which are substantially lower than the corresponding domestic rates increases the rate advantage of transit for wheat destined for the export markets. Without the transit privilege, a shipper who moves his wheat through a terminal elevator on the way to an export market would have to pay the high domestic rate on the first haul plus the export rate from the terminal to the export market. With transit, this shipper can make the same two movements but will pay only the lower export rate from his location to the export market.

Both seasonal and peak-period rates will affect the role and importance of the transit arrangements. Since the through rate is set at the time of the first haul, harvest period movements out of country elevators that transit at inland terminals will be subject to the higher seasonal rates even though the second haul may take place any time during the year. The transit privilege offers no protection from seasonal and peak-period rates.

Given the seasonal pattern of wheat railroad demand which peaks during the harvest period of each year, wheat is a commodity for which railroads will examine the establishment of demand-sensitive rates. The lack of past experience in using such rates and the imprecise nature of their regulations raise questions of how they may be operationally implemented. More important are the questions about the effects that demand-sensitive rates may have on railroad movements of wheat.

Problem Statement

Two broad questions can be raised concerning the effects of demand-sensitive rates on wheat. First, how will wheat shippers and the wheat industry respond to the rates and the economic incentives created by the rates? Second, to what degree can the rates achieve the objectives set forth for them in the RRRRA? Finding answers to these questions is a very large and difficult task. To narrow the problem's scope to within manageable limits, this study focuses upon seasonal rail rates in one particular region. The question addressed is: What effects could the establishment of seasonal railroad rates for wheat in Oklahoma have on the movements of wheat in the state?

Two general effects are expected to be observed. First, since the establishment of seasonal rates, which entails raising or lowering the present level of rates during specific time periods, will change the relative prices of transportation alternatives available to shippers, traffic diversion to or from the railroad mode is possible. This will be evidenced in changes in modal market shares and will affect railroad revenues. In addition, since some non-railroad alternatives are not oriented to the inland terminals, traffic diversions will alter the volumes handled by inland terminals.

Second, a rate differential between the harvest period and the rest of the year could change producers' decisions of when to sell their wheat and could induce the building of new farm and country elevator storage capacity. Shifts in producer marketing patterns will shift transport demand from the harvest period to the rest of the year if the present storage capacities at the farm level and at country elevators can be more fully utilized or if new capacity is built at these locations.

The level of railroad rates throughout the year, and the relationships between rail rates and the rates of other modes, are not the only factors determining shipper transportation decisions. However, rates are important and in the long run they may be the most important factor. Since the establishment of seasonal railroad rates directly affects intermodal rate relationships, this study examines how these relationships change due to seasonal rates and how these changes could affect wheat movements.

Goal and Objectives

The goal of this study is to analyze the possible effects of seasonal rates upon wheat movements in Oklahoma and to use this analysis to answer questions relating to how shippers will respond and whether the objectives of the RRRRA for demand-sensitive rates can be achieved.

The specific objectives of this study are to examine how modal rate relationships are changed when seasonal railroad rates are established on wheat and to use these relationships in determining the changes brought about in:

1. the market share, volume, and revenue of the railroad mode,
2. the selling and storing decisions of wheat producers,
3. the transportation bill paid by producers,
4. the handling and storage volumes at inland terminal facilities,

and,

5. the utilization of wheat transit arrangements.

In the following chapters, a transportation decision model for wheat shippers is developed and used to evaluate the effects of seasonal railroad rates. Chapter II presents the conceptual foundation of the model while Chapter III discusses the formulation of the model. The results pertaining to the five objectives of the study are then discussed in Chapter IV. The last chapter briefly summarizes the most important results and draws conclusions from these results which are relevant for the establishment of seasonal railroad rates for wheat in Oklahoma.

CHAPTER II

PEAK-LOAD PRICING AND SEASONAL RAILROAD DEMAND

Introduction

The economic theory of peak-load pricing provides the rationale for establishing seasonal railroad rates. The purpose of this chapter is to develop this rationale and discuss the theory's principles most relevant to seasonal railroad ratemaking. Contributions to the literature of economics on the peak-load pricing problem are reviewed in order to gain a perspective on the conditions giving rise to the problem and the implications of its solution. Of central importance in this study are the characteristics of railroad demand and their role in the peak-load problem's solution. Hence the factors determining the level and the elasticity of wheat railroad demand are discussed. In the next chapter these factors are incorporated in a model which is used in Chapter IV to estimate the effects of seasonal rates on wheat.

The Peak-Load Pricing Problem in the Literature of Economics

The literature of economics contains numerous contributions dealing with "the peak-load pricing" problem. Although the problem and its solution as applied to public utilities was discussed at least as early as 1929 (3), the present-day literature date primarily from Steiner's (21) article. The papers by Hirshleifer (7), Boiteau (2), and Williamson (26) are some of the best known representatives of this literature. Boiteux's is interesting primarily because it describes one of the earliest efforts to develop the theory of peak-load pricing in conjunction with its application to the French electricity industry.

The peak-load problem is to optimally price a service when the demand for that service varies periodically over time. Three fundamental conditions are prerequisites in the formulation of the problem. First, the service to be priced must be non-storable; production and consumption must take place simultaneously. Second, demand for the service must shift periodically; that is, the demand must move in a regular pattern. Third, production of the service must involve joint costs. Given these conditions, the peak-load pricing problem is to obtain a set of prices for the service which would result if the market for the service was perfectly competitive.

The joint costs in the problem are typically those associated with production capacity. Once a unit of capacity is added to the old production plant, then this capacity is capable of producing service output in succeeding time periods. Capacity costs are jointly incurred by the output in each of these time periods; this characteristic is called time-jointedness. The pricing problem is to allocate the joint capacity costs among the time periods.

This allocation would pose no difficulties if the demands in all periods were identical; capacity costs would then simply be distributed evenly over all time periods resulting in a set of identical prices. Periodic demand alters this set of prices. Since only demand changes between periods, it is evident that the solution set will in some way depend upon demand. In the solution to the peak-load pricing problem, the price in each period is related to the demand in that and other periods in such a way that joint capacity costs are "correctly" reflected in each period's price; perfect competition is the usual standard of correctness.

If railroad transportation meets the three conditions listed above, then the economic theory of peak-load pricing is applicable to seasonal rail ratemaking. The first condition is always met since the production and the consumption of any transportation service, including rail service, are always simultaneous. As for periodic demand, many classes of railroad traffic do exhibit consistent seasonal patterns. The fact that rail rates have previously remained fixed over the year indicates that these patterns represent shifts of demand between periods rather than shifts along one demand curve. Thus the second condition may hold in some railroad situations. Finally, for the third condition to hold, a cost element associated with supplying rail service must have the characteristic of time-jointedness. Costs of rolling stock and rail plant may exhibit this characteristic; to the extent that they do so, economic theory is applicable to seasonal rail ratemaking.

An elaboration on this last point is necessary because the concept of joint capacity cost is critically important to the application of peak-load pricing theory to rail service. The cost of capacity may be considered to be either joint or common when that capacity produces more than one type of output. The difference is whether or not the production ratios of the outputs are fixed or are variable. A classic example of joint costs are those of processing sheep. The two outputs, mutton and wool, are always produced in fixed ratios to one another.

The processing costs are not solely attributable to either wool or mutton are joint costs. Warehousing capacity costs are common costs. A given amount of warehousing capacity can be used to store either some quantity of A or some quantity of B or mixed quantities of both A and B. Since the ratio of the quantity of A stored to that of B can be altered, the warehousing capacity costs are considered common.

Railroad capacity has elements of both joint costs and common costs. At any given time this capacity can be used to produce transportation service for many classes of commodities so that within any one time period its costs are common. Railroad capacity can also be used to produce service in more than one time period so that between time periods capacity costs are joint. The economic theory of peak-load pricing applies only to situations involving joint costs. In applying this theory to railroad ratemaking, the specification of rail service demand must be such that the capacity costs of supplying that service are joint rather than common.

This implies that the demand relevant for seasonal ratemaking is in effect the demand for railroad capacity. Seasonal rates should be established only if the aggregate demand for capacity by all shippers exhibits seasonality. If the demand for a particular type of freight car exhibits a seasonal pattern, then seasonal rates should be established for all shippers demanding rail service which requires this type of freight car. Any shipper demanding service during the peak time period contributes to the peak and should be charged the peak rates. Within a given commodity class of railroad traffic, it is irrelevant whether a shipper's demand is even throughout the year or only occurs during the periods of peak demand; in either case removing his demand during the peak period reduces the peak demand level. This principle also applies between commodity classes; the railroad shippers of any class of commodity who ship during the peak periods contribute to the peak and should be subject to seasonal rates.

Before examining the specific implications of the three conditions for seasonal ratemaking on wheat, it will be useful to illustrate the peak-load problem's solution as it has been developed in the literature of economics. Consider first the solutions presented by Steiner (21), which are formulated with the simplest assumptions on demand and costs.

In the situation depicted in Figure 2, it is assumed that there are two time periods of equal length in which the demand for output in one period (represented by either the curve D_1 or D_2) is independent of the demand in the other time period.[1, 2] Adding the two demands vertically forms the composite demand curve D_{1+2}. This curve indicates the combined price which would be paid if the indicated output quantity was supplied in each of the two time periods. Since D_1 lies above and to the right of D_2 for all output quantities, the first period is the peak period.

The costs of supplying the output are of two types. First, there is a direct cost associated solely with the production of one unit of output. The costs of such inputs as fuel and labor may fall into this category; each unit of these inputs can be identified with the unit of output which they help to produce. In Figure 2, the direct cost per

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[1]Williamson (26) treats the case of time periods of unequal lengths.

[2]See Pressman (20) and Littlechild (13) for approaches to handling interdependent demands.

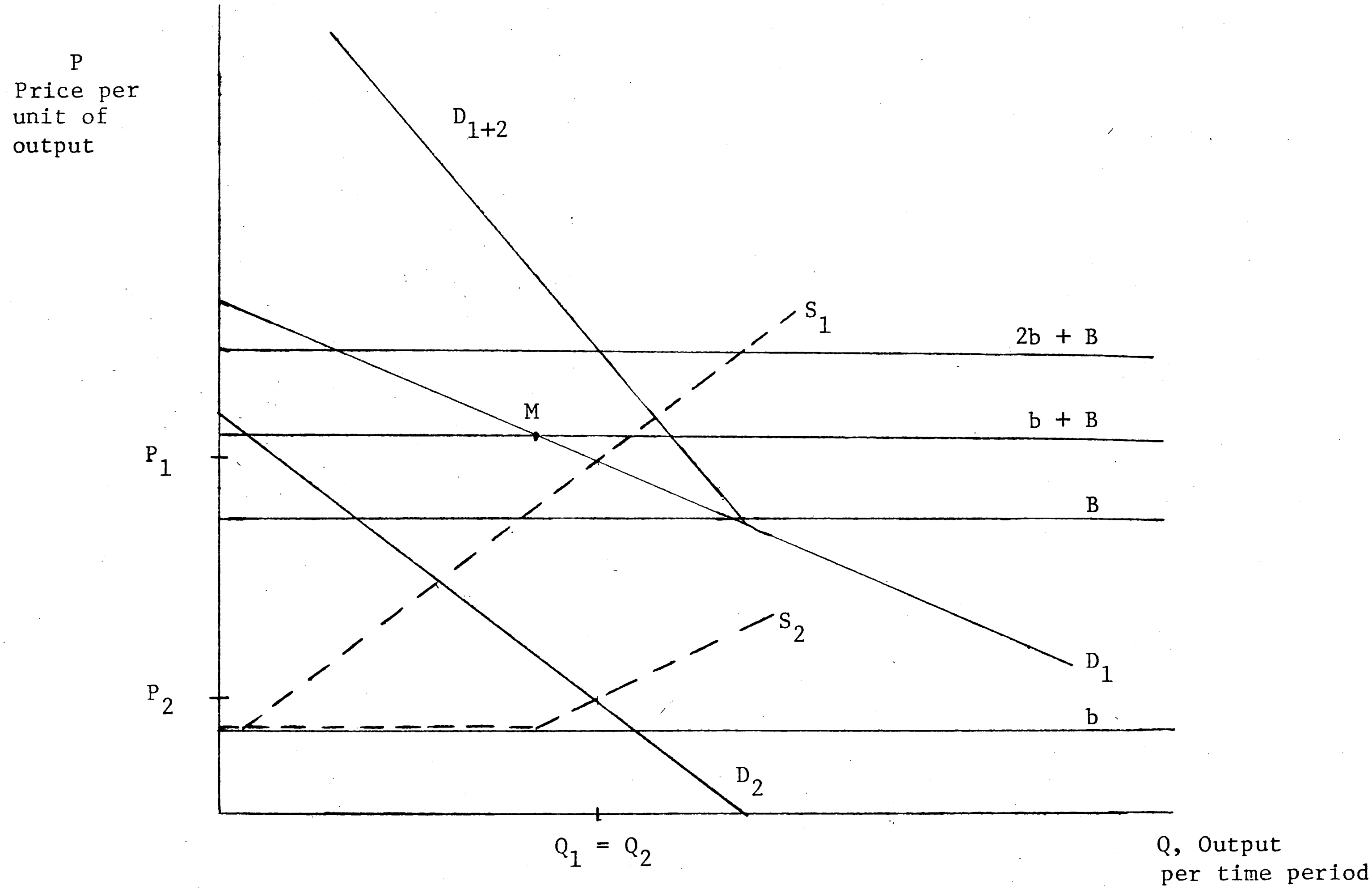

Figure 2. Peak-Load Pricing Problem, First Situation

output unit in either period one or period two is constant over the range of outputs at a level of b.

The second type of cost, also assumed constant over the range of outputs at a level of B per unit of capacity, is the joint capacity cost. This is the cost of adding a unit of capacity capable of producing one unit of output in each of the two time periods. Since the levels of the direct and the capacity per unit costs are assumed constant, the cost curves in Figure 2 represent both average and marginal costs. Adding vertically, the curve 2b + B is the marginal cost curve of producing an output quantity in each of the two time periods.

Note that when one initially starts out producing equal quantities of output in both time periods, the amount 2b + B can be saved only if each period's output is reduced one unit. If only the first period's output is reduced by one unit, the cost saved is b, the per unit operating cost. Since output in the second period remains at its initial level, the same amount of capacity is needed. Though this capacity is not fully utilized in the first period, it is impossible to make use of this unused capacity for supplying demand in the second period.

In a perfectly competitive market, price of the service will be equated with the marginal cost of that service. The difficulty in the peak-load problem is that, due to the presence of joint costs, it is impossible to identify the marginal costs of supplying service in each time period individually. Capacity costs are jointly incurred in both periods. However, it is possible to identify a competitive supply curve in each period. To do this for one period, it is necessary to take into account both the cost information and the demand information of the other time period.

The competitive supply curve for the second time period in Figure 2, S_2, is constructed as follows. To the left of point M, the level of demand in the first time period is great enough that the price in that period more than covers the direct marginal cost b and all of the joint capacity cost B. Quantities of service output in this range would be made available in the second period at a price just covering the operating cost b. No higher price in the second period would be needed since capacity costs are completely covered in the first period. To the left of M, S_2, follows the operating cost curve, b.

To the right of M the level of D_1 falls below the level of b + B. If capacity is to be made available which will supply output quantities to the right of M in both time periods, the price in the second period must cover not only operating cost but also that portion of capacity cost which the first period's price does not cover. Thus to the right of M the supply curve S_2 rises from the cost curve b at the same rate at which D_1 declines. Similarly, a supply curve for the first period, S_1, can also be constructed.

The equilibrium set of prices are those at which the supply curves in each period intersect their respective demand curves. In Figure 2, these prices are P_1 and P_2. The output quantities of each period are identical; $Q_1 = Q_2$. The total amount received by the producer for supplying these quantities, $P_1 + P_2$, is just equal to the marginal cost of supplying the quantities, 2b + B.

If the prices in both time periods were established at the same level, the quantity of output demanded at this price in the first period would always be greater than the quantity demanded in the second period. In the situation depicted in Figure 2, establishing peak-load prices results in equal quantities of service output demanded in both time periods and a greater price in the first period compared to that in the second.[3] While the peak-load solution will always result in a higher price during the period of peak demand, it may not always result in equal quantities of output being demanded in both periods.

In Figure 3, the relationships between demand and supply in each period is such that, at the solution set of prices ($P_1 = b + B$ and $P_2 = b$), the quantity demanded in the first period is greater than that demanded in the second period. Since all of the capacity required by the first period's demand is available for production in the second period, the peak-load solution in this situation does result in unused capacity in the latter period. Peak-load prices will not necessarily eliminate excess capacity in each period; however, they will allow the costs of capacity to be fully recovered when the level of capacity is adjusted to conform with the solution's results.

In the peak-load problems illustrated in Figures 2 and 3, demand in the first period is assumed to be independent of the demand in the second period. The question of the validity of this assumption is of course an empirical one. The establishment of peak-load prices creates price differentials between time periods, and in those situations in which consumers are able to change their purchase patterns in response to the economic incentives created by peak-load prices, the assumption of independent demands may not be justifiable. Unfortunately, relaxing

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[3]This is called the "shifting peak" case by Steiner (21, p. 589) since charging a price in the first period (the peak) equal to b + B and a second period price equal to b will result in the quantity demanded in the first period to be less than that in the second period; the peak shifts to the second period. Figure 3 illustrates Steiner's "firm peak" case.

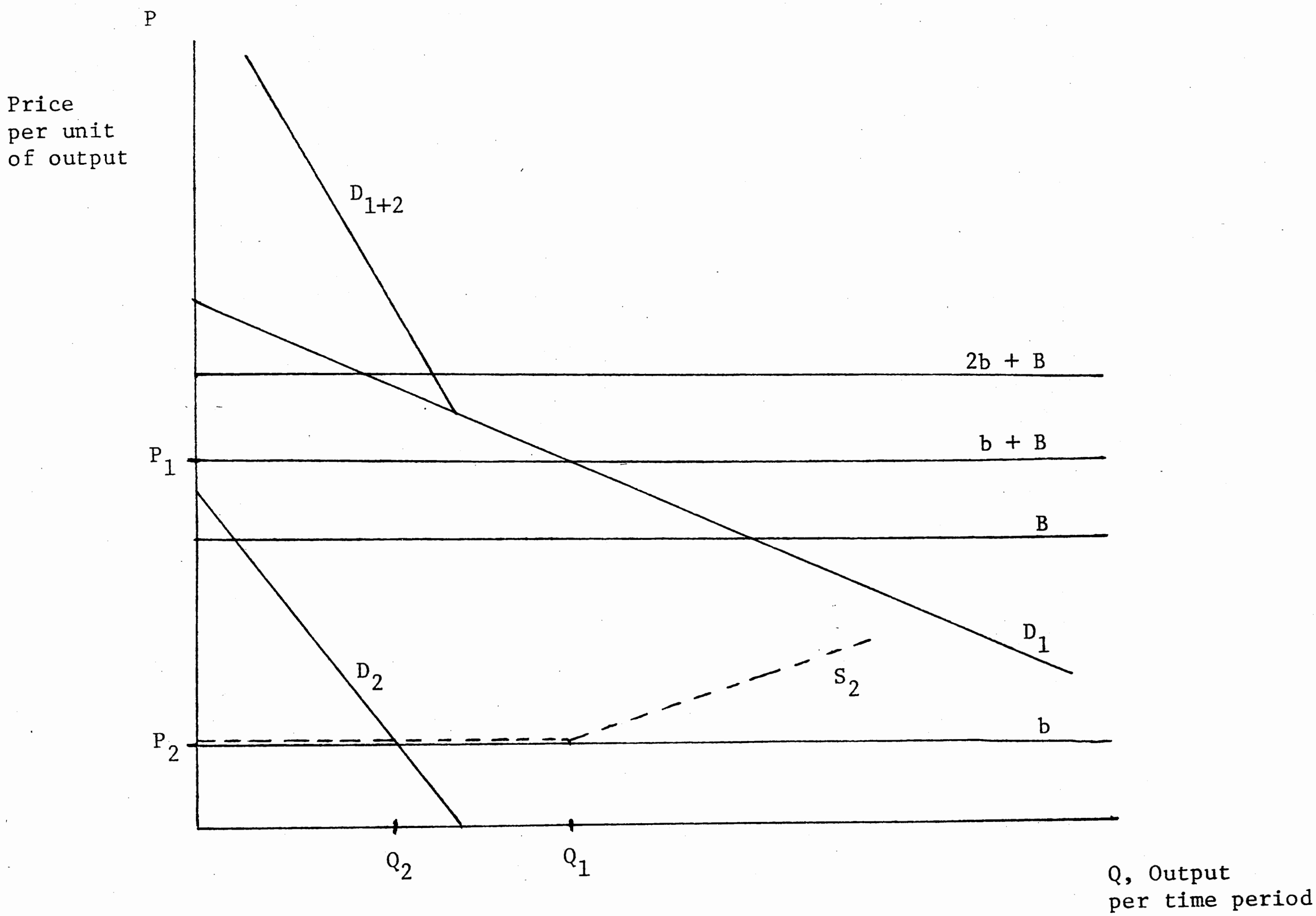

Figure 3. Peak-Load Pricing Problem, Second Situation

this assumption presents difficulties in representing the problem geometrically and in solving it analytically.

Pressman (19) discusses these problems and presents a mathematical formulation of the peak-load problem with interdependent demands. In order to generate a solution with this formulation, a rather restrictive assumption regarding the relationship between demands in different periods must be made.[4] Though this approach cannot be presented geometrically, some idea of the effects of interdependent demands can be gained by considering the situation illustrated in Figure 4.

The position of the demand curve in each period depends upon the price of the output in the other period. Typically the outputs in the periods will be substitutes for one another so that increasing the price in one period will shift the demand curve of the other period upward and to the right. For some of the consumers in the first period, the price differential between periods will be high enough relative to the costs of shifting their purchasing patterns that they will decrease the quantity demanded in the first period (appearing as a shift along that period's demand curve) and will increase the quantity demanded in the second time period (appearing as a shift of that period's entire demand curve).

Initially, the prices in both periods are identical in Figure 4 at the level of P^0. The quantities taken at this price in each period are Q_1^0 and Q_2^0. If the first period's price is then increased to P_1^1, then the quantity of output demanded in this period falls to Q_1^1.

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[4]Pressman's (20, pp. 324-325) approach depends upon the integrability conditions holding for the interdependent demands.

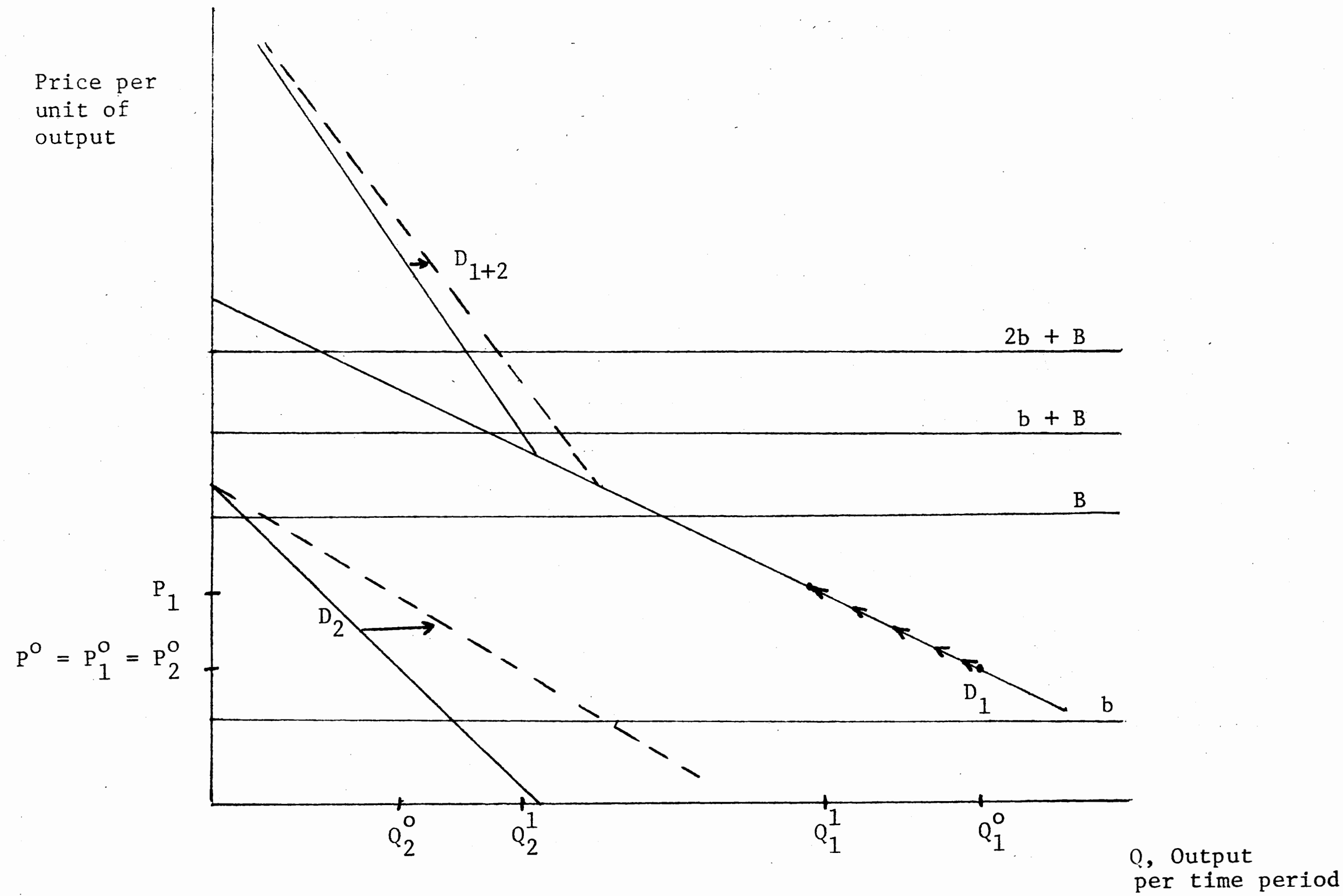

Figure 4. Effects of Interdependent Demand

However, due to the shift in D_2 caused by the decrease in P_1, the quantity demanded in the second period increases to Q_2^1. The shift in the composite demand curve indicates that the final solution may result in a greater amount of capacity than if the demands are independent.

In general, the effects of relaxing the independency assumption are that the price differential between periods is smaller and that there is less excess capacity in the off-peak period than would otherwise be the case with independent demands. Whether or not the interdependent solution's capacity is relatively larger or smaller depends upon the initial price in each period. If the peak period's price needs to be increased, then capacity will be relatively greater than if demands were independent; if the off-peak price needs to be lowered then capacity will be relatively less.

The economic theory of peak-load pricing does provide a rationale for implementing seasonal railroad rates on wheat if the three peak-load conditions hold for wheat rail service. Though wheat traffic may exhibit a seasonal pattern, correct application of peak-load theory to railroad ratemaking requires that a seasonal pattern in the effective demand for railroad capacity be established before implementing seasonal rates. The seasonal pattern of traffic other than wheat may tend to smooth out the demand for capacity, thus negating the need for seasonal rates on wheat.

If the effective demand for railroad capacity does follow a seasonal pattern when all relevant classes of traffic are considered, then theory does indicate that competitive forces will act to create rate differentials between periods. The amount of excess capacity which exists in the off-peak periods due to fixed, non-seasonal rates will be reduced but not necessarily eliminated. Thus the RRRRA's objective of increasing the utilization of the freight car supply is consistent with economic theory.

The desirability of shifting railroad demand from the peak to the off-peak period is not a question which economic theory addresses. However, theory does indicate that such shifts will reduce the magnitude of the rate differential compared to that which will result if demands are independent. The fact that some or all of the shippers affected by the peak period rates might not be able to shift their demand for rail service to the off-peak period does not justify exempting them from seasonal rates. Interdependent demand is an empirical fact affecting the analysis of the peak-load problem but is not a necessary condition for applying the theory.

Finally, the objective of increasing railroad revenues by the use of seasonal ratemaking may or may not be consistent with economic theory. The purpose of peak-load pricing is to allocate joint capacity costs. Theory indicates that peak-load prices set in competitive markets will just cover these capacity costs. In any given railroad situation which meets the three conditions needed for peak-load pricing, moving from fixed rates throughout the year to seasonal rates will increase railroad revenues or decrease railroad capacity (hence capacity costs) or both if the capacity costs are not presently being recovered. Increased railroad revenues may be an indication of price discrimination in railroad rates if railroad capacity costs are being recovered at the present time.[5] The point is that application of peak-load theory to railroad ratemaking requires a thorough analysis of railroad costs as well as railroad demand.

This study does not attempt to analyze railroad costs, so that no conclusion will be reached concerning either where seasonal rates should be set according to economic theory or where they will be set in actual practice. However, by identifying and measuring the most important determinants of railroad demand it will be possible to examine the potential effects of various different sets of seasonal wheat railroad rates on both the railroads and the wheat shippers.

In the following sections of this chapter the principal determinants of railroad demand are identified. First, the factors influencing the individual wheat shipper's demand for transportation service in general are discussed. Important here are the factors determining the wheat marketing pattern over the year. Next, the factors influencing the individual wheat shipper's demand for rail service in particular are examined; especially the influence of relative modal rates. Finally, since the total demand perceived by the railroads is composed of spatially separated individual demands, the aggregation of these individual demands to form the total demand is discussed.

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[5] Steiner (2) argues that price discrimination is present even in the competitive solution to the peak-load problem. For rebuttals to this position, see the article by Hirshleifer (7) and the discussion of this issue in Kahn (12). It is this author's opinion that while price discrimination may be possible, it is not a necessary consequence of applying peak-load theory to railroad ratemaking.

Determinants of Demand for Transportation Service by Wheat Shippers

In order to sell their grain at markets distant from their production locations, wheat shippers must purchase transportation service. Since this service is an input in the wheat production and marketing process, the demand for transportation service is ultimately derived from the final market demand for wheat. The quantity of transport service demanded by wheat producers is thus a function of three prices: 1. final market wheat price; 2. wheat transportation price; and, 3. prices of other inputs in the wheat production process. Together, these prices determine the relative profitability of growing wheat compared to alternative agricultural products. In turn, the relative profitability of cash wheat determines the amounts grown and sold and thus the input quantities, including transportation service, which are used.

Changes in the final market price and the price of other inputs will shift the demand curve for transportation service. On the other hand, changes in the transportation price will result in shifts along the transport demand curve. These latter shifts are determined by what substitutes for transportation are available. Substitutes include changing final market locations, for instance, selling at a more distant market when transport prices decline, and utilizing the wheat on the farm for feed rather than selling it for cash if transport prices rise.

The time patterns of the three prices, wheat price, transport price, and other inputs' prices, will determine the time pattern of transportation demand. Once the wheat is harvested the producer decides when to sell based upon the expected site price of wheat at his location.

Site price is calculated as the final market wheat price minus the sum of transportation, marketing, storing, and opportunity costs; the latter arising from the time value of money. In general, producers will adjust their marketing patterns (i.e., the timing of their sales) to maximize the site price which they will receive.

The establishment of seasonal railroad rates may change both the quantity of transport service demanded and the time pattern of this demand. Increasing harvest period rates will increase the average price of transportation service, thus decreasing the quantity of service demanded; the opposite will occur if non-harvest railroad rates are lowered. Seasonal rates will also change the time pattern of site prices for wheat by introducing a seasonal pattern into the average transport prices. Regardless of how seasonal rates are implemented, any change in the transport demand pattern will be in the direction of increased non-harvest period transport service demanded and decreased harvest period transport service demanded. Increases in harvest period railroad rates will result in movements among the harvest period demand curve to lesser quantities and shifts outward of the non-harvest period transport demand curve.

Determinants of Demand for Rail Service by Wheat Shippers

While the three prices discussed in the previous section determine the demand for transportation service in general, another set of factors determines the demand for rail service in particular. These factors include relative transport modal rates and relative characteristics of modal service quality. Together, these factors influence the wheat shipper's decision on which transportation alternative to use.

The modal alternatives available to producers include own-truck, for-hire truck, rail, barge, and combinations of these. Except for the own-truck alternative, these modes are accessible only through country elevators. Since each mode does not typically serve every final market, the transport decision in reality involves a choice between alternative mode-market combinations. This suggests that final market characteristics may also determine the transport decision, hence railroad demand, of wheat shippers in addition to the relative modal characteristics.

Truck premiums and discounts, protein premiums, moisture discounts, and rebates by regional cooperative elevators to local cooperatives are all examples of differentials in marketing charges between final markets. For the purpose of determining modal demand without considering particular final markets, these marketing differentials may be incorporated into the transport rates of the modes serving each market. In a similar manner, any consistent wheat price differential which exists between final markets may be incorporated into the modal rates to abstract from differences in the transportation alternatives which are not the result of relative modal characteristics.

Transportation service is not homogenous with respect to the quality of service provided by different modes; hence the choice of mode will be influenced by relative service qualities of the transport modes. Characteristics of service quality include the risk of loss or damage of the shipment, the speed of transit, the dependability of receiving the quantity of service requested within a specified time, flexibility in specifying and altering both intermediate and final destinations, and the frequency of service. These quality characteristics can be converted into implicit shipper costs of using each mode; when added to the explicit transportation rate the result is shipper-perceived price of each mode's service.

When final market price differentials and implicit service costs are incorporated into the transport modal prices along with the modal rates, then the relative modal prices are the determinants of modal demand. Assuming that shippers seek to maximize the wheat site price they receive, then the transportation alternative with the lowest price will be chosen. Note that since alternatives are defined to be combinations of modes and final destinations, shippers must include all costs associated with the entire movement when evaluating each alternative's price. For example, the shipper-incurred cost of an alternative involving two modes will include the transport rates of both modes.

For wheat shippers, transport rates tend to be the largest components of transportation prices. Modes with the lowest rates tend to be chosen by shippers minimizing transportation costs. Thus the relationships between modal rates, rate competition, tends to be the primary determinant of the price elasticity of each mode. A high degree of rate competition does not necessarily imply all modes carry the same volume of traffic; it does imply that rate increases by one mode will reduce that mode's traffic volume enough to decrease its revenues. Rate decreases will increase revenues if the new rates undercut those of competing modes to a sufficient degree.

Seasonal rates on wheat could be established either by raising harvest period railroad rates above their present levels or by lowering non-harvest period railroad rates below their present levels. The price elasticity of railroad demand will determine the degree of which wheat traffic shifts to or from the railroad mode. Thus the rate competition faced by railroads in wheat transportation markets will help determine whether seasonal rates can increase railroad revenues.

Aggregate Demand for Wheat Rail Service

Total demand for service faced by railroads is an aggregation of the demands of individual shippers located at spatially separated points. The pattern of rate competition across a region served by railroads tends to divide the region into market areas. Within the railroad market area, the railroad rates are lower than the corresponding rates of competing modes so that shippers in this area tend to choose the railroad alternative. Market area boundaries are those points at which the rates of two modes are equal.

The market area concept can be illustrated by using rate-distance functions for the different modes. These functions relate the rate of a mode from various origins to a destination to the straight line distance between the origins and the destination. Figure 5 shows a hypothetical rate-distance function for both railroad and truck modes. The market area for railroad includes all points at a distance greater than X to the destination. Increasing the railroad rates would be shown by shifting the rail curve upward. This would decrease its market area and the volume of traffic it would carry.

If one were to apply the functions of Figure 5 to a two dimensional area, then the truck market area would be within the circle of radius X around point 0 and the railroad market area would be the points beyond this circle. In the real world, transport rates are related to distance though not in as regular a fashion as in Figure 5. However, enumerating

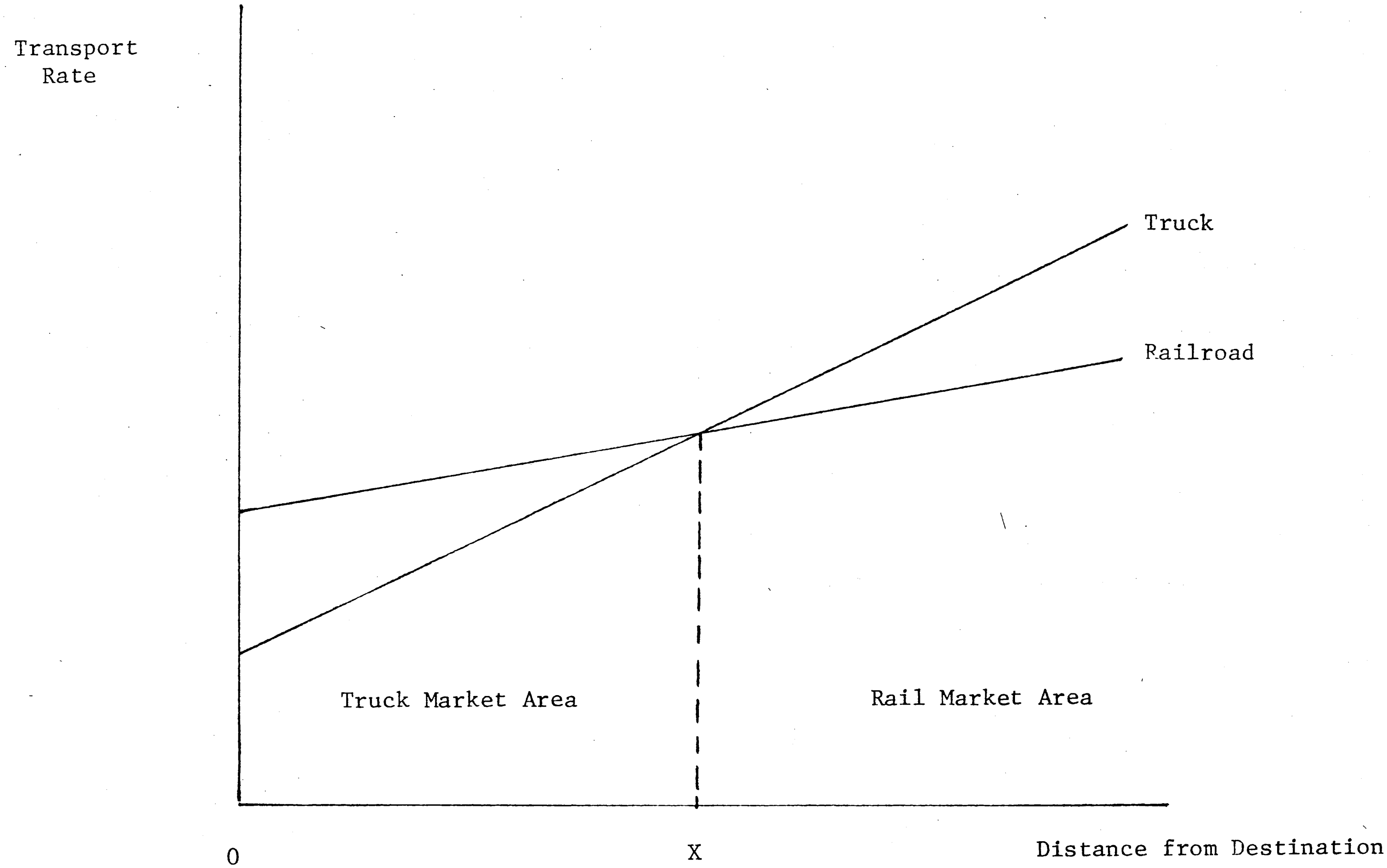

Figure 5. Hypothetical Rate - Distance Functions

each mode's rate at all locations will indicate the areas over which one mode has consistently lower rates than competing modes.

The approach of this study towards measuring the price elasticity of railroad demand is to begin with the rates of each transportation alternative at each location within a region. These, together with the wheat volume at each station, are used to identify the market areas and measure the traffic volume of the railroad mode. Increases or decreases in the railroad rates will shift the boundaries of the railroad market areas, allowing one to measure the changes in rail volume which result from rate increases and modal rate competition.

CHAPTER III

DEVELOPMENT OF THE MODEL

Introduction

The effects of establishing seasonal railroad rates upon the quantity of rail service demanded by wheat shippers was discussed in the previous chapter in terms of shifts of the demand curve and shifts along the demand curve. Shifts of the demand curve take place in the time period in which rates are not changed from their present levels as seasonal rates are implemented. These shifts occur as rail shippers change their wheat marketing patterns in response to the seasonal rate differentials. Shifts along the demand curve take place within the period in which rates are changed. These shifts occur not only as marketing patterns change but also as the presence of rate competition makes other transport alternatives less costly than the one presently used.

The purpose of this chapter is to develop a framework within which the magnitudes of these shifts can be estimated when the present, fixed railroad rates are changed to seasonal rates. In essence, this means measuring seasonal railroad demand. Except in a small number of isolated situations, railroad rates on wheat have not previously been subject to seasonal adjustments. Therefore, there are no historical observations from which seasonal railroad demand can be measured. However, given the present production and marketing patterns of wheat producers, it is possible to estimate the maximum possible shifts which could occur. Since many factors other than transport rates influence the level and timing of railroad demand, the estimates represent the extreme values of the range within which probable changes can be expected to take place.

The following discussion of the model used in this study is composed of three sections. The first outlines the assumptions used of how seasonal adjustments will be implemented on wheat railroad rates. Of importance in this section is the discussion of how seasonal rates will be used with the wheat transit arrangements and the problems this creates for country elevators. The second section describes the procedures used for modeling and estimating the marketing patterns of producers; these patterns determine the level and timing of general transportation demand. In the third section, the transportation decision process is discussed; country elevators use this process to select the transportation alternatives which will be used.

Implementation of Seasonal Railroad Rates for Wheat

It is impossible to know in advance how railroads will attempt to put seasonal rates on wheat into practice. There is no past experience with seasonal ratemaking to draw upon, and the ICC's regulations covering such ratemaking do not contain specific guidelines. In general the seasonal pattern of rates should follow the seasonal pattern of railroad demand. Yet this leaves unanswered some important questions concerning how the rates can be made to follow seasonal changes in demand. What measure of demand will be used to identify a seasonal pattern? Will this measure include only wheat traffic or will it take into account the demands of other commodities? To how large a region will the seasonal adjustments apply? Will railroads act individually or as a group in establishing seasonal rates?

In this study the following assumptions have been made. Seasonal rates on wheat originating within a given region will be established by all of the railroads serving that region. The total volume of wheat railroad traffic, in units of tons or carloads, originating within this region is the measure used to identify the seasonal pattern in the quantity of railroad service demanded by wheat shippers.[1] The volume of non-wheat railroad traffic within the region and the volumes of both wheat and non-wheat railroad traffic outside the region are not considered in establishing the seasonal adjustments on wheat rates within the region. Thus all wheat shippers in the region will experience identical seasonal adjustments in their railroad rates, in terms of the timing and proportional magnitude of these adjustments.

The region selected for this study consists of the forty counties in Oklahoma shown in Figure 6. These counties were selected because the major railroads serving their country elevators allow wheat to be transited at the terminal elevator facilities located at Enid, Oklahoma. Though the panhandle counties are also in Enid's transit area, they were excluded from the study area. Elevators in these counties must handle large volumes of feed grain in addition to the wheat volumes. Thus their wheat storage and transportation patterns are substantially

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[1]For discussion of other measures of railroad demand which could be used to identify seasonal patterns, see the U. S. Department of Transportation (25, pp. 36-40).

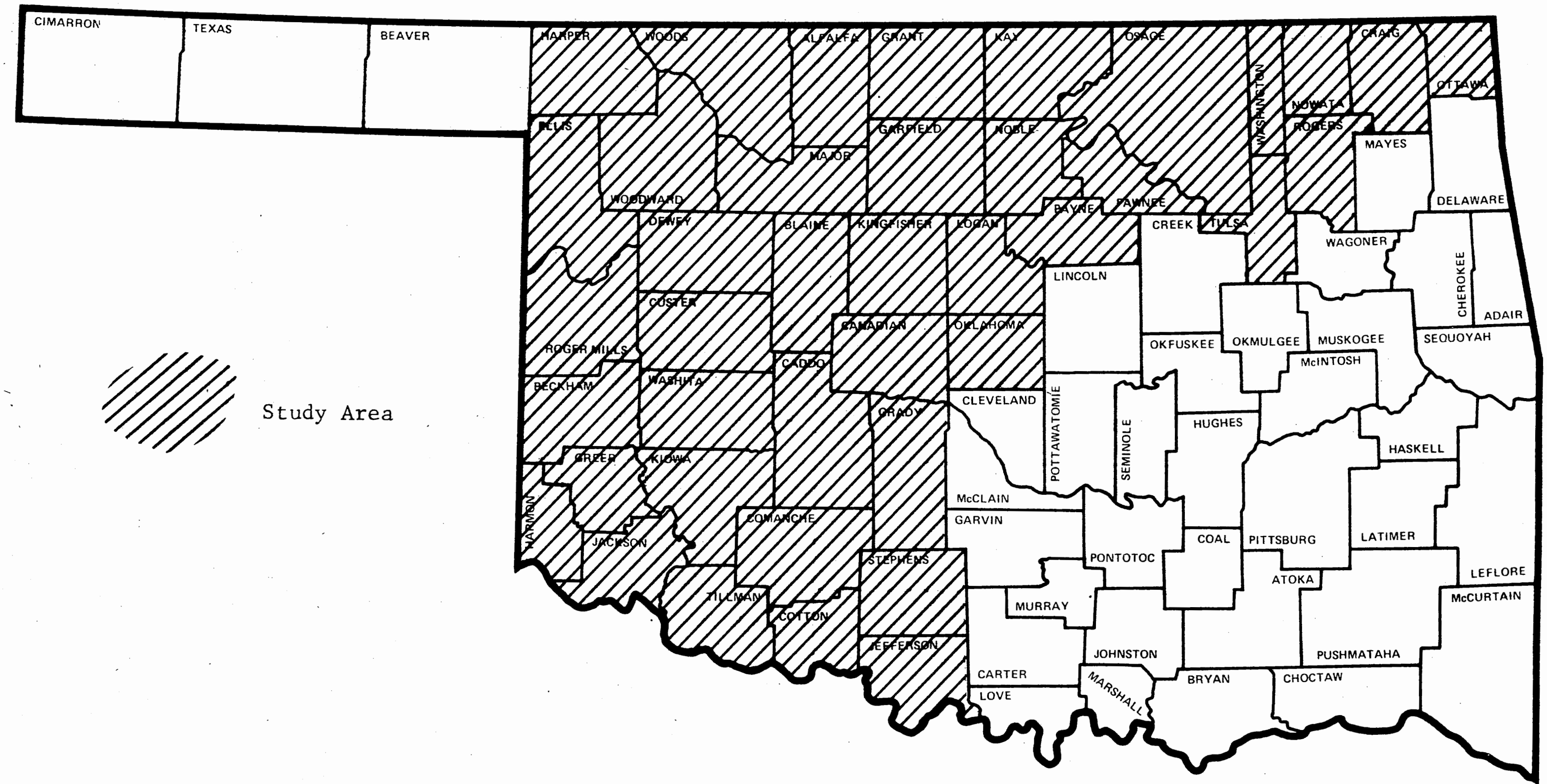

Figure 6. Oklahoma Counties Included in Study Area

different from those of the elevators in the study area which handle only small amounts of feed grains in addition to wheat.

The counties of the study area include most of the major wheat-producing counties of Oklahoma. In 1976 these counties produced 90.1 percent of the state's 151.2 million bushel wheat crop, which is composed primarily of hard red winter wheat (16). The harvest period in this region generally begins around the first of June each year in the southernmost counties; by the first week in July the wheat harvest is essentially complete throughout the entire region.

The year is divided into two periods for establishing seasonal rates (July 1 to July 1). The first period corresponds to the harvest period in the study area; the second period consists of the rest of the crop year after harvest ends. During the second period, it is assumed that any fluctuations of wheat railroad traffic caused by uneven export sales will form no consistent pattern over the years and thus will not influence the timing of seasonal rate adjustments.

Wheat traffic actually begins increasing before harvest starts as country elevators ship carryover wheat stocks into storage at terminal elevators in order to make room for the new crop. However, these traffic increases are generally much smaller than those which occur during the harvest period. Therefore the period of peak railroad rates is assumed to begin at the first of June rather than sometime before that date.

Having divided the year into two rate periods, it is necessary to discuss how transited movements may be priced if seasonal rates are established. When both hauls (from origin to stopover and from stopover to final destination) of a transited shipment take place within one of the time periods, then the railroad rate applicable to that shipment will clearly be the rate in effect during that time period. However, when a country elevator transits wheat at a terminal facility during one time period for storage until the other period, a question arises as to which period's rate will apply to the shipment.

Under the present transit arrangements, a transited shipment is assigned two rates when the first haul in made. The first rate is the short-haul rate from the shipment's origin to the stopover point, which is paid at the time of the first haul. The second rate is the through rate from the origin to the final destination. The unpaid balance of the two rates is paid at the time of the second haul.[2] The shipper eventually ends up paying only the through rate.

Note that under the present transit arrangements the through rate on a transited shipment is assigned at the time of the first haul. The through rate on this shipment remains at that level if rail rates are increased or decreased anytime within one year after the first haul. Thus there appears to be a precedent for handling seasonal rates on transited movements in the same manner. In this study, the through rate is the seasonal rate in effect during the time period in which the first haul takes place.

This method of handling the through rates on transited shipments when seasonal rates are implemented will cause problems for country elevators storing wheat at the terminals during harvest. In order to quote the site price of wheat to producers which they will receive, a country elevator takes the final market price and subtracts from it the

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[2]A negative balance is refunded by the railroad to the shipper.

cost of transportation, handling and marketing charges, and any storage fees incurred up to that time. If this elevator has moved by rail transit some of the wheat it received at harvest into storage at a terminal elevator, then this wheat has been assigned the high, harvest period railroad rate. The problem for the elevator is which through rate, harvest period or non-harvest period, to use in quoting site prices to producers on terminal stored wheat during the non-harvest period.

The elevator has at least three alternatives from which to choose when quoting the site price of wheat during the non-harvest period. First, it could simply use the non-harvest railroad rate. This would result in a loss sustained by the elevator amounting to the seasonal rate differential at its location times the volume of wheat it had stored at the terminal elevator during harvest. This loss represents the economic incentive created by seasonal rates for the elevator to build additional storage capacity. Every producer delivering wheat into the country elevator during harvest would perceive this rate differential as an economic incentive to store the wheat until after harvest instead of selling it during harvest.

The second alternative is for the country elevator to continue using the harvest period through rate when the non-harvest period begins. This rate is used until all out-of-house wheat stocks are sold;[3] for the in-house wheat stocks the site price is quoted using the non-harvest period rate.[4] The country elevator in this case sustains no

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[3]Out-of-house stocks refer to wheat held at a terminal elevator in storage for a country elevator. In-house stocks refer to wheat held in storage at the country elevator itself.

[4]This assumes that out-of-house wheat stocks are sold first by the country elevator in order to maximize storage revenues on its in-house stocks.

transportation losses due to seasonal rates. Only some of the producers, the last ones to sell in the non-harvest period, perceive an economic incentive created by seasonal rates to store instead of sell during harvest. If the elevator uses the non-harvest period rates for quoting site prices on wheat received after harvest, then the producers who receive the harvest period railroad rate when they sell their elevator-stored wheat after harvest will perceive the seasonal rate differential as an economic incentive to build new on-farm storage or utilize presently unused farm storage.

The third alternative is for the elevator to use an average through rate to quote site prices after the harvest period. This average is composed of the harvest rate and the non-harvest rate weighted by the volumes of out-of-house stocks and in-house stocks of wheat held at the beginning of the non-harvest period. As with the second alternative, the elevator will sustain no transportation losses due to seasonal rates using this alternative. All producers will perceive identical economic incentives created by seasonal rates to store their wheat at the country elevator (or at the terminal elevator) during the harvest period rather than sell it. However, this incentive is less than the seasonal railroad rate differential since the weighted average rate is greater than the non-harvest period rate.

If the third alternative is used, all producers will perceive an economic incentive created by seasonal rates to store their wheat in on-farm storage rather then to either sell it during harvest or store it at an elevator during harvest. The magnitude of this incentive is equal to the full seasonal rate differential for these producers who presently sell their wheat during harvest. For those who store their wheat at an elevator during harvest, this incentive is equal to the difference between the weighted average rate and the non-harvest period rate. It is assumed in both cases that the country elevator will use the non-harvest period through rate when quoting the site price to producers delivering wheat to the elevator during the non-harvest period.

If the country elevator does not have to transit wheat at a terminal elevator for storage during the harvest period, then is will not have to contend with the above problem of what rate to use for quoting site prices during the non-harvest period. In this case, all producers will perceive an economic incentive, creased by seasonal rates and equal to the seasonal rate differential, to store their wheat at the elevator instead of selling it during harvest. There will be no incentive created by seasonal rates to store on the farm rather than in the country elevator, or to build new country elevator storage, since there is already excess storage capacity at the country elevator.

However, if the country elevator ships wheat by rail transit into storage during harvest, it will be faced with the question of how to quote site prices on this wheat when the producers decide to sell. It is evident from examining the three possible pricing schemes that the elevators' choices will have differing impacts upon which producers perceive the economic incentives to store rather than sell during harvest, and upon the magnitudes of these incentives which are created by seasonal rates.

For the purposes of this study, it is assumed that country elevators in this study area elect to use the first pricing alternative discussed above. That is, the local site price quoted to producer in a given time period is calculated using the seasonal railroad rate in effect at that time. This will result in transportation losses caused by seasonal rates for those country elevators lacking sufficient storage capacity during the harvest period.

Production and Marketing Patterns Within the Study Area

Movements of Wheat From Country Elevators

The establishment of seasonal railroad rates on wheat will most directly affect the choice made by country elevators between using the railroad mode and using some other transport mode. The model discussed in the next section of this chapter describes the process by which elevators make this transportation decision. Inputs to this model include not only the rates of the transport alternatives at each elevator location within the study area, but also the quantities of wheat at each location which are associated with the transportation decisions. This section discusses how these quantities are estimated and how they are used in the model.

Since the year has been divided into two periods for establishing seasonal rates, it is necessary to know the quantity of wheat moving out of each country elevator in each of the time periods. During the harvest period some of the wheat moving out of the country elevators has been sold by the producers and is moving to a final market.[5] Other wheat moving out of country elevators during harvest goes to terminal elevators for storage until after harvest; this is wheat which producers

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[5]This assumes that the country and terminal elevators do not hold wheat on their own accounts.

wish to store but for which the country elevators have no storage capacity available. During the non-harvest period wheat moving out of country elevators has been sold by producers and is moving to final markets.[6] Thus, at each country elevator, the volumes of three separate movements must be estimated: the two movements during the harvest period to a final market and to a terminal elevator, and the movement during the non-harvest period to a final market.

The terminology to be used in the following discussion is given below. The subscript "c" indicates the particular country elevator located at point c within the study area.

$M1_c$ = Volume of wheat shipped during the harvest period to a final market;

$M2_c$ = Volume of wheat shipped during the harvest period to a terminal elevator for storage until after the harvest period;

$M3_c$ = Volume of wheat shipped during the non-harvest period to a final market;

V_c = Volume of wheat received during the year beginning June first;

α_c = Proportion of V_c received during the harvest period, $0.0 \leq \alpha_c \leq 1.0$;

β_c = Proportion of $(V_c * \alpha_c)$ sold during the harvest period, $0.0 \leq \beta_c \leq 1.0$;

St_c = Volume of $(V_c * \alpha_c)$ stored at c from the harvest period until the non-harvest period;

St^*_c = Storage capacity net of working space and inventories of grains other than wheat held on June first; and,

CS_c = Volume of wheat carryover stocks held on June first.

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[6] See note 5 in this chapter; also, it is assumed that movements of country elevator carryover stocks of wheat into terminal elevators immediately prior to harvest are negligible enough not to affect the peak rating period for railroad rates.

At country elevator c, the volume of wheat of the first movement, $M1_c$, is calculated from the equation:

$$M1_c = V_c * \alpha_c * \beta_c \ . \qquad (1)$$

This assumes that none of the carryover stocks of wheat, CS_c, will be sold by producers during the harvest period. Additionally, it is assumed that no country elevator will retain wheat on its own account after a producer sells it. The second assumption is made not only because it simplifies the model and its analysis but also because of the difficulty in obtaining information from private elevators on their holding and marketing of elevator-owned wheat.

The volume of the second movement, $M2_c$, depends upon the amount of storage capacity at c available to store the new crop relative to the amount of wheat producers wish to store at the elevator during the harvest period. The amount of available storage capacity is given by the expression $[St_c^* - CS_c]$; the amount of wheat producers wish to store at the elevator is given by the expression $[V_c * \alpha_c * (1 - \beta_c)]$.

If the relationship holds that:

$$St_c^* - CS_c \geq V_c * \alpha_c * (1 - \beta_c)] \ , \qquad (2)$$

then elevator c has sufficient storage capacity available at harvest to store all wheat which producers wish to be stored in an elevator. In this case the elevator will not have to ship wheat into storage at a terminal elevator during harvest so that,

$$M2_c = 0; \text{ and } St_c = V_c * \alpha_c * (1 - \beta_c) \ . \qquad (3a)$$

However, if (2) does not hold and the elevator does not have sufficient storage capacity, then the following is true.

$$M2_c = [V_c * \alpha_c * (1 - \beta_c)] - [St_c^* - CS_c]; \text{ and} \qquad (3b)$$

$$St_c = St^* - CS_c \ .$$

Hence the volume of the second movement is the difference, if any, between the volume of wheat that producers wish to store in commercial storage at harvest and the volume of storage capacity available at the country elevator for storing this wheat. It is assumed that all country elevators will completely fill their available storage during the harvest period before they begin to ship wheat into storage at a terminal elevator since by doing so that will maximize their storage revenue.

Finally, the volume of the third movement, $M3_c$, which is wheat moving from the country elevator to a final market in the non-harvest period, is calculated with the equation:

$$M3_c = CS_c + V_c * (1 - \alpha_c) + St_c \; . \qquad (4)$$

Note that as a consequence of (4), no provision is made for the volume of carryover stocks of wheat into the next year. When the expressions for $M1_c$, $M2_c$, and $M3_c$ are summed, the result is $(V_c + CS_c)$, indicating that in this model the total volume of wheat which is shipped out of the country elevator, c, over the entire year is equal to the volume of wheat which it receives from producers during the year plus the volume of wheat which it held as carryover at the beginning of that year's harvest period.

Since the establishment of seasonal railroad rates on wheat may change the marketing actions of producers, two adjustments have been added to the above procedure for calculating the three movements from each country elevator. The first concerns the volume of wheat which producers sell during the harvest period. Seasonal rates will increase the economic attractiveness of selling wheat during the non-harvest period relative to the harvest period; hence if their establishment changes producers' marketing actions at all, it will tend to decrease the volume of wheat sold by producers during the harvest period (that is, $M1_c$ will be decreased). This is incorporated into the model by placing another variable, γ, into equation (1) to make it:

$$M1_c = V_c * \alpha_c * \beta_c * \gamma \ . \tag{5}$$

The other equations are also modified by multiplying β_c by γ wherever β_c appears.

This new variable, which may take on values from 0.0 to 1.0, is the proportion of the original amount of wheat that was reported to have been sold by producers during harvest without seasonal rates which will continue to be sold during the harvest period after seasonal rates are established. For example, a "γ" equal to 1.0 can be used in the model to simulate producers continuing to sell the same volume of wheat at harvest as was originally estimated. A "γ" equal to 0.0 in the model would indicate that producers do not sell any wheat at harvest.

The second adjustment concerns the location at which producers store their wheat. In equation (4) the expression $V_c * (1 - \alpha_c)$ represents the volume of wheat that is received by country elevator c during the non-harvest period. This wheat must come from on-farn storage. Any on-farm storage capacity which is not already being used for storing cash wheat, seed wheat, or other grains could be used to store additional cash wheat by producers; this would tend to decrease the quantity of wheat stored in commercial storage facilities. Such a decrease would be important at those elevators which must ship wheat by a railroad during the harvest period into storage at a terminal since this wheat will take the higher, harvest period railroad rate.

The addition of a new variable, $OFSC_c$, representing the unused amount of on-farm storage capacity of the producers delivering wheat to country elevator c, into equations (3) and (4) of the model enables one to decrease the volume of the second movement ($M2_c$) and increase the volume of the third movement ($M3_c$) by up to this amount.

Two things should be noted about these two adjustments. First, both must be applied equally at each of the country elevators in the model. That is "γ" is identical for each elevator; and, if the use of OFSC at one country elevator is allowed, it must be allowed at all country elevators.[7] Second, these two adjustments are inputs into the model and are not influenced or determined by the model's other inputs or its outputs. The level and structure of the seasonal railroad rates which are used in the model bear no relationships within the model to these adjustments.

The time pattern of wheat transportation rates is only one of the many factors which determine the decisions by producers of when to sell their wheat. Attempting to incorporate within the model the relationship between this pattern of rates and the marketing actions of the producers at each of the country elevators would not only add a great deal of complexity to the model but would also present very difficult problems with data collection. Therefore the approach taken in this study with regard to the response of producers to seasonal railroad rates is to estimate the maximum possible changes which could occur in the marketing actions of producers and to estimate the sensitivity of the model's results (railroad traffic volumes, revenues, etc.) to these changes.

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[7]In any one solution, "γ" is identical for all locations. The model can be analyzed using different values of "γ".

One affect of the establishment of seasonal railroad rates on wheat not dealt with explicitly within the model is the possibility of an increase in capital investment in storage capacity by either producers or country elevators. Given an expected level of demand for commercial storage, a country elevator decides whether or not to invest in additional storage capacity based upon a comparison of the added revenues and savings from this capacity with the added costs of providing storage service. The costs include those of building, operating, and maintaining the new capacity; the revenues include not only those from the storage fees charged to producers but also any savings on transportation rates made possible by the establishment of seasonal railroad rates. Recall that transportation losses will occur at those elevators which must ship wheat into storage at a terminal elevator during the harvest period due to a lack of sufficient storage space at that country elevator. If the elevator cannot cover its transport loss by passing it on to its producers (see the last two pricing alternatives for elevators discussed in the first section of this chapter), then that elevator may either absorb the loss through reduced profitability or it may eliminate the loss by building additional storage capacity.

The establishment of seasonal railroad rates on wheat may increase producers' demands for commercial storage and result in transport losses at those country elevators with insufficient amounts of storage capacity for those demands. Whether or not the elevators build additional storage will depend not only on their ability to pass the transport losses on to the producers but also on the amount of the increase in storage demand that they experience. For the reasons already stated above, changes in the marketing actions of producers, thus the increases in storage demand, that result from seasonal railroad rates have not been explicitly modeled. However, it is possible to obtain estimates from the model of the maximum amount of economic incentives to build additional storage capacity which will be generated by seasonal railroad rates.

For the producers, seasonal railroad rates may induce investment in on-farm storage capacity primarily if such rates make it more profitable (i.e., result in a higher site price at the farm) to store wheat on the farm and to ship it directly to a final market, thus bypassing the country elevator. The economic comparison to be made in this case is between the cost of using commercial storage with railroad transportation and the cost of using on-farm storage with some form of truck transportation (either for-hire or farm-owned trucking). Again, in order to simplify the model and the data requirements, no provision is made for increasing the amount of on-farm storage capacity within the model.

Collection of Data for Estimating $M1_c$, $M2_c$, and $M3_c$

Questionnaires were sent to each country elevator in the study area requesting the information needed to estimate the volume of each of the three movements, M1, M2, and M3.[8] In those cases in which a private or a cooperative firm operated more than one elevator, a single questionnaire was sent to the main elevator requesting information on the main

[8] A list of the country elevators located in the study area was obtained from the Farmers Cooperative Grain Dealers Associations of Oklahoma (5) and the Oklahoma Grain and Feed Association (18).

and branch elevators together. These questionnaires, a copy of which is shown in Appendix B, were sent on March 2, 1977, with a secondary mailing sent to those who had not responded by March 21, 1977.

Since transportation rates are quoted for locations rather than for the individual firms at those locations, the country elevators in the study area were grouped into 195 locations, at each of which was located one or more elevators. For 119 of these locations, responses to the questionnaires were received from all of the elevators. For 19 other locations, some responses were received but at least one elevator failed to answer at each location. No responses were received from the elevators at 57 locations.

At each location with a complete set of questionnaire responses, the individual elevators' data were aggregated together to obtain estimates for V_c, α_c, β_c, St_c^*, CS_c, and $OFSC_c$, relevant for each location as a whole. For the locations at which there were partial or no questionnaire responses, estimates of the above variables had to be generated using both the data that was available from the responses and data available from secondary sources. The discussion below outlines the procedures used to generate these estimates.

Estimates for V_c, the volume of wheat received during the year starting with the harvest period, were generated first. On county highway maps, market areas were drawn around each of the 195 locations. A market area is that region within which the country elevators at the location draw wheat from producers. Boundaries between market areas are formed by points equidistant in road milage from each of two adjacent locations. It was assumed that producers deliver their wheat to the closest country elevator and do not ship wheat directly to a final market, to a terminal elevator, or to a more distant country elevator.[9]

Next, the amount of wheat grown for cash sales in each county was estimated. Wheat production by counties for 1976 was obtained from the Oklahoma Crop and Livestock Reporting Service (16). From these county production figures was subtracted an estimate of the wheat seed used in the next year's plantings. Seed usage was calculated using the number of acres planted in 1977 and an average seeding rate (bushels per acre) for each county.[10] It was assumed that producers obtain seed wheat from their own last year's wheat crop (or from a neighbor's located in the same market area) and that this wheat is stored entirely in on-farm storage from the harvest period until planting in the fall. These seed usage figures were also used later in calculating the amount of unused on-farm storage capacity.

The volumes of wheat received at those locations with complete sets of questionnaire responses from the country elevators were subtracted from the appropriate county total (that is, the volume of wheat actually reported to have been received during 1976 at a location whose market area was included in one county was subtracted from that county's cash wheat production figure) to arrive at the volume of wheat sold for cash

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[9]Several minor exceptions are made. First, producers located closer to Enid or Catoosa than to any other location are assumed to deliver their wheat to these terminal facilities directly. Second, the presence of flour mills at Blackwell, Oklahoma, and Okeene, Oklahoma, which draw wheat from producers in their immediate vicinity, means that these producers do deliver wheat directly to a final market. Estimates of the wheat volumes received by these flour mills from producers were obtained from the mills and were netted out of the total wheat volume received at each of these locations.

[10]Wheat acres planted in 1977 were obtained from the Oklahoma Crop and Livestock Reporting Service (17). Seeding rates were obtained from the Oklahoma State Agricultural Experiment Station (19).

in each county. This volume was then allocated among those locations with partial or no responses whose market areas include parts of that county. The allocation in each county was based upon the size of each location's market area contained in that county relative to the market areas of all locations contained in that county. The primary assumption is that the production of wheat in each county is homogeneous throughout that county's area. The end result was that for each of the 195 locations, the volume of wheat received during the 1976 crop year were available either directly from the questionnaire responses or indirectly from the above procedure.

The combined storage capacities of the elevators at each location, if not available from the questionnaire responses, were obtained from the two directory lists used for identifying the country elevators within the study area (see footnote 8).

The proportions, α_c and β_c, for those locations with partial responses were assumed to be the same as the percentages in the responses which did come from elevators at those locations. For those locations at which no country elevator responded to the questionnaire, estimates for α_c and β_c were obtained by using the proportions from the nearest location which did have responses or by averaging the known proportions at two or more locations adjacent to the unknown location.

At this point it was necessary to estimate the working space, the stocks of grains other than wheat held on June first in 1976, the stocks of wheat held on June first in 1976, and the total amount of on-farm wheat storage for those elevators which did not respond to the questionnaire. From the above calculations and from the directory listings, estimates for the unknown country elevators were available for V_c, α_c,

β_c, the total storage capacity, the type of ownership (private or cooperative), and the region within the study area where each elevator was located. From the set of complete data obtained from the questionnaire responses, equations relating each of the unknown variables (working space, on-farm sotrage capacity, etc.) to several of the known variables (V_c, α_c, etc.) were estimated.[11] Using these equations, values of the working space, the grain stocks, the wheat stocks, and the on-farm storage capacity for those elevators from which there was no response were estimated. For locations with two or more elevators, the estimated values for each elevator were added to obtain the values of the missing variables.

The estimates of the stocks of grains other than wheat held on June first and of the working space were subtracted from the total storage space to obtain an estimate of St_c^*. The estimate of the stocks of wheat held on June first was an estimate of CS_c.

Finally, in order to obtain estimates of the amount of unused on-farm capacity, $OFSC_c$, at all locations, the total amount of on-farm storage capacity at each location, obtained either from the questionnaire responses or from the equation estimated for the nonresponding elevators, was used. From this capacity was subtracted the volume of wheat received after harvest at that location $[V_c * (1 - \alpha_c)]$ and the volume of wheat seed stored on the farms within that location's market area. The latter was estimated for each location by allocating the estimated amount of seed usage in each county among those locations whose market areas

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[11] The "maximum R^2 improvement" technique of the Statistical Analysis System was used for these estimation (1). See Appendix C for the estimated equations.

included parts of that county. The allocation was based on the relative amount of the county included in each market area compared to the total area of the county. If it is assumed that producers used this storage capacity only for cash wheat and seed wheat, then the estimate of $OFSC_c$ is the additional amount of wheat which could have been stored on the farms during that year.

The above discussion describes the procedures used for estimating the values of the variables needed to calculate $M1_c$, $M2_c$, and $M3_c$ from equations (1) to (4). With the resulting volume data set, it is possible to use the 1976 production and marketing volumes with the transportation model, and to adjust these volumes to take into account decreased producer selling during the harvest period and/or increased wheat storage at the farm level.

Tables I and II summarize the aggregate amounts of storage capacity in the study area and the aggregate volumes of wheat production and marketing.

Modeling the Transportation Decisions Made by Country Elevators

With the year divided into two parts, the harvest period and the non-harvest period, the preceding section discusses the procedures used to calculate the volumes of three wheat movements at each of the locations in the study area. For each movement, the country elevators at each location must decide upon the transport mode to use and the desination to go to. The purpose of this section is to outline how this transportation decision is modeled in this study.

TABLE I

AGGREGATE STORAGE CAPACITIES IN THE STUDY AREA

		1976 (1000 bu.)
	Country Elevators	
1.	Total storage capacity minus working space and stocks of other grains on June 1 (St_c^*)	84,621.0
2.	Carryover stocks of wheat held on June 1	21,390.9
3.	Storage capacity available for the new crop on June 1	63,230.1
	On-Farm Storage	
4.	Total on-farm storage capacity	27,973.2
5.	Storage used for seed	6,406.0
6.	Storage used for cash wheat	7,136.8
7.	Unused on-farm storage capacity	14,430.4

TABLE II

PRODUCTION AND MARKETING WHEAT VOLUMES AGGREGATED OVER THE STUDY AREA, 1976

	1976 (1000 bu.)
1. Wheat sold during the harvest period ($\sum_c M1_c$)	23,785.6
2. Wheat sold during the non-harvest period from the country elevators:	
a. Stored in the country elevators	77,323.4
b. Stored on the farms	7,136.8
Total ($M3_c$)	84,460.2
3. Wheat shipped to terminal elevators during the harvest period for storage ($M2_c$)	41,672.7
4. Total cash wheat production plus carryover wheat stocks	149,918.5

Before discussing specific details of the decision model, it will be helpful to give a brief account of it in general. For each movement of wheat for which a transport decision must be made, it is assumed that the country elevator is faced with a limited set of transportation alternatives from which to choose. Each alternative consists of the particular mode (or modes) used to affect the movement, the final destination of the movement, and the transport rate. This rate is the price spread between the final market price at the Texas Gulf ports and the elevator's local site price if that transport alternative is chosen. The decision rule for choosing between the alternatives within each set is to select that alternative with the lowest transport rate (which will maximize the local site price). As will be discussed below, the aggregate volume of trucking over the entire study area can be limited in the model.

The Sets of Transportation Alternatives for $M1_c$, $M2_c$, and $M3_c$

The first movement of wheat from each station, M1, represents the wheat which producers have sold during the harvest period and which must be moved out of the country elevators to a final market during that period. For this movement, five transport alternatives are available at each location:

1. Truck the wheat to the terminal facilities at Enid, Oklahoma, from whence it will be trucked to the Texas export ports;
2. Truck the wheat to the terminal facilities at Ft. Worth, Texas, from whence it will be trucked to the Texas export ports;
3. Move the wheat on the rail transit privilege through the terminal facilities at Enid, Oklahoma, to the Texas export ports;

4. Truck the wheat to the terminal facilities at Catoosa, Oklahoma, from whence it will be barged either to the export port at New Orleans, Louisiana, or to flour mills in the southeastern parts of the country; and,

5. Truck the wheat directly to the Texas export ports.

Under each alternative, the wheat leaves the country elevator during the harvest period.

For the second movement of wheat at each location, M2, which is the wheat which must be moved during the harvest period to a terminal elevator for storage, only the first three of the above alternatives are available to choose from. Neither the terminal facility at Catoosa nor the terminal facilities at the Texas ports have sufficient storage capacity to store wheat from the harvest period until the non-harvest period. Hence only alternatives which result in the wheat moving into Enid or Ft. Worth are considered for this movement of wheat. As is the case for the first movement, under each of the alternatives for the second movement the wheat leaves the country elevators during the harvest period; however the wheat volumes of M2 leave the terminal facilities in the non-harvest rather than harvest period.

All five of the above alternatives are again considered for the movement of wheat from the country elevator during the non-harvest period, M3. The only difference between this set of alternatives and that for M1 are the rate levels; those of the former are the non-harvest period rate levels and those of the latter are the harvest period levels.

There are several points concerning the five alternatives which need to be discussed. First, 23 locations have no railroad service and cannot consider alternative three. For all but one of these locations, it is less costly to choose one of the four remaining alternatives than to ship wheat by truck to the nearest location with railroad service and to rail it from there.

Second, it has been assumed that railroad shipments from country elevators will transit at the terminal facilities at Enid, Oklahoma. In addition to the 23 locations which are without rail service, there are also 20 locations that do have rail service but cannot transit at Enid. However, all of these locations can transit at Ft. Worth so that alternative three may be considered as moving the wheat by a railroad through the Ft. Worth terminal facilities rather than through Enid.

Third, it is assumed that all wheat flat-trucked into Enid or Ft. Worth (alternatives one and two respectively) is trucked to the Texas export ports from those terminals. This assumption is made because the truck rate from each of those terminals to the export ports is typically less then the corresponding railroad rate from that terminal to the ports.

Fourth, although some of the wheat going into the terminal facilities at Enid or Ft. Worth actually moves from these terminals to domestic flour mills, the price paid to the country elevator is the Gulf bid price minus transportation charges from that elevator to the Gulf. The exceptions to this occur when, in order to obtain a specific quality of wheat to fill a domestic mill's order, the terminal facility offers premiums to country elevators for certain grades of wheat. However, since the timing and amount of these premiums are highly variable and since the distribution of the different grades of wheat among the country elevators would be very difficult to obtain, no attempt has been made to incorporate such premiums into the model. From the standpoint of each country elevator in the model, the final destination for all of its wheat is the export market at the Gulf.

Rates for the Transportation Alternatives

Corresponding to each transportation alternative for each of the three movements of wheat is a transport rate representing the difference between the wheat bid price at the Gulf export ports and the local site price at each country elevator's location. For the first two alternatives, trucking to Enid and trucking to Ft. Worth, this rate is composed of two parts. The first part is the truck rate from the country elevator to the terminal's location and the second part is the wheat bid differential between the price paid for wheat delivered at the Gulf and the price paid for wheat delivered by truck to that terminal. The rate on the third alternative is the through railroad rate from the country elevator to the Gulf ports. The rate on the fourth alternative also has two parts: the truck rate from the country elevator to Catoosa plus the bid differential between the Gulf wheat price and the price paid for wheat delivered at Catoosa. The rate on the fifth alternative is simply the truck rate from the country elevator to the Gulf ports.

The above rates and bid differentials were obtained from several sources. Truck rates for alternatives one and two were estimated using the rate-distance relationships reported by Johnson and Mennem (11).[12] For each location in the study area, the highway milages from that location to Enid, Oklahoma, and Ft. Worth, Texas, were obtained from state highway maps. Using these milages in the appropriate rate-distance function generated estimates for the truck rates on wheat from each location to Enid and Ft. Worth. The bid price differentials for alternatives one and two were obtained from the publication Market News and were those applicable in May of 1977 (22).

The through railroad rates on wheat from Oklahoma origins to the Gulf export ports were the published railroad rates current up to and including the rate increases of Ex Parte 336 (effective January 7, 1977) and were obtained from the Enid Board of Trade (4). These rail rates were applicable in May of 1977.

The truck rates for the truck-barge alternative were estimated using the same rate-distance relationship that was used for estimating truck rates into Enid. The bid price differential between the Gulf price and

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[12] The rate-distance relationship for trucking from Oklahoma points to Enid that are reported by Johnson and Mennem is given as:

(a) $$\text{Rate} = \underset{(0.1727)^*}{3.1486} + \underset{(0.0036)^*}{0.1038}\,(\text{Miles}) - \underset{(0.00001537)^*}{0.00008134}\,(\text{Miles})^2.$$

$R^2 = .9834$ $F = 5117.10^*$

Rate = truck rate (¢/bu.)

Miles = highway milage between origin and Enid, Oklahoma

The rate-distance relationship for trucking from Oklahoma points to Ft. Worth is given as:

(b) $$\text{Rate} = \underset{(0.7998)^*}{6.4353} + \underset{(0.0067)^*}{0.07940}\,(\text{Miles}) - \underset{(0.00001321)^*}{0.00002248}\,(\text{Miles})^2.$$

$R^2 = .9702$ $F = 1108.07^*$

Rate = truck rate (¢/bu.)

Miles = highway milage between origin and Ft. Worth, Texas the price paid for wheat delivered at Catoosa was set at 27 cents per bushel, as reported in Johnson and Mennem (11). Sources within the industry confirmed that this differential was applicable during May of 1977, and indicated that the differential remains fairly constant throughout the year.

Estimates for the truck rates from Oklahoma origins to the Gulf ports were obtained by contacting a number of country elevator managers throughout the study area and obtaining from them estimates of the truck rate they must pay (as of May, 1977) to move wheat directly to the Gulf. These rates tended to follow a linear relationship with highway milage to Galveston, Texas. Elevators in the extreme southern portion of the study area typically paid a truck rate of 30 cents per bushel; elevators in the extreme northwestern portion typically paid a rate of slightly above 40 cents per bushel. The linear rate-milage relationship was used to estimate rates on alternative five for the locations in the study area.

Truck rates for hauling wheat, both within Oklahoma and interstate from Oklahoma, are not published since wheat is an exempt agricultural commodity. The actual truck rates at any given location will vary throughout the year in response to changes in the demand for and supply of trucking service. Sources within the industry indicated that the level and structure of the truck rates used in this study do conform fairly accurately to the actual truck rates in May of 1977.[13]

Seasonal railroad rates are introduced by multiplying either the railroad rates for movements one and two by a given proportionality

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[13] Structure of truck rates refers to the relationship between the truck rates at two locations.

factor greater than 1.0 to represent harvest period rate increases or the rail rates for movement three by a factor less than 1.0 to represent non-harvest period rate decreases. The rate levels of each of the other alternatives can also be increased or decreased in a similar fashion. For alternatives with two rate parts, each part can be increased or decreased separately.

Transportation Decision Rule

Each country elevator is assumed to select the transportation alternative with the lowest total rate for each of the three movements. Other factors which may influence these decisions, such as relative service quality characteristics, have not been considered in this study. The establishment of seasonal railroad rates will directly alter the relative transportation rates both between modes and between time periods. This decision model will indicate the effects of these changes in relative rates assuming that wheat shippers base their transport decisions solely on transport rates.

Aggregate Truck Constraints

Although no attempt is made in this study to model and estimate the supply of truck service available at each country elevator location, it is felt that some method of limiting the total volume of trucking in each period is desirable. This is provided for in the model in the following way.

The total amount of trucking capacity in each period is defined as the total number of trucks available in the study area in each period times the number of days in each period. Hence the truck constraint is defined in units of truck-days.

At each location for which the transport decision for one of the three movements is to use an alternative employing trucks, the number of truck-days required to accommodate the volume of that movement from that station is calculated. Assuming that the average truck hauls the legal capacity limit of 833 bushels (50,000 lbs.), drives at an average highway speed of 45 mph, spends an average of 2.5 hours during the harvest period and 1.0 hours during the non-harvest period on each haul for loading, inspections, and unloading, and observes the legal truck work rules, then an estimate of the truck-days required to move "ν" bushels of wheat from that terminal to a terminal "m" miles away is given by:

$$\text{truck-days (harvest period)} = \frac{\nu}{833}\left[\left(\frac{m * 3.6}{45} + 2.5\right) \div 24\right]; \tag{6}$$

$$\text{truck-days (non-harvest period)} = \frac{\nu}{833}\left[\left(\frac{m * 3.6}{45} + 1\right) \div 24\right] . \quad [14] \tag{7}$$

The truck-days for each location selecting either a truck or truck-barge alternative for the first movement and a truck alternative for the second

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[14] Truck work rules established by the Interstate Commerce Commission state that a truck driver may drive no more than 10 hours after 8 consecutive hours off. On the average, this implies that 1.0 hour of driving time required 0.8 hours off. The driving time is given by the expression $[\frac{2 * m}{45}]$ since "m" is the one-way milage. Multiplying this expression by 1.8 to account for the rest time yields the expression $[\frac{3.6 * m}{45}]$. Adding either 2.5 or 1.0 hours for loading, etc. (depending upon in which time period the haul takes place), results in the total number of hours required to make one trip. The number of trips required is given by the expression $[\frac{\nu}{833}]$.

movement are summed over all locations and compared to the harvest period truck constraint. Similarly, the truck-days for all locations selecting a truck or truck-barge alternative for the third movement are summed and compared to the non-harvest period constraint.

If either of the two truck-day sums are greater than the corresponding truck constraints, then the solution is recalculated with some locations being forced to choose the railroad alternative even though a truck alternative has a lower rate. The locations are ranked in descending order according to the difference between the rail rate and the lowest cost trucking alternative at each location. Starting with the location with the largest positive difference, each location is allowed to select the truck alternative. When the running total of truck-days required by the wheat volumes of the locations up to that point just equals the truck constraint, then no more locations are allowed to select the truck alternative. The remaining locations must select the railroad alternative.

The rationale for using this procedure is that the elevators perceiving the greatest difference between the railroad rate and the lowest non-railroad rate will be the more willing and able to bid up the non-railroad rate and attract trucking service. If the difference between the railroad and the non-railroad rates is very small and trucks are in short supply relative to demand, then the elevator with this small difference will be less willing to raise its bid for truck service and will be less likely to attract that service.

Aggregations of the Three Movements

Once the transport decision for all three movements is calculated for each location, then the volumes corresponding to these decisions can be aggregated to provide a more concise picture of the effects of seasonal rates. The aggregated volumes of each transportation alternative indicate the volumes of wheat handled and stored at the terminal facilities at Enid, Ft. Worth, and Catoosa separately. The volumes aggregated over the three modes of railroad, truck, and truck-barge are used to calculate market shares and changes in railroad traffic levels. Revenues (volume times rate at each location) can also be calculated and aggregated by alternative and by modes in each time period. These aggregate revenues provide information on railroad revenues, average transport rates and total transport bills paid by shippers, and the economic incentives created by seasonal rates to defer harvest shipments until the non-harvest period. In the next chapter, the results of using the model to analyze the effects of seasonal railroad rates on wheat are presented.

CHAPTER IV

RESULTS

The Base Solution

If the volumes of the three wheat movements at each location are held at their estimated 1976 levels and the rates on all transportation alternatives are held at their May, 1977 levels, then the resulting output from the model is called the base solution. This solution provides a convenient reference point from which to measure the effects of establishing seasonal railroad rates.

Table II in the previous chapter summarizes the estimated wheat shipments from country elevators in the study area during 1976. Thirty-six percent of the 65.5 million bushels of wheat which moved during the harvest period was wheat which had been sold by producers (M1); the remaining 64 percent of this volume was moving into storage at a terminal facility (M2). Though a greater volume of wheat left country elevators during the non-harvest period (M3 comprised 56 percent of the total volume moved in both periods), the average weekly volume was must lower since the non-harvest period is considerably longer than the harvest period.

This is somewhat misleading since wheat which is moved into storage at terminals during harvest is moved out of these terminals after harvest and should be taken into account when measuring the overall volume of wheat traffic. The average weekly volume of Oklahoma wheat moved out of the country and terminal elevators in the study area during the harvest period was over six times greater than that during the non-harvest period. Thus whether one considers wheat traffic from only the country elevators or from both country and terminal elevators, the average traffic level is substantially higher in the peak, harvest period compared to the off-peak, non-harvest period.

Modal Volumes and Revenues for M1, M2, and M3

Table III presents the aggregated volumes and revenues for the three transport modes which are generated in the base solution. Railroad is clearly the dominant mode in the harvest period, indicating that railroad rates at their present levels tend to be lower than the rates of other modes throughout the study area. This is not to say that railroads face no competition for this traffic. The level of competition depends upon the relationship between railroad rates and the rates of the next-best nonrail alternatives. This relationship will be discussed later in this chapter when the effects of raising harvest railroad rates are examined.

The truck-barge alternative is only available for movements one (M1) and three (M3) since the terminal facilities at Catoosa lack the storage space to handle any significant proportion of movement two's volume. The Catoosa water transport market area during the harvest period includes the northeastern counties of the study area; railroad rates and truck rates are higher than the combined truck-barge rates at locations in this market area. The western market boundary for Catoosa extends up to the eastern edge of the major wheat producing areas (see Figure 7). Even a small movement westward of this boundary will divert significant volumes of M1 to the facilities at Catoosa. Wheat moving into storage

TABLE III

BASE SOLUTION VOLUMES AND REVENUES
AGGREGATED OVER THE STUDY AREA

M1 - Wheat Sold by Producers and Shipped From Country Elevators During the Harvest Period

Mode	Volume (1000 bu.)	%	Revenue ($)	%
Truck	2,925	12.3	1,166,853	12.7
Railroad	18,795	79.0	7,308,060	79.4
Truck-Barge	2,065	8.7	730,079	7.9
Total	23,785	100.0	9,204,992	100.0

M2 - Wheat Shipped From Country Elevators to Terminal Elevators for Storage During the Harvest Period

Mode	Volume (1000 bu.)	%	Revenue ($)	%
Truck	3,956	9.5	1,627,941	9.9
Railroad	37,716	90.5	14,801,114	90.1
Total	41,672	100.0	16,429,055	100.0

M3 - Wheat Sold by Producers and Shipped From Country Elevators During the Non-Harvest Period

Mode	Volume (1000 bu.)	%	Revenue ($)	%
Truck	36,719	44.3	13,131,423	42.5
Railroad	32,866	53.0	17,006,432	55.0
Truck-Barge	2,258	2.7	786,682	2.5
Total	82,843	100.0	30,924,512	100.0

M1, M2, and M3 Combined

Mode	Volume (1000 bu.)	%	Revenue ($)	%
Truck	43,601	29.4	15,926,217	28.2
Railroad	100,877	67.7	39,115,584	69.1
Truck-Barge	4,323	2.9	1,516,760	2.7
Total	148,301	100.0	56,558,544	100.0

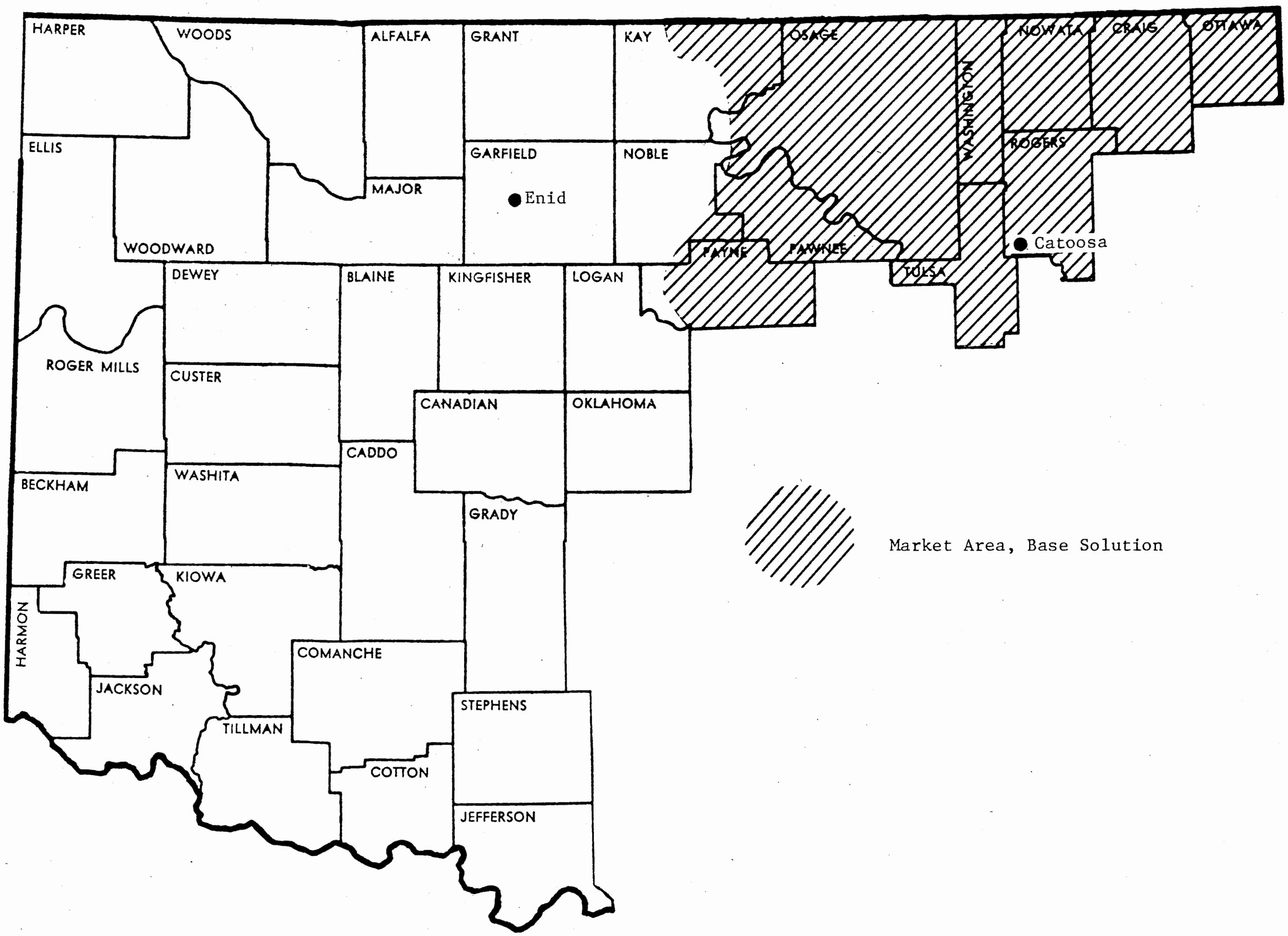

Figure 7. Catoosa Market Area, Base Solution

at a terminal elevator during harvest from locations in the shaded area of Figure 7 move by railroad to Enid or Ft. Worth.

In the base solution and in all other solutions discussed in this chapter, the alternative of trucking directly to the Gulf ports is not considered in the harvest period. Hence the only truck alternatives available for M1 are those in which the wheat is trucked through the terminal facilities at Enid or Ft. Worth. In the base solution, the only country elevators selecting one of these two alternatives for M1 and M2 are those which do not have railroad service at their locations. With the present transport rates, all of these elevators elect to truck the wheat through Ft. Worth's terminal elevator. The Ft. Worth truck market areas in the harvest period are shown in Figure 8.

Since the harvest and non-harvest rates of each alternative are equal in the base solution, the market shares of the three modes for the third movement would be the same as for the first movement except for the fact that trucking to the Gulf is considered after harvest. The rate on this alternative tends to be lower than the rates on the other alternatives at almost all of the locations throughout the study area. Thus the number of trucks available in the non-harvest period is the only limiting factor preventing most of the shippers from using this alternative. Due to this truck constraint, the truck market share in the non-harvest period is only 44 percent, allowing the railroad mode to carry just over half the wheat traffic originating from country elevators after the harvest period.

Overall, railroads carry almost 70 percent of the annual volume of wheat traffic and earn almost 70 percent of the total revenues generated by this traffic. During the harvest period, railroads face traffic

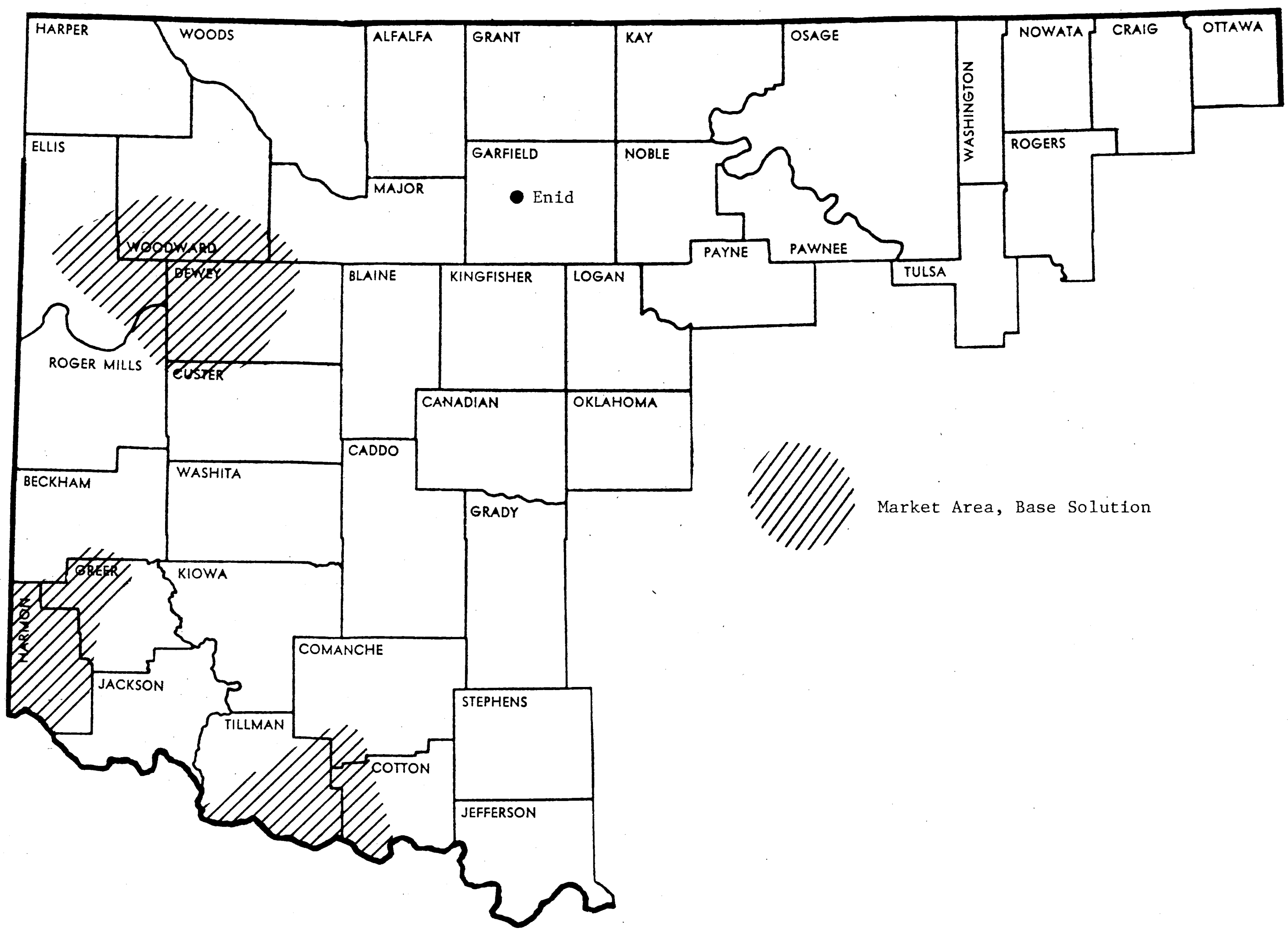

Figure 8. Ft. Worth Trucking Market Area, Harvest Period, Base Solution

diversion to the truck-barge alternative though this occurs in a limited geographic area of generally low wheat production. During the non-harvest period, diversion of potential railroad traffic to long-haul truckers is limited only by the amount of trucking capacity.

Marketing Patterns of Producers

Producers sold 16 percent of the total amount of available wheat (new cash crop plus carryover stocks) during the harvest period. Even if country elevators had sufficient storage capacity to hold the remaining 84 percent, this still implies that the average weekly volume of shipments from country elevators would be twice as high during harvest than after harvest. The fact that over 41.5 million bushels of wheat have to be shipped out during harvest due to insufficient storage capacity at country elevators greatly aggravates the imbalance between harvest and non-harvest traffic levels.

Since it is assumed that all country elevators fill their own storage capacity before shipping wheat to a terminal for storage, the only prospect of reducing the volume of M2 without building new capacity is to increase utilization of existing on-farm storage facilities. From Tables I and II it can be seen that almost half of this capacity is filled with seed wheat and cash wheat immediately after the harvest period. If no carryover stocks of grain are held in the remaining storage space, then 14.4 million bushels of on-farm storage capacity is not being used. This excess capacity can be used to reduce the volume of M2 if it is located near the country elevators which presently ship to a terminal for storage.

The volume of M1 can be reduced if producers are given sufficient incentives to store the wheat which they now sell during harvest. If this wheat can be stored on the farm or in country elevators, then the decrease in M1's volume will result in an increase in M3's volume. The excess farm capacity mentioned above is available for this wheat; in addition, seven percent (six million bushels) of the total country elevator capacity is left unused at the end of the harvest period and is available for storing any wheat formerly sold at harvest. The distribution of this excess capacity within the study area will determine the degree to which the decreases in M1's volume increase the volume of M3.

Rate differentials between the harvest period and the non-harvest period are the economic incentives for reducing the volume of wheat sold at harvest, increasing the utilization of on-farm storage, and building new storage capacity. In the base solution differentials are present due to two conditions: 1) the truck-barge alternative is not available for movement two; and, 2) the alternative of trucking directly to the Gulf is not available for either movements one or two. The difference between the average rate paid on M2 and that paid on M3 is 2.4 cents per bushel.[1] Comparing the first and the third movements, the different in the average rate paid on M1 and that paid on M3 is 2.3 cents per bushel.

The marketing pattern which exists in the base solution takes into account the fact that these rate differentials are present even though railroad rates are not seasonal. It is the amounts by which these rate

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[1]The difference in the average rates in calculated by subtracting the rate paid on M3 from that paid on M2 at each location, multiplying by the volume of M2, and summing over all locations. Dividing this sum by the total volume of M2 results in the difference of 2.4 cents per bushel in the base solution.

differentials increase when seasonal railroad rates are established which will be the economic incentives inducing changes in the base solution's marketing pattern.

Producer's Transportation Bill

The revenue figures given in Table III are also the amounts paid by producers for the transportation services of each mode. The average transportation rates paid by producers, shown in Table IV, are calculated by dividing the revenue figures by their associated wheat volume figures. With the establishment of seasonal railroad rates the average rates paid by producers in the study area will change. The seasonal adjustment in the level of railroad rates and the traffic diversions, either between modes or between time periods, will be responsible for the average rate changes.

Storing and Handling Volumes at the Terminal Elevators

The volumes of wheat received at each of the three terminal locations are shown in Table V. As discussed before, except in Catoosa's market area, all shippers who have railroad service available select the railroad alternative rather than one of the truck alternatives to Enid or Ft. Worth. In the non-harvest period, truck shipments to the Gulf do not pass through either Enid or Ft. Worth; this alternative diverts a large proportion of the non-harvest wheat volume away from these two terminals.

In the harvest period, locations which must choose a truck alternative due to the absence of railroad service select the Ft. Worth truck

TABLE IV

AVERAGE TRANSPORT RATES, BASE SOLUTION
AVERAGED OVER STUDY AREA

Movement	Mode	Average Rate (¢/bu.)
M1	Truck	39.9
	Railroad	38.9
	Truck-Barge[1]	35.4
	Total, M1	38.7
M2	Truck	41.1
	Railroad	39.2
	Total, M2	39.4
M3	Truck	35.8
	Railroad	38.8
	Truck-Barge[1]	34.8
	Total, M3	37.3
M1, M2, M3 Combined	Truck	36.5
	Railroad	39.0
	Truck-Barge[1]	35.1
	Total, M1, M2, M3	38.1

[1]The barge rate in both periods is 27¢/bu.; this is the differential between the price paid for wheat delivered to Catoosa and the Gulf export price.

TABLE V

HANDLING AND STORAGE VOLUMES AT TERMINAL ELEVATORS, BASE SOLUTION

		Terminal Elevator Location	
	Enid (1000 bu.)	Ft. Worth (1000 bu.)	Catoosa (1000 bu.)
Handling Alone:			
M1 Truck	1.6	2,923.8	2,064.6
Railroad	17,563.4	1,231.9	--
M3 Truck	164.6	1,064.8	2,258.4
Railroad	43,246.3	619.3	--
Total	60,975.9	5,839.8	4,323.0
Storage:			
M2 Truck	0.0	3,956.3	--
Railroad	36,359.0	1,357.2	--
Total	36,359.0	5,313.5	--

alternative rather than the Enid truck alternative. The small amounts for the latter alternative shown in Table V are the result of producers in the immediate area around Enid delivering wheat directly to Enid's terminal facilities. Otherwise, the rates favor trucking to Ft. Worth rather than to Enid.

The reason for this is that the bid price for wheat delivered by truck to Enid is 20 cents per bushel less than the bid price for wheat delivered by truck to Ft. Worth. For a country elevator to truck to Enid rather than Ft. Worth, the truck rate from its location to Enid must be at least 20 cents per bushel less than its truck rate to Ft. Worth. This situation exists only at a comparatively small number of locations in Garfield county around Enid and in Grant, Alfalfa, and Woods counties. Since all of these locations have railroad service and use it in the base solution, there is no trucking into the Enid terminals.

Shipper Costs of Railroad Car Shortages

It has been assumed that all railroad shipments will transit at either Enid or Ft. Worth since all locations in the study area which have rail service are within either Enid's or Ft. Worth's transit area. Of course, railroad shipments of movement two must pass through one of these terminals since this wheat is going into storage. It is assumed that railroad shipments of movements one and three also utilize the transit privilege to pass through either Enid or Ft. Worth in order to gain the benefits of the terminals' comparative advantages in marketing the grain.

If there is a shortage of railroad cars restricting the amount of service to railroad shippers, then these shippers must select the next best nonrail alternative for the wheat which cannot go by railroad. Truck allowance is an alternative which shippers may consider in addition to the other truck and truck-barge alternatives. To use truck allowance, a shipper hires a truck to move the wheat to a designated railroad station. The wheat is shipped by railroad from that station to the final destination when railroad cars become available. The shipper pays the through railroad rate applicable at his location plus the truck rate to the designated station; the railroad pays the shipper an allowance which partially covers the truck rate. Since the shipper does contribute some amount towards paying for the trucking cost in addition to paying the full railroad rate, the rate on the truck allowance alternative is higher than that on the railroad alternative.

Suppose that during a railroad car shortage, railroads allocate the cars they do have among railroad shippers so that each shipper experiences the same relative amount of shortage; for instance, each shipper can ship by railroad only 80 percent of the volume he would have shipped if there was no car shortage. The remaining amount of wheat must be shipped by a nonrail alternative. In the base solution, the next-best nonrail alternative is not always truck allowance. In the first place, truck allowance is not available at all locations with railroad service. Secondly, at those locations with truck allowance, the total rates paid for this alternative average almost 10 percent higher than the railroad rates. At many locations where the railroad rate is the lowest among all alternatives, there is a truck or truck-barge alternative with a rate lower than the truck allowance rate; shippers at these locations do not select the latter alternative.

Of the wheat in movement one which must go by the next-best nonrail alternative due to a railroad car shortage, 37 percent will move by truck allowance, 51 percent by truck to Ft. Worth, and 12 percent by truck-barge through Catoosa. The average rate paid is 42.1 cents per bushel, an eight percent increase over the average railroad rate which would have been paid if adequate railroad service had been available.

For movement two, Catoosa is not an alternative so that 54 percent of the wheat will move by truck allowance if railroad cars are not available, 43 percent will move by truck to Ft. Worth and three percent will be trucked (not by truck allowance) to Enid. The average rate paid by all railroad shippers for the next-best nonrail alternative is

42.6 cents per bushel. This compares to the average railroad rate paid of 39.2 cents per bushel (see Table IV), an increase of 8.7 percent.

Effects of Seasonal Railroad Rates on Modal Splits

Increasing the Harvest Period Railroad Rates

Seasonality in railroad rates can be established either by increasing the present railroad rates during the harvest period, by decreasing them during the non-harvest period, or by some combination of these two actions. Although increasing the harvest period rates may result in some railroad shippers shifting their harvest period shipments into the non-harvest period, there is also a possibility that within the harvest period competing modes will absorb some traffic formerly going by railroad, thus permanently lowering the total volume of railroad traffic carried over the year. By holding the total volume of the three movements at each station at their estimated 1976 levels and increasing railroad rates on M1 and M2, the effects on this second possibility can be ascertained.

Results were obtained from the model with harvest period railroad rates increased three, five, seven, and ten percent above their present levels. Since non-harvest period railroad rates were kept at their present levels, the modal volumes and revenues for movement three remain the same as in the base solution (see Table III). With each successive increase, a larger number of country elevators selected a nonrail alternative. The aggregate truck constraint in the harvest period was reached when railroad rates were increased ten percent. In order to analyze what would happen with unrestricted amounts of trucking, results were obtained with railroad rates increased ten percent and unlimited trucking allowed.

As railroad rates are increased, the water transport market boundary of Catoosa moves steadily westward, penetrating the heaviest wheat-producing counties of the study area. Even a three percent railroad rate increase will extend Catoosa's market area throughout most of Kay county; a ten percent increase (with the truck constraint) will result in the market area expansion shown in Figure 9. Within this additional area, Catoosa draws 2.3 million bushels of wheat in the harvest period which formerly went by railroad. Unconstrained trucking extends the market area into Alfalfa county with another 0.8 million bushels going by truck-barge instead of railroad. Since Catoosa is not an alternative for the second movement, the above increases in Catoosa's volume during the harvest period decrease only the railroad volume of the first movement, M1.

The alternatives of trucking to Enid and Ft. Worth are available for both movements one and two. The volume of trucking also increases steadily as harvest period railroad rates are successively raised. Figure 10 shows the major areas from which grain is trucked to one of these two terminals during the harvest period when harvest railroad rates are increased ten percent. Trucks carry an additional 2.6 million bushels of the first movement and 5.7 million bushels more of the second movement in this solution compared to the base. If unlimited amounts of trucking are allowed and harvest period railroad rates are raised ten percent, then the volumes of truck alternatives increase so that 5.9 million bushels of M1 and 13.6 million bushels of M2 go by these alternatives which had previously chosen the railroad alternative in the base solution.

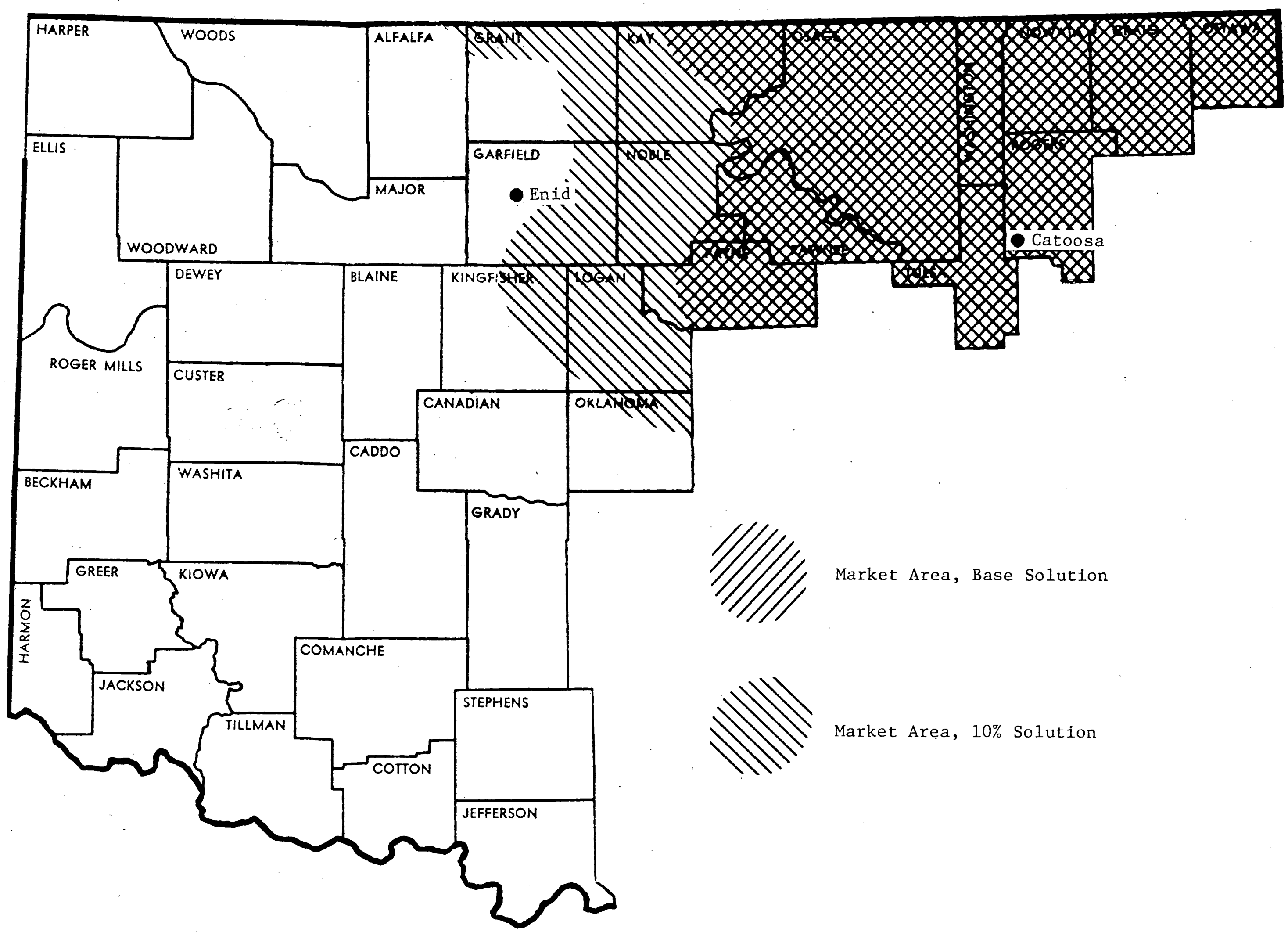

Figure 9. Expansion of Catoosa Market Area, 10% Solution

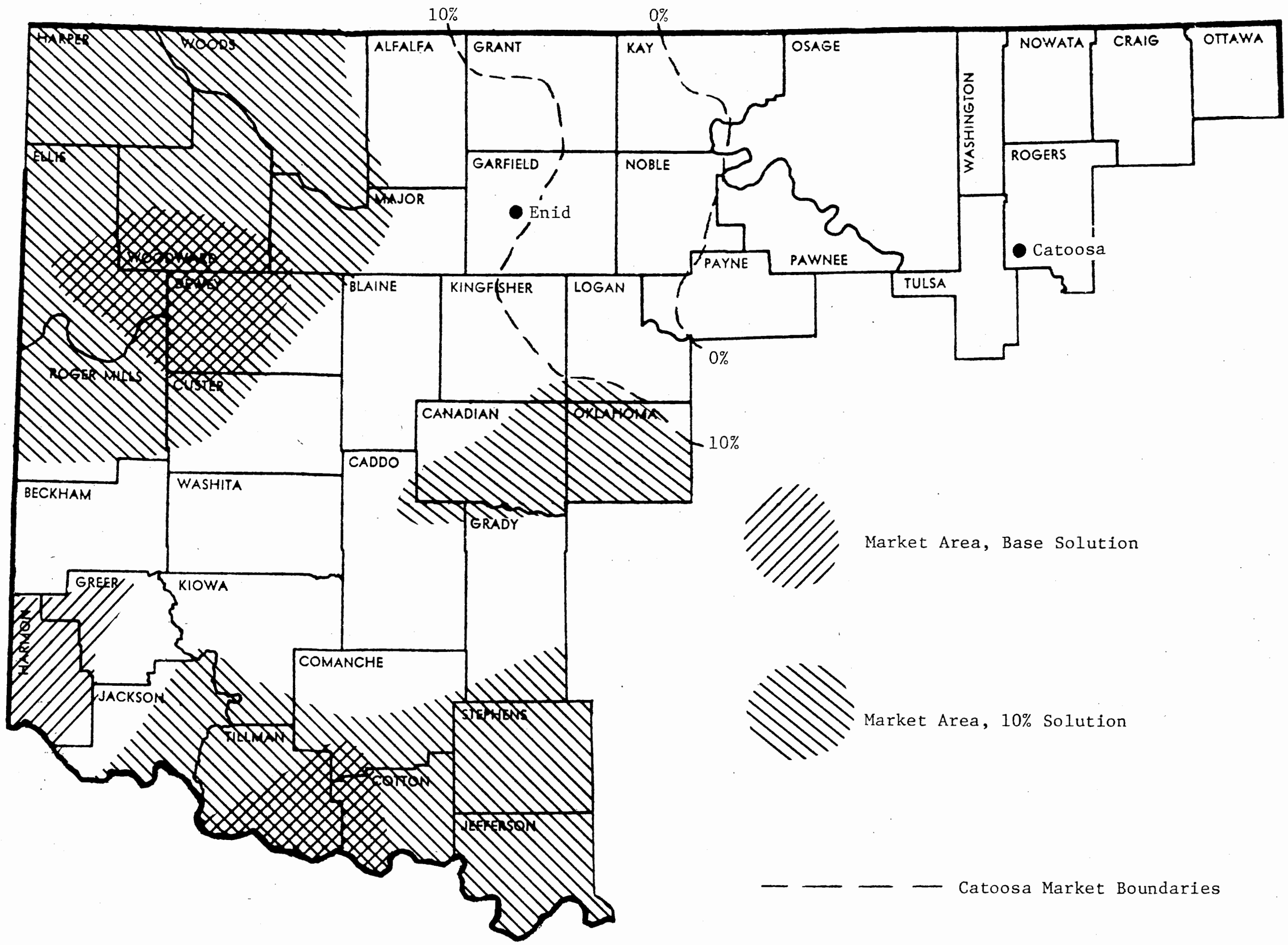

Figure 10. Expansion of Ft. Worth Truck Market Area, Harvest Period, 10% Solution

The declines in the volume of railroad traffic in the harvest period due to modal competition when railroad rates are increased are shown in Table VI. These declines do decrease the level of peak period railroad traffic relative to the off-peak railroad traffic level. This occurs only because the quantity of railroad service demanded in the harvest period declines; railroad demand in the non-harvest period remains unchanged. Despite railroad rate increases, total revenues generated by the remaining railroad traffic decline for each level of rate increase. The revenue decrease is substantial in the ten percent, unconstrained trucking solution. This behavior of railroad revenues indicates that the own-price elasticity of railroad demand is less than -1.0.

The own-price elasticity of demand is the percentage change in the quantity of service purchased due to a one percent change in the price of that service. Since the quantity purchased falls as its price is raised, this elasticity is negative. If the percentage decline in quantity is greated than the percentage rise in price, then revenue falls as the price is raised and the demand is said to be elastic. This is the case with aggregate railroad demand in the study area during the harvest period.

The average own-price elasticity of demand can be calculated for movements one and two for each increase in railroad rates from the information in Table VI. Dividing the percent volume change by the corresponding percent increase in railroad rates results in average elasticities which are less than -1.0 in all cases. For movement one, these elasticities range from -2.6 to -3.7 (-4.8 in the unconstrained case) while for movement two they range from -1.02 to -1.5 (-3.6 unconstrained).

TABLE VI

RAILROAD VOLUME AND REVENUE CHANGES DUE TO INCREASES IN HARVEST PERIOD RAILROAD RATES, MOVEMENTS 1 AND 2[1]

% Increase in Railroad Rate Level	Volume (1000 bu.)	% of Base	Revenue ($)	% of Base
Movement 1				
0 (base solution)	18,795	100.0	7,308,060	100.0
3	17,247	91.8	6,889,148	94.3
5	15,322	81.5	6,200,069	84.8
7	14,178	75.4	5,820,707	79.6
10	13,831	73.6	5,840,700	79.9
10[2]	9,777	52.0	4,069,713	55.7
Movement 2				
0 (base solution)	37,716	100.0	14,801,114	100.0
3	36,565	96.9	14,780,201	99.9
5	35,782	94.9	14,712,279	99.4
7	34,231	90.8	14,261,038	96.4
10	32,029	84.9	13,658,036	92.2
10[2]	24,076	63.8	10,198,768	68.9

[1]Rates on nonrail alternatives and railroad rates in the non-harvest periods are at their present (base) levels; total volume of each of the three movements is unchanged from the base solution.

[2]Unlimited trucking allowed.

Movement one elasticities are greater in absolute value than those of movement two due primarily to the presence of truck-barge competition for shipments of movement one but not for movement two shipments.

The elastic demand for rail service in the harvest period is caused by the number of close substitutes for this service. In this case, these substitutes are the services of the truck and the truck-barge modes. The "closeness" of these substitute services is indicated by the levels of their transport rates relative to the railroad rates throughout the study area. It is evident that the rates of other modes are close enough to railroad rates that railroads cannot increase their revenues by increasing their rates during harvest.[2]

This is not to say that rate increases will not increase railroad profits. The profitability of such moves can only be ascertained by examining the behavior of railroad costs as railroad traffic declines. Since this study does not analyze costs, no conclusions can be reached concerning how railroad profits will be affected by railroad rate increases in the harvest period.

The revenue figures in Table VI do suggest that the railroads may experience a decline in their cash-flows if seasonal rates are established on wheat. More importantly, the behavior of railroad revenues should be an indication that the revenue objective in Section 202(d) of the RRRRA may not be achieved. Thus the ICC may have to weigh the tradeoffs of decreased railroad revenues versus more even wheat traffic flows over the year if seasonal railroad rates are proposed which increase harvest period rates.

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[2]The effects of shifting railroad demand between periods are examined in the next section of this chapter.

The above analyses assume that nonrail rates will remain constant at their base levels when harvest period railroad rates are increased. Since the demand for trucking services increases as railroad rates increase (due to diversion of railroad traffic to the truck mode), truck rates may also be expected to increase. Assume that a five percent railroad rate increase during the harvest period brings about a five percent increase in all truck rates during harvest. The effects of this situation are different for movements one and two.

The combined rate of the truck-barge alternative for the first movement is not increased the full five percent since only the truck portion of this rate is increased. The rate relationships between the railroad alternatives and the truck alternatives for movement one remain the same as in the base solution since both are increased the same proportion. Hence the only change from the base solution for movement one is a diversion of traffic to the truck-barge alternative. Some of Catoosa's additional traffic formerly went by railroad and the remaining additions went by truck to Ft. Worth. The decrease in this rail traffic is less than the increase in railroad rates (-3.4 vs. +5.0 percent) so that movement one railroad revenue increases over that of the base solution.

Although Catoosa is not an alternative for movement two, railroad traffic for this movement also declines. The diversion in this case is to the flat-truck alternative since only the short haul truck rate from country elevator to the terminal facility (which occurs in the harvest period) is increased five percent; the long haul truck rate from the terminal to the Gulf remains the same as in the base solution since this movement takes place after harvest. Though movement two railroad traffic declines, the railroad revenue from the remaining traffic increases 2.4 percent, indicating that the loss in traffic is less than the increase in rates.

While it appears that increased harvest period railroad rates do smooth out the level of railroad demand throughout the year by diverting harvest period railroad traffic to other modes, it is evident that such increases will result in revenue losses to the railroads unless the harvest period rates on other modes increase in response to their demand increases. Though lessening the smoothing effects on railroad traffic levels, such increases in nonrail rates are necessary for railroad revenue gains.

Decreasing the Non-Harvest Period Railroad Rates

Seasonal railroad rates can also be established by lowering the level of railroad rates in the non-harvest period. In addition to possibly shifting some harvest period railroad traffic to the non-harvest period to take advantage of the lower railroad rates, there is also a possibility that traffic can be attracted from other modes during this period. To examine the latter possibility, railroad rates during the non-harvest period were decreased by five percent and ten percent with all other rates being held at their base levels and the total volume of the third movement being held at its estimated 1976 level.

From the railroads' point of view, the results are not encouraging. In both cases, total non-harvest railroad volume does increase; however, in neither case does this traffic increase compensate for the rate decrease so that railroad revenues fall with both rate decreases. The primary competition for the railroads in this period is direct trucking to the Gulf. The problem is that even for those shippers using a railroad alternative in the base solution, the rate on direct trucking is less than the railroad rate. Only the aggregate truck constraint prevents these railroad shippers from using the truck alternative instead. A ten percent railroad rate decrease cannot close the gap between the direct truck rate and the railroad rate at most of the locations.

It should be recognized that there are two railroad demand curves in each year, one relevant for the harvest period and one relevant for the non-harvest period. In the model's solutions discussed in this section, it has been assumed that these two demand curves are independent of one another; no wheat traffic has been allowed to shift from the harvest to the non-harvest period. With this assumption, the results indicate that wheat demand for railroad service in the harvest period is elastic with respect to railroad rate increases. The results also indicate that railroad wheat demand in the non-harvest period is inelastic with respect to railroad rate decreases. These two results are compatible with one another since they refer to shifts along different demand curves.

To summarize this section, the degree of competition between the transport modes which prevails over the entire study area prevents the railroads from achieving higher revenues through seasonal ratemaking, whether this entails increases in railroad rates in the harvest period or decreases during the non-harvest period. Seasonal fluctuations in the level of railroad demand can be reduced, but only through the permanent diversion of traffic away from the railroads and subsequent loss in railroad revenues.

For all of the solutions discussed in this section, the volumes of the three movements at each location have been kept at their estimated 1976 levels. The assumption is that producers will not alter their marketing patterns in response to the rate differentials between periods created by the establishment of seasonal rates. The next section of this chapter examines the maximum amounts by which these patterns could be altered and the magnitudes of the economic incentives created by seasonal railroad rates which may induce such changes.

Effects of Increased Storage Induced by Seasonal Railroad Rates

There are three ways in which seasonal railroad rates could reduce the level of harvest period railroad traffic through inducing more storage at the farm or country elevator levels. A transport rate differential between the harvest and the non-harvest periods could 1) induce producers to sell less wheat during the harvest period and to store it in presently unused on-farm or country elevator storage, 2) induce producers to increase the utilization of their existing on-farm storage capacity with wheat which is presently moving to terminal facilities during harvest for storage, and 3) induce either producers or country elevator managers without excess storage capacity at the present time to build new storage capacity.

As indicated in the discussion of the base solution, the amount of excess storage capacity that is estimated to have been present after the 1976 harvest is 14.4 million bushels at the farm level and 11.4 million bushels in the country elevators; a total of 25.8 million bushels of unused capacity. Although this total is greater than the aggregate volume of movement one in the base solution, the distribution of this excess capacity among the individual country elevators in the study area is not identical to the distribution of the volumes of movement one among the elevators. Thus not all of the wheat which producers are induced to store rather than sell in the harvest period when seasonal railroad rates are established will be stored on the farms or at country elevators. If the additional volume which producers wish to store is greater than the amount of excess storage capacity on their farms or at the country elevator, then the amount of wheat which cannot be stored locally must be shipped into storage at a terminal elevator during harvest.

At most, the establishment of seasonal railroad rates could induce producers not to sell any wheat during the harvest period. In this case, 15.5 million bushels of the available 25.8 million bushels of unused farm and country elevator storage capacity will be utilized to store the wheat which, in the base solution, makes up movement one. Since the total volume of movement one in the base solution is 23.8 million bushels of wheat, 8.3 million bushels (23.8 - 15.5) remains to be stored when producers decide to store all wheat during the harvest period. This 8.3 million bushels must move into storage at a terminal elevator during harvest since this wheat volume is not situated at the same locations which have the remaining 10.3 million bushels (25.8 - 15.5) of excess farm and country elevator storage capacity.

The volume of wheat which is moving into storage at a terminal elevator during harvest in the base solution can be reduced if the establishment of seasonal railroad rates induces the storage of this wheat at on-farm storage facilities instead of at terminal facilities.

In the base solution, this wheat is delivered by producers to country elevators for storage at harvest. These country elevators must ship it to a terminal since their storage facilities are filled.[3] Seasonal railroad rates could induce the producers of this wheat to store it on their farms rather than deliver it to the country elevator for storage.

As with movement one, not all of the aggregate excess storage cpacity on the farms in the study area can be used to reduce the volume of movement two. Many locations have more excess farm capacity than the volume of their movement two shipments. In the model, allowing use of the available farm storage to reduce the volume of movement two shipments results in an additional 10.3 million bushels of wheat being stored on the farm during harvest when compared to the base solution. The total volume of movement three is increased by 10.3 million bushels as the producers sell this wheat from out of farm storage during the non-harvest period.

The rate differentials between the harvest period and the non-harvest period that are created by seasonal railroad rates are economic incentives which may induce more storage during the harvest period. If a producer perceives a given rate differential between periods which is created by seasonal railroad rates, whether he decides to store during harvest rather than sell depends upon a comparison of all benefits and all costs associated with storing rather than selling. In addition to paying a lower transportation charge if he stores, another economic

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[3]The fact that this wheat is part of movement two in the base solution indicates that it is shipped from these elevators into storage at a terminal due to lack of excess storage capacity at the country elevator.

benefit to the producer of storing includes the possibility of receiving a higher final market price for his wheat during the non-harvest period.[4] Costs of storing rather than selling include storage charges, the opportunity costs of money tied up in wheat inventory, and the possibility of receiving a lower final market price for his wheat during the non-harvest period. Whether the economic benefits of storing wheat during harvest rather than selling it which are created by seasonal railroad rates are great enough to induce more storage depends upon whether the total benefits become larger than the total costs of storing rather than selling.

Similarly, for decisions of whether to build new storage capacity, either on the farm (by producers) or at country elevators (by the elevator owners), the total benefits of the new storage must be compared to the total costs. Seasonal railroad rates will add to the benefits which presently exist, but without knowing the levels of present benefits and costs it is not possible to know for how much potential storage capacity the establishment of seasonal railroad rates will result in higher total benefits than total costs. From the model's results, it is possible to examine the economic incentives to store during harvest which are created by seasonal railroad rates alone.

Examining the most extreme case of a ten percent increase in harvest period railroad rates, the weighted average rate differential between the harvest and non-harvest period is 5.6 cents per bushel. Since the base

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[4] Although it is the country elevator, not the producer, which explicitly pays the transportation rate, the producer ultimately pays for the transportation service by receiving the local site price for his wheat composed of the final market wheat price minus (among other marketing charges) the transportation rate.

solution has an average differential of 2.4 cents per bushel (due to differences in the alternatives available in each period), the establishment of ten percent seasonal railroad rates creates 2.2 cents per bushel of annual economic incentive, on the average, for shippers to decrease their harvest period demand for transport service by storing more wheat during harvest at the farm and country elevator levels.

It is not possible to forecast to what extent this 2.2 cents per bushel incentive will induce greater utilization of existing farm and country elevator storage capacity. However, it is clear that it will not be sufficient alone to induce the building of new storage capacity in the study area. Estimates of the cost of new on-farm capacity range from 50.6 cents per bushel of space for an 11,000 bushel capacity bin up to 115.5 cents per bushel of space for a 1,000 bushel capacity bin.[5] Costs per bushel of country elevator storage capacity are considerably higher than these figures.

Using the perpetuity concept with an effective annual interest rate of ten percent, the annual capital cost of the largest farm storage bin is 5.06 cents per bushel of space. This is more than twice the 2.2 cents per bushel annual benefit which is gained by building this new capacity and using it to reduce harvest period shipments. Using this perpetuity concept to calculate the breakeven interest rate, a producer would have to be able to borrow the money for building new storage at an annual

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[5]The cost data include the cost of construction and installation and have been inflated five percent to reflect price increases since 1976. Data were obtained from Mennem (14).

interest rate of 4.3 percent (2.2 ÷ 50.6) in order for the annual economic benefits of additional storage to just equal the annual capital costs of that storage.

Though 2.2 cents per bushel is the average incentive over the entire study area when harvest railroad areas are increased by ten percent, the incentive created at each individual location does not exceed 5.06 cents per bushel (the maximum individual incentive in the study area is 4.47 cents per bushel). Locations with the highest railroad rates in the base solution are those at which a ten percent rate increase would come closest to creating an incentive of over 5.06 cents per bushel. However, these are the locations which tend to switch to nonrail alternatives with rates less than the harvest railroad rates so that the magnitude of their incentives are less than the difference between harvest and non-harvest railroad rates.

Effects of Seasonal Railroad Rates on the Producers' Transport Bill

Increases in the harvest period railroad rates will always increase the total transport bill paid by producers. However, the percentage increase in this total bill will not be as great as the percentage increase in railroad rates. Rate competition allows some shippers to switch from railroad to a competing mode during harvest; though these shippers pay higher transport rates than they did in the base solution, the nonrail rates which are paid are less than the increased railroad rates. In addition, shippers who are able to switch their harvest period railroad shipments to the non-harvest period will not have to pay the higher, harvest period railroad rates.

Table VII illustrates that rate competition keeps the increases in average transport rates paid by shippers below the railroad rate increases. With a ten percent increase in harvest period railroad rates, the average rate paid on movement one shipments is 41.3 cents per bushel, or a 6.7 percent increase from the base period average rate of 38.7 cents per bushel. The increase in the average rate paid on all three movements combined is much less than the corresponding railroad rate increase since all movement three shipments had no rate increase at all.

Though the average rates paid by all shippers increase less than the harvest period railroad rates increase, some shippers gain relative to other shippers. Those shippers who switch from railroad to a competing mode during the harvest period experience less of an increase than do shippers continuing to use railroad. Shippers who ship a large proportion of their annual wheat volume after harvest will experience a smaller increase in the average rate they pay on this total volume than do shippers who ship predominantly during the harvest period.

Shifts in wheat traffic between periods further limit the increases in the average transport rate paid on all shipments when harvest period railroad rates are increased. Allowing excess on-farm storage capacity to be used in the model effectively shifts transport demand from the harvest period to the non-harvest period. Some of the wheat which is moving into storage at a terminal elevator during harvest when this excess capacity is not used is stored on the farms during harvest when the excess capacity is allowed to be used; this wheat then moves out during the non-harvest period rather than in the harvest period. Since this wheat takes the relatively lower non-harvest rate (if it moves by

TABLE VII

AVERAGE TRANSPORT RATES PAID BY SHIPPERS FOR HARVEST PERIOD RAILROAD RATE INCREASES OF 0, 3, 5, 7, and 10 PERCENT

Movement	Mode	Average Rate (¢/bu.)				
		0 (base)	3%	5%	7%	10%[1]
M1	Truck	39.9	39.8	40.3	40.6	40.5
	Railroad	38.9	39.9	40.5	41.1	42.2
	Truck-Barge	35.4	37.0	38.5	39.1	39.3
	Total	38.7	39.6	40.1	40.6	41.3
M2	Truck	41.1	40.9	41.4	42.6	43.0
	Railroad	39.2	40.4	41.1	41.7	42.6
	Total	39.4	40.5	41.2	41.8	42.7
M1, M2, M3 Total		38.1	38.6	38.9	39.1	39.5

[1]Constrained by aggregate truck capacity.

railroad), the resulting average transport rate on all shipments will be lower when this excess capacity is used than if it is not used.

For example, in the base solution the average rate paid on shipments of all three movements is 38.1 cents per bushel (see Table VII). When harvest period rail rates are increased five percent and excess on-farm storage capacity is not allowed to be used in the model (i.e., when there are no traffic shifts between time periods), this average rate paid on all shipments is 38.9 cents per bushel. If excess on-farm storage is allowed to be used in the model with a five percent rate increase, then the average transport rate is 38.7 cents per bushel. Though harvest period railroad rates are increased five percent, shifts in railroad traffic to other transport modes within the harvest period help limit the increase in the rate paid to 2.1 percent; shifts in wheat traffic from railroad to other modes within the harvest period and from the harvest period to the non-harvest period limit the increase in the average rate paid to 1.6 percent. Thus not only does intermodal rate competition held protect shippers from railroad rate increases; but the ability to shift harvest period railroad demand to the non-harvest period by utilizing excess storage capacity also provides additional protection from such increases.

Decreases in non-harvest period railroad rates will decrease the total transportation bill of shippers from its level in the base solution. A ten percent railroad rate decrease results in a 5.6 percent decline in the average rate paid on movement three shipments and a three percent decline in the average rate paid for the shipments of all three movements combined. The average rate paid on movement three shipments does not decline by ten percent because some wheat is already moving by truck at rates more than ten percent less than the present railroad rates. The shippers of this wheat will not switch to the railroad mode; hence they do not realize any gains from the lowering of non-harvest period railroad rates.

Effects of Seasonal Railroad Rates on the Terminal Facilities of Enid, Ft. Worth, and Catoosa

In the base solution, the Enid terminals are dependent upon the railroad mode for receiving wheat from the country elevators in the study area. As railroad rates during the harvest period rise, shippers select nonrail transport alternatives which do not involve the Enid terminal facilities. The volume of wheat handled by the Enid terminals (exclusive of storage) declines as the wheat is moved through Catoosa by truck-barge and through Ft. Worth by truck. Enid's storage volume declines as this wheat moves into the storage facilities at Ft. Worth by truck.

The expansion of Catoosa's market area as harvest railroad rates are increased has been discussed earlier in this chapter (see Figure 9). With harvest period railroad rates increased by ten percent, Catoosa diverts 2.3 million bushels of wheat which had been transited at Enid in the base solution. Compared to the base solution, this 2.3 million bushels represents a 13 percent loss in the volume of wheat from the study area which is handled (exclusive of storage) at the Enid terminals during harvest. For Catoosa, this 2.3 million bushels represents a 213 percent gain in the volume of wheat from the study area which it handles during harvest.

The increased amount of trucking into Ft. Worth as harvest railroad rates are increased has also been discussed earlier. Only part of this increased truck volume is wheat which had been transited by railroad at Enid in the base solution; the other part of the additional truck volume at Ft. Worth had been transited by railroad at Ft. Worth in the base solution. When harvest period railroad rates are increased by ten percent, 2.1 million bushels of wheat from movement one are diverted from Enid to Ft. Worth. In addition, the volume of wheat from the study area which is stored at Enid during the harvest period decreases by 4.6 million bushels as this traffic of movement two is diverted to Ft. Worth for storage.

In all, Enid receives 9.0 million bushels less during the harvest period when harvest railroad rates are increased by ten percent than it received in the base solution. Ft. Worth receives 6.7 million bushels of the wheat diverted from Enid; Catoosa receives the remaining 2.3 million bushels of wheat which are diverted from Enid during the harvest period. It should be noted that these handling and storing volumes refer only to wheat drawn from the study area.

When railroad rates in the non-harvest period are decreased, the volume of wheat handled at Catoosa declines by one million bushels, all of which switches to transiting by railroad at Enid. In the base solution this one million bushels had used a quantity of the aggregate trucking capacity for moving into Catoosa; when the volume switches to railroad with the ten percent railroad rate decrease, this quantity of trucking becomes available for trucking directly to the Gulf. Despite a ten percent decrease in railroad rates, the volume of wheat trucked to the Gulf increases. This wheat comes primarily from locations transiting wheat at Ft. Worth.

When excess on-farm storage capacity is allowed to be utilized, the storage volumes of both Enid and Ft. Worth decline; Enid's storage volume falls by 8.6 million bushels and Ft. Worth's volume falls by 1.7 million bushels. Since all of the wheat which is stored in this on-farm capacity moves out of the country elevators after the harvest period, the terminals at Enid, Ft. Worth, and Catoosa all gain handling volumes in the non-harvest period. Enid gains in handling volumes about 9.2 million bushels, Ft. Worth gains only 0.3 million bushels, and Catoosa gains 1.1 million bushels. These handling and storage figures are the results of increasing harvest period railroad rates by five percent and either allowing or not allowing excess farm storage to be utilized in the model.

Finally, if the establishment of seasonal railroad rates induces shippers to store wheat instead of selling it at harvest, then the handling volumes at all three terminal locations decline and the storage volumes at Enid and Ft. Worth increase. For instance, if producers decide to continue selling in the harvest period only 90 percent of the wheat which they had sold in the base harvest period in response to a five percent increase in harvest period railroad rates, the harvest period handling volume at each terminal location drops by ten percent. Since country elevators have insufficient storage capacity to store all of the additional wheat which producers wish to store, some of this wheat must be moved to a terminal facility for storage during harvest.

With harvest period railroad rates increased by five percent above their present levels, two solutions of the model were compared, one with γ equal to 110 and the other with γ equal to 0.9. It was estimated that producers sold 23.8 million bushels of wheat in 1976. If they sold only 90 percent of this volume due to the establishment of seasonal railroad rates, an additional 2.38 million bushels of wheat would have to be stored during harvest. Country elevators could store only 0.53 million bushels of this additional volume. If the remaining wheat to be stored was sent to a terminal elevator, then the terminals at Enid would receive and store an additional 1.42 million bushels of wheat while Ft. Worth terminals would store an additional 0.43 million bushels.

Effects of Seasonal Railroad Rates on Utilization of the Transit Privilege

The declines in total railroad volume when harvest period railroad rates are increased, shown in Table VI, indicate the extent to which utilization of the rail transit privilege erodes due to rate competition in the study area. These declines are lessened somewhat when producers alter their marketing patterns to store more wheat during harvest rather than selling it. In this case, wheat railroad demand is shifted from the harvest to the non-harvest period. In effect, wheat shippers substitute non-harvest railroad service, rather than harvest nonrail service, for railroad service during harvest.

Table VIII illustrates that the utilization of the truck allowance, when railroad cars are in short supply and harvest period railroad rates are increased, declines even more rapidly than the utilization of the transit privilege. During car shortages, the Enid terminals receive even less wheat, for both handling and storage, during harvest since a large majority of shippers who would have transited wheat at Enid with adequate railroad service find that nonrail alternatives other than truck allowance have the next lowest rate after that of the railroad alternative.

One question that may arise is whether the railroad mode may continue to be used when seasonal railroad rates are established but without utilizing the rail transit privilege. The rationale for doing this is that the non-transit railroad alternative may be cheaper for movement two than the transit railroad alternative.

TABLE VIII

UTILIZATION OF THE TRUCK ALLOWANCE PRIVILEGES, PERCENTAGE OF RAILROAD SHIPPERS FOR WHICH TRUCK ALLOWANCE IS THE NEXT-BEST NONRAIL ALTERNATIVE

Movement	Harvest Period Railroad Rate Increase (%)				
	0%	3%	5%	7%	10%
M1	36.6%	19.8%	9.8%	1.1%	1.1%
M2	53.8%	33.1%	18.7%	.5%	.5%

For example, at a given location which can transit at Enid, let:

R = present export railroad rate to the Gulf (the through rate);

r = present domestic railroad rate to Enid;

e = present export railroad rate from Enid to the Gulf; and,

x - 1.0 = proportional increase in harvest period railroad rates.

The rate on the railroad transit alternative for moving wheat into storage at Enid during harvest is (R * x). The corresponding rate on the railroad, nontransit alternative is ([r * x] + e). Note that the export rate from Enid, e, remains at its present level since the second haul from Enid to the Gulf takes place after the harvest period.

The two rates are equal when:

$$R * x = (r * x) + e \qquad (8)$$

Solving (8) for "x" results in:

$$x = e \div (R - r) \qquad (9)$$

Equation (9) can be used to calculate the harvest period percentage increase in railroad rates which will equate the rates of the railroad, transit and the railroad, nontransit alternatives. The larger the difference (R - r), the smaller the percentage increase in harvest period railroad rates needed to equate the rates on the two alternatives.

At the present time, e = 39.6 cents per bushel. Hillsdale, Oklahoma, has one of the largest differences between R and r; at this location:

$$R - r = 42.0 - 15.6 \tag{10}$$

$$= 26.4 \text{ cents per bushel.}$$

With e = 39.6 cents per bushel and (R - r) equal to 26.4 cents per bushel, "x" in (9) equals 1.5. Harvest period railroad rates must increase at least 50 percent before a country elevator at Hillsdale, Oklahoma, will switch from transiting shipments of movement two to railing these shipments without using the transit privilege.

Since the rate difference of 26.4 cents per bushel is the largest in the study area, it is obvious that harvest period railroad rates must be increased much more than 50 percent before nontransit railroad alternatives become more attractive than transit rail alternatives at very many locations. It is also obvious, given the results of increasing harvest period railroad rates by only ten percent, that at increases of 50 percent and more nonrail alternatives will be cheaper than either of the railroad alternatives, transit or nontransit, at most if not all locations in the study area.

CHAPTER V

SUMMARY AND CONCLUSIONS

Introduction

The volume of wheat moving from country elevators in Oklahoma tends to follow a seasonal pattern. During harvest the traffic volume is relatively high as wheat is shipped to final markets for sale and to terminal elevators for storage. During the rest of the year after harvest, the average level of wheat traffic from country elevators is comparatively lower. Although wheat traffic volumes consistently have followed this seasonal pattern, railroad rates for wheat have remained fixed throughout the year.

The establishment of seasonal railroad rates for wheat has been made possible by the passing of the RRRRA of 1976. These rates are to be designed to achieve certain objectives of the Act; the primary objectives are to even wheat railroad demands over the year and to increase railroad revenues generated by wheat traffic. Smoothing the demand for rail service throughout the year will help alleviate some of the problems of recurrent freight car shortages. Increased railroad revenues will improve the cash-flows of railroads and, depending upon the nature of the railroad costs, may increase the profitability of wheat traffic. The probability of successfully achieving these objectives of the Act will determine whether railroads propose seasonal rates for wheat and whether the ICC approves these rate proposals.

The goal of this study is to examine the degree to which the objectives can be achieved by implementing seasonal railroad rates in Oklahoma's wheat transportation market and to estimate the effects of seasonal rates on the participants in this market. The method used focuses upon the transportation decisions made at country elevators. The volumes of wheat movements from each elevator in the harvest period and in the non-harvest period are estimated. These volumes are then assigned to the transportation alternative yielding the highest site price at each elevator.

The base solution represents a situation where all rates are set at their present levels and the volumes of each movement are held at their estimated, 1976 levels. The rates of all transportation alternatives can be adjusted by percentage increases or decreases to incorporate seasonality in the railroad rates and possible responses in the rates of competing transport modes. The volumes of each wheat movement can be adjusted to reflect increased utilization of on-farm storage capacity and decreased harvest period wheat sales by producers.

Summary of Results

Effects on Railroad Volumes and Revenues

If there are no changes in the volume of each wheat movement, then traffic diversion to or from the railroad mode is the principal effect of establishing seasonal railroad rates for wheat. As harvest period railroad rates are increased, traffic is diverted from the railroads to competing modes. For increases of from 3.0 to 10.0 percent, average own-price elasticities of railroad demand for wheat sold at harvest (movement 1) range from -2.6 to -3.7 and for wheat moved to terminal elevator storage at harvest (movement 2) elasticities range from -1.02 to -1.50. The elastic nature of railroad demand during harvest is reflected in the decline of total railroad revenues as rates are increased.

When harvest period railroad rates are increased ten percent, traffic diversion is sufficient to decrease total railroad revenues by $2.6 million. The amount of traffic diversion to the truck and truck-barge modes is sufficient to fully utilize the 600 trucks estimated to be available in the study area during harvest. If 1100 trucks are available during harvest, the ten percent increase in railroad rates will result in enough traffic diversion away from the railroad mode to decrease its annual revenues by $7.8 million, a loss of almost 21.0 percent of current railroad revenues attributable to Oklahoma-originated wheat traffic. Railroad rate increases in the harvest period can yield increased railroad revenues only if traffic diversions to competing modes are limited by rate increases of these competing modes.

When railroad rates are decreased in the non-harvest period, traffic diversions to the railroads from competing transport modes occur. However, railroad traffic additions do not offset the rate decreases; the own-price elasticity of railroad demand in the non-harvest period tends to be inelastic for rate decreases. Annual railroad revenues decline $1.4 million when railroad rates in the non-harvest period are decreased ten percent from their present levels. Rates on the alternative of trucking directly to the Gulf during this period are presently so low relative to railroad rates that the volumes of traffic diversion away from this alternative to the railroads are not enough to offset the railroad rate decreases.

Effects on Wheat Storage Volume

The volume of harvest period wheat shipments from country elevators can be reduced if the rate differentials between the harvest and the non-harvest periods created by seasonal railroad rates induce the storage of more wheat on the farms or in country elevators during harvest. A ten percent increase in harvest period railroad rates creates an average rate differential of 2.2 cents per bushel in the study area. How much this differential would increase the utilization of farm and country elevator storage capacity which is not presently used with fixed railroad rates has not been estimated in this study. However, it has been estimated that 26 million bushels of excess capacity was available just after the 1976 harvest.

If the excess farm and country elevator storage capacity is utilized to the fullest extent possible when harvest period railroad rates are increased by five percent, the total volume of wheat traffic moving from country elevators during harvest declines by 15.5 million bushels. A majority of this wheat is shipped by railroad after harvest since the limited number of trucks available in the study area in this period are fully utilized at the present time. Additional utilization of storage capacity during harvest makes railroad demand during harvest more elastic with respect to rate increases and railroad demand in the non-harvest period less inelastic with respect to rate decreases.

The annual economic incentives created solely by seasonal railroad rates to build new storage capacity are less than the annual capital costs of new capacity. Ten percent increases in harvest period railroad rates create at most 4.47 cents of gross annual benefits per bushel of new capacity; the lowest annual capital cost for new on-farm storage is 5.06 cents per bushel of space. Rate increases over ten percent are unlikely to create larger incentives due to the amounts of traffic diversion away from the railroad mode.

Effects on Producers' Transport Bill

The large volume of traffic diversion away from the railroad mode when harvest period railroad rates are increased limits the increase in the total transport bill paid by producers. This bill increases only 3.5 percent when railroad rates increase ten percent. However, the relative economic position of producers at different locations will be changed by railroad rate increases during harvest. Producers at locations continuing to ship by railroad during harvest will be at a disadvantage relative to producers at those locations which either do not presently ship by railroad during harvest or do presently use the railroad and switch to a nonrail alternative for less than a ten percent rate increase.

Effects on Terminal Elevators

Because the terminal elevators at Enid presently have a rate advantage only for railroad traffic, these facilities will experience declines in the wheat volumes they handle if harvest period railroad rates are increased. Ten percent increases in these rates will decrease Enid's harvest period handling volume from the study area by 9.1 million bushels; of this amount, 4.6 million bushels represent storage volume losses. The

Catoosa terminal facilities gain 2.3 million bushels of wheat formerly handled at Enid; the Ft. Worth terminals gain the remaining volume of Enid's handling losses.

Effects on Transit Utilization

When harvest period railroad rates are increased to high enough levels, the rates of the transit railroad alternative become higher than the rates of the nontransit railroad alternative. If this were the case, shippers would prefer the latter alternative over the former. However, rate increases of over 50 percent are required before this situation occurs at any location within the study area. Substantial traffic diversion from railroad to competing modes occurs at much lower levels of harvest period railroad rate increases. This traffic diversion will prevent the railroads from considering seasonal railroad rates which would eliminate use of the transit privilege by railroad shippers. However, if freight car shortages continue to occur when seasonal railroad rates are established, railroad shippers will not make use of the truck allowance privilege. Instead they will choose a less expensive, truck alternative for moving wheat when railroad cars are not available.

Conclusions

The results of this study indicate that rate competition is prevalent in Oklahoma's wheat transportation market. If seasonal railroad rates for wheat are established by rate increases during the harvest period, sufficient diversion of railroad traffic to competing transport modes occurs that railroad revenues decrease. Although this diversion tends to lower the level of railroad traffic relative to the non-harvest railroad traffic, this is achieved by reducing total traffic rather than by shifting traffic between periods.

Railroad wheat traffic presently moving during harvest may be shifted to the non-harvest period if producers are given sufficient economic incentives to store more wheat on their farms or in country elevators. Rate competition limits the magnitude of the incentives created by seasonal railroad rates. Rather than storing more wheat at harvest, shippers will continue to move the wheat during harvest but by a nonrail mode rather than by the railroad mode. In particular, rate incentives created by seasonal rates do not become large enough to cover the costs of building new storage capacity. The maximum incentive created by a ten percent increase in railroad rates is below the lowest estimate of new capacity cost; in addition, this maximum incentive only occurs due to the limited number of trucks in the study area during harvest. If sufficient aggregate trucking capacity was available, the maximum incentive would be lower.

The incentives created by increased harvest period railroad rates are greatest for those locations at which the peak railroad rate is lower than the rates of competing modes. Hence shifts in railroad traffic between the two time periods are most likely to occur at locations not switching to a nonrail mode when railroad rates are increased. The decline in total railroad revenues will be greater if shifts of traffic between periods occur at these locations than if shifts do not occur.

The prevalence of rate competition facing the railroads in Oklahoma's wheat transportation market will force the railroads, and the Interstate Commerce Commission, to evaluate the tradeoffs between seasonal ratemaking objectives in the RRRRA. Seasonal railroad rates on wheat can, to some extent, smooth out the seasonal demand for rail service over the year. However, total railroad revenues will decline when seasonal rates are established. Rate competition prevents both objectives, smoothing seasonal railroad demands and increasing railroad revenues, from being achieved simultaneously by implementing seasonal railroad rates for wheat in Oklahoma.

Though rate competition is prevalent in the study area as a whole, it is not equally present at all locations within the study area. The relative economic positions between shippers at different locations will be changed if seasonal railroad rates are established. When harvest period railroad rates are increased, shippers continuing to ship by railroad will be at a disadvantage relative to shippers who are not now shipping by railroad or to shippers who are able to switch to a competing, nonrail mode. When non-harvest railroad rates are decreased, it is the nonrail shippers not switching to railroad who are at a disadvantage relative to railroad shippers. Regardless of how seasonal rates are established, railroad shippers who are able to shift their harvest demands for transportation service to the non-harvest period will be at an advantage relative to railroad shippers who cannot shift their harvest period demands for transportation service.

The pattern of rate competition within the study area has resulted in the terminal elevators at Enid having a comparative rate advantage over the terminal facilities at Catoosa and Ft. Worth for drawing wheat from country elevators in the study area. This advantage is based upon the present railroad rates and their relationships to nonrail rates. Seasonal railroad rates, which alter these rate relationships, will change Enid's comparative advantage over the other terminals for drawing Oklahoma wheat. Since Enid is presently rail-oriented, it is in a situation similar to that of country elevators which presently ship by railroad: seasonal railroad rates which are established by increasing harvest period rates will result in Enid losing some of its advantage over Catoosa and Ft. Worth so that, compared to the present situation, Enid will be at a disadvantage.

It is possible that these conclusions concerning the effects on Enid's terminal elevators may be mitigated if seasonal railroad rates were established over a broader geographic region than the study area. Although Enid may be disadvantaged for drawing Oklahoma wheat relative to the present time, Enid may gain an advantage for drawing Kansas wheat if seasonal railroad rates are established in Kansas. Comparing truck rates to Enid to railroad rates at several Kansas points, it appears that increased harvest period railroad rates in Kansas may make trucking to Enid a cheaper alternative than the railroad alternative at points north and northwest of Enid in Kansas.

Establishing seasonal railroad rates over a broader geographic region may also alter the conclusions reached in this study for the railroads. The pattern of rate competition within a broader region may not be as pervasive as it is in Oklahoma; if this were the case, railroad revenue declines in the Oklahoma wheat transportation market resulting from seasonal railroad rates could be more than offset by revenue gains in the rest of the region. As is evident from the results of this study, the degree of modal rate competition varies widely among individual locations.

The rationale developed in economic theory for applying seasonal rates is based upon the presence of seasonal variation in the effective demand for railroad capacity. One principle of the theory of peak-load pricing is that all shippers in the peak season contribute to the peaking in demand for railroad capacity; all of these shippers should be subject to peak seasonal rates. In establishing that seasonal demand patterns exist, railroads should take into consideration not just the demands for railroad service of one commodity such as wheat, but they should also consider the service demands of any other commodity group which requires the same railroad capacity.

Finally, it should be noted that the models used in peak-load pricing tend to have fairly simplistic assumptions concerning the nature of demand. This study indicates that a much closer examination of the characteristics of railroad demand is needed in order to make use of peak-load pricing theory in seasonal ratemaking. In particular, for establishing seasonal railroad rates for wheat one must consider the presence and strength of rate competition between transport modes and the degree of railroad demand interdependencies between time periods.

Recently it has become evident that railroads will apply demand-sensitive rates in their grain transportation markets. The first rate tariff proposing demand-sensitive rates was filed on grain and soybeans. This tariff proposed the establishment of seasonal rates on grain between points in Indiana and Illinois and the Southern Territory. On September 14, 1977, the Interstate Commerce Commission (8) approved the tariff, thus initiating the new type of railroad ratemaking in grain transportation markets.

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APPENDIXES

APPENDIX A

REGULATIONS FOR SEASONAL RAILROAD RATEMAKING

ADOPTED BY THE INTERSTATE

COMMERCE COMMISSION

REGULATIONS ADOPTED

Title 49 - TRANSPORTATION
Chapter 10 - INTERSTATE COMMERCE
Sub Chapter B - PRACTICE AND PROCEDURE
Part 1109 - REQUIREMENTS AND PROCEDURES RELATING TO RAILROAD REVITALIZATION AND REGULATORY REFORM ACT OF 1976.
Part 1109.10 - STANDARDS AND EXPEDITIOUS PROCEDURES FOR ESTABLISHING RAILROAD RATES BASED ON SEASONAL, REGIONAL, OR PEAK-PERIOD DEMAND FOR RAIL SERVICES.

Amend 49 C.F.R. §1109 by adding thereto as follows:

§1109.10 Standards and expeditious procedures for establishing railroad rates based on seasonal, regional, or peak-period demand for rail services.

a) Purpose. This regulation establishes standards and expeditious procedures designed to promote rates which are intended to 1) provide sufficient incentive to shippers to reduce peak-period shipments, through rescheduling and advance planning; 2) generate additional revenues for the railroad; and 3) improve (i) the utilization of the national supply of freight cars, (ii) the movement of goods by rail, (iii) levels of employment by railroads, and (iv) the financial stability of markets served by the railroads, as required by section 15(17) of the Interstate Commerce Act.

b) Definition. The term "demand-sensitive rate" means a rate or charge that is proposed for the purpose of influencing seasonal, regional, or peak-period demands for rail services.

c) Title Page. In addition to requirements of 49 C.F.R. 1300.3, the title page of publications containing demand-sensitive rates must show the following notation:

"This tariff (or supplement or loose leaf amendment) contains a demand-sensitive rate (see item(s) _______) within the meaning of 49 C.F.R. 1109.10(b)."

d) Letters of Transmittal. When a tariff, supplement or loose leaf amendment containing a demand-sensitive rate is accompanied by a transmittal letter, the letter shall bear the following notation:

"This tariff (or supplement or loose leaf amendment) contains a demand-sensitive rate (see item(s) _______) within the meaning of 49 C.F.R. 1109.10(b)."

(e) Standards. In furtherance of the policy of the Congress as declared in section 101(b) of the Railroad Revitalization and Regulatory Reform Act of 1976 and as reflected in section 202(d) of that Act, the Commission considering tariffs filed under this section shall be guided by:

(1) The need to encourage the establishment of demand-sensitive rates and incentives to the shippers;

(2) The need to encourage ratemaking innovation by railroad management;

(3) The need to permit changes to or rescissions of a demand-sensitive rates as required by changes in the circumstances which prompted establishment of the rate;

(4) The need to assist the railroads in attaining adequate revenue levels; and,

(5) The need to improve (i) the utilization of the national supply of freight cars, (ii) the movement of goods by rail, (iii) levels of employment by railroads, and (iv) the financial stability of markets served by the railroads;

(6) The ability of the affected industry within a specific area to react positively to the proposed demand-sensitive rate consistent with statutory goals; and,

(7) when the cancellation of a demand-sensitive rate is at issue, shippers' investment made for the purpose of availing themselves of the incentive offered thereunder will only be considered where:

(i) the rate has been in effect for at least two years without substantial change; or

(ii) the shipper can show that the carrier has made representations regarding the duration of the rate schedule and that the shipper has in fact relied on such representations to his detriment.

(f) Justification Statements. Justification statements may be filed concurrently with seasonal, regional, or peak-period tariffs to show that the proposed rates fall within the purview of

§1109.10(a). Information of the type specified in §1109.10(i) if included in the justification statement, would assist the Commission in its initial evaluation of the proposal.

(g) Protest(s) and Investigation. Protests to a tariff (or supplement) making reference on the title page to §1109.10(a) must be verified and filed in accordance with §1100.42(f). In the event of investigation or suspension, these proceedings will be accorded priority, and modified procedure (49 C.F.R. §1100.45 to 1100.54), to the extent feasible, will be followed.

(h) Cancellation of a Demand Rate. A demand rate published pursuant to this section may be cancelled on 30 days' notice and the cancellation supplement will not be suspended within three years of the data of its initial publication, unless an affected shipper makes a showing pursuant to Section 1109.10(e)(7).

(i) Reply to Protest. Replies to protests of rate proposals under this section should be filed and served promptly in accordance with §1100.42(e). Respondents are urged to submit the cost and revenue date specified in §1109.10(i) unless previously furnished under §1109.10(f).

(j) Initial Statement. In order to expedite the proceedings in the event of the suspension of tariff schedules, setting forth seasonal, regional or peak-period rates or in the event that investigation without suspension of such schedules is ordered, respondent railroad or railroads shall submit in writing, under verification, within 20 days following service of the order of suspension or investigation cost and revenue data of the type hereinafter specified.

(1) Definitions.

(i) "Traffic at Issue" is that traffic affected by the proposed seasonal, regional or peak-period rates. For seasonal or peak-period rates it includes similar traffic handled during the so-called "off-seasonal" or "off-peak" periods.

(ii) "Study period" is defined as follows:

For seasonal or peak-period rates, the study period shall consist of the 12-month period ending on the last effective day of the seasonal or peak-period rates. For example, if the seasonal or peak-period rates are effective July 1 through September 30, 1976, the "study period" shall be October 1, 1975 through September 30, 1976. Based on the foregoing, the "off-season" or "off-peak" period will be that period from October 1, 1975 through June 30, 1976.

For regional rates, the study period shall consist of a 12-month period, the first month of which shall not percede by more than 15 months the date on which the tariff proposal is filed.

(2) Cost and Revenue Data.

(a) For seasonal or peak-period rates, cost and revenue data shall include: (but see 1109.10(j)(4) below)

(i) The Seasonal or Peak-Period (Specify Period), indicating

(a) The total variable costs and total revenues (in dollars), assuming the proposed seasonal or peak-period rates were in effect for the specified period; and, the revenue-to-variable cost ratio (percent) resulting therefrom, and

(b) The total variable costs and total revenues (in dollars), assuming the proposed seasonal or peak-period rates were not in effect for the specified period; and, the revenue-to-variable cost ratio (percent) resulting therefrom.

(ii) Off-Seasonal or Off-Peak Period (Specify Period), indicating the actual or estimated total variable costs and total revenues-to-variable cost ratio (percent) resulting therefrom.

(iii) Full Study Period (Specify Period), indicating the total variable costs and total revenues (in dollars) for the full study period, and the revenue to variable cost ratios (percent) resulting therefrom, based on a combination of (2)(i)(a) and (2)(ii) on the one hand, and (2)(a)(i)(b) and (2)(a)(ii) on the other hand.[1]

(b) For regional "all year" rates, cost and revenue data shall include:

(i) The total variable costs and total revenues (in dollars) for the one-year study period, assuming the regional rates were in effect, and

(ii) The total variable costs and total revenue (in dollars) for the one-year study period, assuming the proposed rates were not in effect.

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[1]Cost/revenue comparisons are to be submitted for the seasonal or peak-period, off-season or off-peak period and full study period. This will enable the Commission to examine the data on an annual basis, so that costs for a portion of the period would not necessarily be controlling.

(3) Accompanying Explanation. A full explanation of the methods, procedures and data used to determine the total variable costs and total revenues as required in items (2) above shall be submitted.

(4) Alternative Data. The submission of the above evidence represents data which the Commission believes would provide a basis for meaningful analysis of the lawfulness of such rates. However, respondent railroads may justify their proposal on the basis of other relevant evidence or cost levels. A full explanation of the methods and procedures used shall be provided.

(k) Reporting Requirements. Commencing with the year ending December 31, 1976, and for subsequent years thereafter, until further order, all common carriers by rail, subject to section 20, Part I of the Interstate Commerce Act, shall submit annual information reports showing those seasonal, regional, or peak-period rates published in accordance with section 15(17) of the act, the total milage hauled, tonnage carried, and revenues derived therefrom compared with the same statistics from the preceding year. In addition, these reports, which shall be filed with the Commission within 45 days following the last day of the effective seasonal, regional, or peak-period rates, as defined by §1109.10(a), shall show whether the rates accomplished their intended purpose.

APPENDIX B

QUESTIONNAIRE USED IN STUDY

Questionnaire

1. What is the name and location of your elevator? ________________

____

2. What is the current licensed storage capacity of your elevator?

________________ bu.

3. How much of this capacity is typically reserved for working space?

________________ bu.

4. What were the total wheat volumes received by your elevator in the two reporting periods covering the 1975 and the 1976 harvest periods?

1975 ________________ bu.

1976 ________________ bu.

5. Approximately what percentage of the total wheat volumes was received during the months of June and July?

1975 ________________ %

1976 ________________ %

6. What were the in-house stocks of wheat held on June 1st?

1975 ________________ bu.

1976 ________________ bu.

7. What were the in-house stocks of all other grains held on June 1st?

1975 ________________ bu.

1976 ________________ bu.

8. Approximately what percentage of the wheat received at harvest is sold by the producers during that harvest period?

________________ %

9. What is the volume of on-farm wheat storage currently used by farmers in the area served by your elevator?

________________ bu.

APPENDIX C

EQUATIONS USED TO ESTIMATE VOLUMES AND CAPACITIES OF NONRESPONDING ELEVATORS

The following equations were used to estimate values for the working space, carryover stocks of wheat on June 1, 1976, carryover stocks of grains other than wheat on June 1, 1976, and on-farm storage capacity at each country elevator in the study area which did not respond to the questionnaire (Appendix B).

The explanatory variables used in these equations are:

SC = current licensed storage capacity (1000 bushels);

VR75 = volume of wheat received in the 1975 harvest period (1000 bushels);

VRAH75 = volume of wheat received after the 1975 harvest period (1000 bushels);

PR75 = proportion of the total volume of wheat received in the 1975 crop year which is received during the 1975 harvest period (1000 bushels);

TRY75 = volume of wheat received in the 1975 crop year divided by the storage capacity; and,

X = 1 if elevator is cooperatively owned,
= 0 if elevator is privately owned.

Immediately below each equation is the coefficient of multiple correlation (R^2) and standard error of each coefficient. "*" signifies significance at the five percent level.

Working Space (1000 bushels):

(1) WS = 8.865 + 0.0422 (SC) + 0.02668(VR75).

R^2 = .42 (0.0118)* (0.00970)*

Wheat Carryover Stocks in 1976 (1000 bushels):

(2) WHST76 = -1.194 + 0.1782(SC) + 31.234(X)

R^2 = .42 (.0223)* (16.378)

Grain Carryover Stocks in 1976 (1000 bushels):

(3) GRST76 = -9.644 + 0.0484(SC) + 0.000042$(SC)^2$

R^2 = .30 (0.0390) (0.000024)

On-Farm Storage Capacity (1000 bushels):

(4) OFSC = -410.576 + 1.5517(VRAH75) + 6.7711(TRY75) + 466.159(PR75)

R^2 = .29 (0.3069)* (3.7371) (304.113)

VITA 2

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Master of Science

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