IMPACTS OF SEASONAL RAIL RATES ON GRAIN FLOWS AND STORAGE IN NORTH DAKOTA

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HIGHLIGHTS

The impact of seasonal railroad rates on grain shipments and storage during 1967-1974 is reported in this research report. Two levels of seasonal rates were in effect from 1967 through 1974 during the period for which flow data were available. North Dakota is the only grain originating area where seasonal rates have been in effect and where data on seasonal flows of grain are available.

Seasonality of grain production and off-farm sales of grain by farmers have resulted in rail car shortages during peak demand periods and frequently underutilization during off-peak periods since rail service was initiated. Seasonal rail rates that are higher during peak demand periods and lower during nonpeak periods have been suggested as an incentive to even out the flow of grain, improve the productivity and profitability of railroads, and reduce the seriousness of harvest-time rail car shortages.

Major conclusions of the study were that seasonal rates were not effective in modifying the significant seasonal flows of rail grain shipments. In fact, seasonality of rail grain flows became more pronounced during the study period, presumably due to changes in exogenous variables. For example, the average monthly index for August increased from 109 in 1967 to 151 in 1979. Results from the demand estimation equation reveal that peak rail rate differentials used during the study period would affect seasonal grain flows only slightly. Truck shipments also were seasonal, but the peaks and valleys were not as pronounced as for rail movement.

Grain movements via rail were more sensitive to truck costs than to rail rates, while the demand for truck transportation was elastic to both rail rates and truck costs.

Construction of new on- and off-farm grain storage was unaffected by seasonal rail rates. Other factors seemed more important than seasonal rail rates. Farmers would have to receive a seasonal discount of at least 19.2¢/bu. to compensate for storage costs if all other factors were constant. Grain marketing personnel were opposed to seasonal rates because of the added complication to their work, a feeling that such rates would not work, and the fact that there was a year-round railcar shortage anyway. They felt seasonal rates were of minor importance among the many factors influencing the timing of grain sales. Results of this study confirm this attitude.

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William W. Wilson, Steven C. Hvinden and John G. Cosgriff*

INTRODUCTION

Reported in this bulletin is an analysis of the influence of seasonal rail rates on the movement of wheat, transport modes, and on location of storage facilities. Specific objectives were to describe the historical conditions associated with seasonal rail grain rates in North Dakota; to check for trends and seasonality patterns in grain flows from North Dakota and for trends in storage capacity and grain inventory locations; to evaluate the extent to which seasonal rates have affected the modal share and timing of grain shipments and location of new grain storage capacity; and to identify economic incentives provided by different levels of seasonal rates and attempt to gauge their influence on grain flows from North Dakota.

The Railroad Revitalization and Regulatory Reform Act (4R Act) of 1976 directed the Interstate Commerce Commission to look with favor on seasonal and regional peak period rates that might smooth seasonal and cyclical rail service demands, encourage new investments by shippers to even out demands, and generate new revenues for railroads (15). Agriculture may be directly affected by such rate proposals. Railroads have always had the right to propose seasonally differentiated rates, but

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North Dakota is the only grain originating area where seasonally differentiated rates have come into use for more than a limited trial period.

Seasonal rail rates were first introduced for North Dakota origins in 1963. A further downward adjustment in off-season rates was made in 1971. In December 1974, seasonal rates were canceled.

Analysis of the impacts of the on-again/off-again seasonal rate structure is made possible by extensive grain flow data available since 1967 from the North Dakota Public Service Commission through the Upper Great Plains Transportation Institute. Thus the impacts of the seasonality feature of rail rates can be analyzed for the August 1967-November 1974 period and nonseasonality of rates from December 1974.

History of North Dakota Wheat Rail Rates

The oldest existing wheat rates in North Dakota are those prescribed on July 1, 1930 by the Interstate Commerce Commission (ICC) in Docket 17000, Part VII, Grain and Grain Products (8). These rates, increased by the various general increases, are still in effect in North Dakota today. In addition to establishing the rates in Docket 17000, the ICC also prescribed the services that the railroads were to provide under this rate structure. The rates have thus become known as the full-service rates. Services provided under the Docket 17000 rates include "standard free time for loading and unloading; diversion and reconsignment; one or more stops in transit for milling, cleaning, sacking or storing at interior points or the markets; and one free stop en route for the purpose of inspecting the grain to obtain grade" (5). Although the Docket 17000 rates are still in effect in North

Dakota, very little--if any--wheat has moved under these rates since 1960.

Responding to severe unregulated motor carrier competition in the early 1960's, the railroads established reduced rates for grain and grain products originating from some North Dakota stations. These rates, referred to as Group 3 rates, took effect in 1960 and, unlike Docket 17000 rates, provided for an additional charge for inspection stops (6).

The railroads serving North Dakota first introduced a seasonality feature into their grain gathering freight rate structure in 1963. The purpose of the seasonal adjustments was to reflect the differences on demand for rail transportation during the two different shipping seasons of November through May and June through October of each year. Ancillary services remained unchanged.

Group 3 rates were lowered approximately 10% in 1963 from North Dakota origins (except in the extreme eastern portion of the state) for the winter months. The reduced rates offered from November through May were then referred to as Group 4 rates. The Group 4 rates (November-May), like the Group 3 rates (June-October), were not "full service rates" since they included an additional charge for en route inspection not found under the Docket 17000 rates. A majority of the rail wheat movement until 1971 was moved under Group 3 and Group 4 rates.

Once again in response to intensive motor carrier competition, the railroads on December 11, 1971 reduced rates from North Dakota to Minneapolis and Duluth. This adjustment applied only to wheat and wheat products and changed the accessorial services available to shippers reducing the carriers' cost of gathering grain and, thus, permitted substantial rate reductions to be made without loss of earning to the carriers. The 1971 adjustment reduced the Group 3 and Group 4 rates approximately 25% and changed the seasonal period to June, July, and August for the summer rates. However, to preserve rail revenues, services were drastically cut under the new "restricted service" or "frill free" rates.

Reduction in services by the three railroads which accompanied their 1971 wheat rate reductions is summarized as (3):

1. The Burlington Northern's frill-free rates, summer and winter, are restricted . . . as follows:

   Rates apply only on wheat, wheat flour, and mill feed. Minimum weight is not less than 80,000 pounds; whereas, Docket 17000 rates are 80% of marked capacity but not less than 50,000 pounds.

   No inspection en route, sampling, diversion, or reconsignment privileges.

   Bill of lading to be tendered at origin . . . No subject to standard demurrage rules. Car must be loaded and bill of lading showing consignee, destination station, and destination industry must be tendered at origin station within 10 daylight hours [from when it is spotted].

Twenty-four consecutive additional hours for loading will be allowed at the charge of $50 for boxcars and $80 for hopper cars.

Forty-eight hours are allowed for unloading with one credit given for unloading within 24 hours and one debit given for each day beyond 48 hours and an excess of debits over credits at month end to be charged $30 per excess. Milling, cleaning, or blending is allowed.

2. Soo Line provisions . . . are essentially the same as the Burlington Northern except that:

   An additional 24 hours for loading at origin at cost of $50 for boxcars and $80 for hopper cars is not allowed.

   Instead, the shipper may . . . load and bill the car to destination within 10 daylight hours and furnish name of unloading elevator by 4:00 p.m. the next day. He will have to pay an additional $50 on a boxcar and $80 on a hopper car.

3. The Milwaukee's adjustment provides:

   Not less than 100,000 pounds minimum weight. No transit for milling or storage is allowed.

One stop for inspection en route or one diversion or reconsignment, but not both, is allowed without further charge.

Forty-eight hours are allowed for loading and there is no usual $50-$80 charge for 10 hours restriction. Holding for loading beyond 48 hours is subject to standard demurrage rates.

The railroads rationale for retaining the seasonality feature under the new "restricted service" rates was the same as in 1963. Basically, the railroads perceived that the quantity demanded for rail transportation exceeded supply in the summer months, while the opposite was true during the winter months. Therefore, the seasonal rates were developed to discourage shipments during periods of heavy demand and encourage shipments during weak demand periods. A more balanced rail movement throughout the entire year allowing more efficient utilization of equipment was the desired result.

North Dakota, in 1971, had three rate structures applying to wheat and wheat products.

1. Docket 17000 or "full service" rates were the highest but included a number of accessorial services.
2. Group 3 and Group 4 rates were lower than the Docket 17000 rates but did not allow a free stop for inspection.
3. The new "restricted service" summer and winter rates that were approximately 25% less than Group 3 and Group 4 rates but had drastically reduced accessorial services.

Wheat shippers in North Dakota could choose, to some extent, the rate and service level that they desired. After 1971, however, the majority of North Dakota's wheat moved under the "restricted service" rates.

In the spring of 1974, the railroads initiated a case before the Interstate Commerce Commission to repeal the lower winter rates, thus establishing the higher summer rates on a year-round basis.

On December 1, 1974, the railroads were allowed to cancel their winter level restricted service rates and raise them to the summer level. Shippers protested the cancellation of the winter rates arguing that the railroads had not restored services when they were allowed to raise their rates the year around to the summer restricted service level. Although the case involving the winter rates is still under litigation, "summer" restricted service rates now apply year around from North Dakota origins (5).

The basic argument put forth by the railroads in support of the cancellation of the winter rates was that "the seasonal marketing of grain which justified the seasonal variations in the gathering grain rates structure no longer exists (4)." Specifically, Burlington Northern argued (4):

1. That during the 22-month period from September 1972 to July, 1974, "there was not enough seasonality of movement to create a car surplus in the Twin City Region, except on June 3, 1974 and that surplus disappeared even though the higher-rated summer season was entered."

2. ". . . that there is no visible relationship between the prices of various grains and the railroad's seasonal application of rates."

3. That with the wide swings in prices (from January 1972 to July 1974), it has become impossible to level out movements of grain by varying freight rates.

4. " . . . that an increase in storage capacity over the past years demonstrates that the farmers now have the ability to store grain on the farm at harvesttime . . . this capacity to store grain in large quantities at harvest also negates the rationale for seasonal rates' existence."

Overall, the railroads perceived in 1974 that the quantity demanded for rail transportation exceeded supply or was strong enough year round to negate their incentive to encourage shipments during the winter months and discourage shipments during the summer months.

From 1974 to present, the wheat rate structure has remained basically the same. The majority of the wheat transported by rail from North Dakota moves under the restricted service summer rates subsequently increased under various general rate increases since 1974.[1]

Seasonal Demand and Peak Period Pricing

The movement of North Dakota wheat exhibits a strong seasonal pattern (Fig. 1). Wheat growers typically ship more grain in the summer and fall (peak period) compared to the winter months (trough period) as farmers are liquidating current inventories to make storage available for the new

[1]There have also been some minor rate adjustments on wheat from some origins in extreme eastern North Dakota.

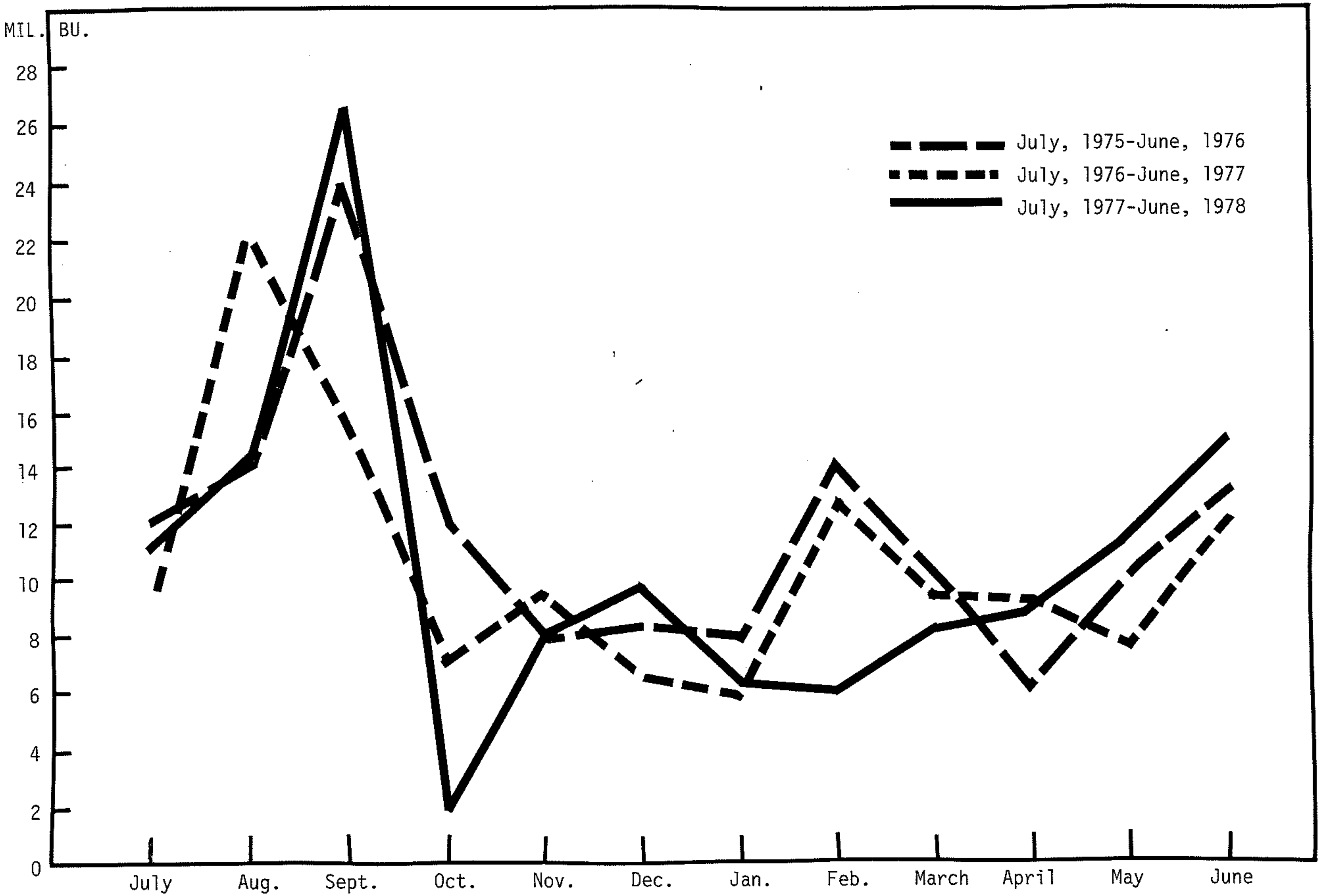

Figure 1. North Dakota Hard Red Spring Wheat Shipments by Month, 1975-78.

Source: (18)

crop and also are marketing some of the new crop. This situation creates a capacity problem for the railroads. If railroads have enough capacity to handle the peak-period demand, overcapacity will exist during the trough period. If they have only enough capacity to handle the trough period, a car shortage will develop during the peak period.

Car shortages in the past have been rationed by car service orders and railroad car allocation schemes. Under a free market system, the pricing mechanism could also be used to ration the supply of cars and possible result in a more efficient allocation of resources. Rail rates would depend upon the shifts in demand relative to the supply of cars. Rates would be relatively low during the trough period and would increase as the peak-period demand approaches or exceeds supply.

Potential rail traffic may have been lost to other modes, such as unregulated trucks, because of the inability of railroads to lower rates in periods of trough demand. Shippers may have been forced to pay a higher price during the trough period since railroads have been unable to adjust their rates according to shifts in demand. Railroad revenues may have been lost because of the inability of railroads to raise rates during peak-demand periods.

The 4R Act encouraged more reliance on the free market in the determination of rail rates. Specifically, the act encouraged experimentation and establishment of rates based on seasonal or peak-period demand for rail services. The goals of these rates included: (1) reduced peak-period shipments, (2) additional railroad revenue, and (3) improvement of (a) the utilization of freight cars, (b) the movement of goods by rail, (c) railroad employment, and (d) financial stability of markets served by railroads (15).

Definition of Peak-Period and Seasonal Rates

It is important to distinguish between rates based on peak-period and seasonal demand.[2] Peak-period demand implies variations in demand where a period of high demand (peak period) is followed by a period of low demand (trough period). This peak and trough pattern of demand recurs over time, but is not necessarily "periodic" in the sense of recurring at any particular interval. Additionally, the duration of any peak or trough need not correspond to the duration of any other peak or trough. An example of an irregularly occurring peak-period demand is the variation in demand generated by large grain shipments due to international sales.

Seasonal rates, on the other hand, are a particular kind of peak-period rates. Seasonal demand implies variations in demand that are regularly recurrent generally at some particular time of year. For example, the peak demand for harvest workers may occur in September of each year. Also seasonal demand generally lasts for a particular length of time.

Examples of Peak-Load Pricing

A familiar example of rates based on peak-period demand (also seasonal demand) is the telephone rates system. When the bulk of the pressure is being placed on the telephone system between 8:00 a.m. and 5:00 p.m.,

[2]Discussion concerning peak-period and seasonal rates, necessary conditions for seasonal rates, implication of railroads' inability to peak-load price, and examples of peak-load pricing are based on (13 and 17).

rates are high. Between 5:00 p.m. and 11:00 p.m. when the demand is less, rates go down; and they become lower still after 11:00 p.m. Low weekend rates also exist, but increase after 5:00 p.m. on Sunday which is a popular time for personal calls.

Peak load pricing has been frequently used in the airline industry. Simat, Helliesen, and Erichner, Inc., examined the experience of Southwest Airlines with peak-period rates. The airline initiated a weekday fare (peak period) and an evening and weekend fare (trough period). The weekday fares were 40% higher than the weekend and night fares. As a result of this peak-load pricing policy, Southwest had a higher percentage of seats occupied on its night and weekend flights than it does on its weekday flights. Total traffic also went up considerably in all markets where this pricing policy was used. This example indicates that peak-load pricing diverted traffic from the peak to the trough and resulted in the capacity being more fully utilized. It also demonstrated that increased volume in a decreasing cost industry allowed Southwest's peak-period rates to be less than the year-round regulated rates of other carriers.

Carlin and Park investigated peak-period pricing with respect to airport congestion. Small private aircraft were tying up airport capacity when it was needed by commercial flights at LaGuardia Airport in New York. The minimum take-off fee was increased from $5 to $25 between 8:00 a.m. and 10:00 a.m., Monday through Friday, and between 3:00 p.m. and 8:00 p.m. every day. General aviation apparently reduced activity as much as 40 percent during the hours when the $25 minimum applied.

Transportation fares in some cities are based on peak-period pricing. In Philadelphia, ConRail issues yellow and green tickets; the green tickets can be used only in the off-peak period and are cheaper than the yellow peak fare tickets. This pricing policy is designed to discourage peak use by discretionary travelers (shoppers, etc.) and encourage off-peak use. The Washington, D.C. Metro System charges $.55 for a peak-period ride and $.40 for an off-peak ride. Cabs in Washington, D.C. have a $.50 surcharge for passengers in the peak-period. The Philadelphia-Lindenwold High Speed Line offers free parking after the morning rush hours in its pay parking lots to encourage off-peak use.

A road-user pricing policy was initiated in Singapore to try to reduce downtown traffic during the morning rush. An auto had to have a sticker on it in order to enter the downtown area during the morning peak period. The stickers could be purchased at $1.50 per day, a high price given the standard of living in Singapore. Parking rates also were doubled. The net result has been that the number of cars entering downtown during the morning peak has been reduced by more than half.

Trends and Seasonal Patterns

Grain Flows and Seasonality

Inherent in the production and marketing of grain is the fact that grain flows tend to be seasonal. The nature and extent of seasonality in grain movements from North Dakota during the 1967-78 period is described and analyzed in this section. Seasonal aspects of grain prices are evaluated as well. Grain movements analyzed are hard red spring (HRS) wheat shipments from North Dakota to all destinations from August 1967 to November 1978. Rail and truck movements are evaluated separately. Prices for HRS wheat are also evaluated for seasonality from January 1967 through December 1977.

A multiplicative time series model was used to calculate monthly indexes to determine the nature and extent of seasonality. There are four components for each data series: trend (T), cyclical (C), seasonal (S), and irregular (I). The raw data, being composed of these four components, are commonly represented as TCSI.

The remainder of the analysis entails decomposing the data so that the seasonal (S) component can be examined specifically. To do this, a 12-month moving average of the original series was calculated which cancels out the effect of seasonal highs and lows and represents the trend-cycle (TC) component of the raw data. The original series (TCSI) is then divided by the 12-month moving average (TC) in order to determine the seasonal-irregularity (SI) component for each month. In order to isolate the seasonal (S) component, the SI factor is averaged for each month over several years. The effect of the averaging is to cancel out the irregular (I) factor so the seasonal index can be examined specifically. These monthly indexes should be interpreted as the percentage of the annual average.

The specific procedure used in this project was the X-11 Seasonal Adjustment Program distributed by the U.S. Bureau of the Census, Economic Research and Analysis Division. The X-11 program is similar to the decomposition procedure described above with the two exceptions. First, it uses either a 9, 13, or 23 term weighted moving average, depending on the irregularity of the data for establishing the trend-cycle curve. A 13 term moving average was used in this analysis. Second, extreme values of the SI ratio are replaced or modified depending on the number of standard deviations the particular percentage departs from the mean.[3]

Results of the Time Series Analysis

Rail Movements

Monthly HRS wheat rail movements and the SI ratios (average over the time series by month) are given in Table 1. SI ratios should be interpreted as the percent of moving average (after the trend/cyclical component has been removed) and indicate the nature of seasonality in the series. Months with peak movements are June, August, September, October, and November as indicated by the SI ratios. For example, the SI ratio indicates that August movements are 152% of the annual monthly amount. Off-peak movements, as expected, are the winter months.

In Table 2, the SI ratios over the series are reproduced by month. Analysis of variance was used to determine whether variability in the monthly movements are in fact seasonal or due to chance. The hypothesis to be tested is that the means of the SI ratios are equal among months or, alternatively, the means are unequal thereby implying seasonal movements. The calculated F ratio is 12,294 which is greater than its theoretical value at the 1% level of significance so the null hypothesis is rejected.

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[3]A more detailed explanation of the time series decomposition procedure in general and the X-11 package in particular can be found in (12 and 14).

TABLE 1. AVERAGE MONTHLY MOVEMENTS AND SEASONAL-IRREGULAR (SI) RATIOS FOR HARD RED SPRING (HRS) WHEAT BY RAIL FROM NORTH DAKOTA, 1967-78.

Month	HRS Wheat Movement*	Unmodified SI Ratio**
	(million bushels)	
January	5.99	74
February	5.78	75
March	6.53	80
April	6.20	81
May	6.16	76
June	8.15	103
July	7.40	95
August	11.04	152
September	12.06	167
October	9.21	120
November	9.04	119
December	6.79	86

*Average monthly movements for 1967-78.

**Average monthly SI ratios for 1967-78.

The conclusion is that monthly movements are significantly different from each other and not due to chance.[4] HRS wheat flows are seasonal with the peaks and troughs as shown in Table 1.

Seasonal indexes for each month with the irregularity component removed are reproduced in Table 3. The nature and amplitude of seasonality in rail grain movements has changed through time, particularly the movements from June through December. June, July, August, and September have always been months with peak movements but their magnitude has increased since 1967. For example, the monthly index for August has increased steadily from 109 to 151. Offsetting this increase is the decreasing

[4]Analysis of Variance was applied to the SI ratios because the S ratios are smoothed for irregularity and consequently, testing of hypotheses using S would be inappropriate.

TABLE 2. SI* RATIOS BY MONTH FOR HRS WHEAT RAIL MOVEMENTS FROM NORTH DAKOTA, 1967-78.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1967	--	--	--	--	--	--	--	104	140	130	130	55
1968	81	69	117	72	76	93	117	98	114	156	134	102
1969	66	70	84	85	79	89	108	112	157	115	76	109
1970	90	66	69	91	70	80	93	128	190	114	165	60
1971	63	63	133	89	69	104	65	265	209	71	114	92
1972	71	78	90	76	65	125	68	165	116	122	108	107
1973	103	75	61	83	112	117	93	121	127	109	110	112
1974	94	77	82	98	57	98	71	117	196	212	170	79
1975	64	57	87	101	78	91	105	132	257	121	82	76
1976	70	85	86	45	82	111	86	268	220	87	87	76
1977	58	131	97	81	60	117	116	162	129	110	132	76
1978	54	57	78	72	90	108	125	153	142	95	125	--
Average	74	75	89	81	76	103	95	152	167	120	119	86

*SI is the seasonal irregular component and indicates the nature of seasonality. It should be interpreted as the percent of the moving average.

trend of seasonal factors for October, November, and December. This implies that railway attempts to reduce the peak-load problem using the price system have been ineffective.

Examination of the monthly index for August indicates that its average rate of increase was 5.5 index points/year from 1967 to 1971 but only 1.41

TABLE 3. MONTHLY SEASONAL COMPONENTS FOR HRS WHEAT RAIL MOVEMENTS FROM NORTH DAKOTA, 1967-78*.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1967	--	--	--	--	--	--	--	109	146	131	127	103
1968	77	68	87	84	74	90	100	111	152	129	127	101
1969	75	68	86	83	73	93	96	118	157	125	124	101
1970	76	69	83	83	72	98	91	125	159	120	120	101
1971	79	70	80	84	70	102	85	131	161	117	119	101
1972	80	71	78	87	69	105	81	134	164	115	115	98
1973	81	72	79	87	69	106	81	135	166	115	112	93
1974	80	73	81	88	69	107	87	136	167	113	109	89
1975	76	73	83	87	71	107	93	139	170	110	110	84
1976	70	72	85	86	73	106	101	143	169	107	110	79
1977	64	71	86	83	76	107	106	148	168	104	110	77
1978	62	71	87	81	78	109	108	151	165	101	110	--

*Derived from an average of the SI component using a 3-term moving average for each month. Data for the leading seven months of 1967 were unavailable.

from 1971 to 1974--the time in which seasonal pricing was used. The rate of increase rebounded to 3.10 per year after the seasonal rates were suspended. Whether this dampening of the rate of increase can be attributed to seasonal pricing cannot be determined from the analysis.

Motor Carrier Movements

Table 4 contains the monthly average motor carrier shipments of HRS wheat from North Dakota as well as the calculated SI ratio. The results indicate that the peak months are June through November, the off-peak being the remainder of the year. Note that the peaks and valleys for truck movements are not as extreme as those for rail. This supports the contention that trucks, due to their price flexibility and equipment mobility throughout the year, have the ability to even out their movements and make better use of their capacity.

TABLE 4. AVERAGE MONTHLY MOVEMENTS AND SI RATIOS FOR HRS WHEAT BY MOTOR CARRIER FROM NORTH DAKOTA, 1967-78.

Month	HRS Wheat Movement*	Unmodified SI Ratio**
	(million bushels)	
January	2.46	81
February	2.72	88
March	2.97	97
April	2.73	87
May	3.05	94
June	3.40	107
July	3.69	114
August	4.13	129
September	3.73	120
October	3.01	101
November	3.17	100
December	2.84	93

*The average monthly movements are averaged by month over the years 1967-78.

**The average monthly SI ratios are averaged by month over the years 1967-78.

In Table 5, the SI ratios for each month are reproduced. Analysis of variance was used to test whether the seasonality effect was significant. The calculated F is 4.622, significant at the 1% level, which indicates that the movements are seasonal.

TABLE 5. SI RATIOS BY MONTH FOR HRS WHEAT MOTOR CARRIER MOVEMENTS FROM NORTH DAKOTA, 1967-78.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1967	--	--	--	--	--	--	--	102	118	99	103	73
1968	93	87	104	89	93	114	128	114	93	108	97	83
1969	87	95	100	78	91	103	137	120	119	98	91	128
1970	96	75	89	106	85	114	109	121	119	108	108	92
1971	82	76	90	81	83	136	114	135	119	98	119	101
1972	60	83	83	93	97	81	124	168	129	94	79	77
1973	55	105	113	88	148	22	77	150	128	101	105	105
1974	119	70	124	53	40	105	93	91	146	186	162	94
1975	77	65	75	94	101	112	120	124	151	99	71	80
1976	72	99	99	69	104	143	106	165	89	74	97	85
1977	70	143	94	110	102	138	110	105	118	81	81	106
1978	78	73	92	100	96	115	129	155	112	59	90	--
Average	81	88	97	87	94	107	113	129	120	101	100	93

Seasonal indexes for motor carrier movements (after elimination of the irregularity components) are listed in Table 6. Unlike the apparent trend for more intensified seasonality described for rail movement in more recent years, there does not appear to be a trend for changing seasonality in truck movements. The nature and extent of seasonality is significant and has been consistent through the years.

TABLE 6. MONTHLY SEASONAL COMPONENTS FOR HRS WHEAT MOTOR CARRIER MOVEMENTS FROM NORTH DAKOTA, 1967-78.*

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1967	--	--	--	--	--	--	--	114	113	103	99	85
1968	91	85	97	87	89	111	124	116	114	103	101	86
1969	88	84	95	87	89	109	123	122	115	103	101	88
1970	83	85	95	87	89	107	119	130	118	101	101	90
1971	78	84	96	86	89	105	113	137	123	101	101	92
1972	73	83	97	85	90	104	107	141	129	101	99	93
1973	70	82	98	83	93	106	105	144	131	99	96	91
1974	68	83	99	84	96	112	104	142	131	96	92	91
1975	69	82	98	85	98	118	106	140	127	91	90	91
1976	72	80	96	89	100	124	111	137	124	85	88	92
1977	74	80	93	91	101	127	116	139	119	79	87	91
1978	74	82	92	93	101	130	117	141	115	76	87	--

*Derived from an average of the SI component using a 3-term moving average for each month.

HRS Wheat Prices

Similar analysis was used to evaluate the seasonality of prices for HRS wheat from 1967 through 1977. In Table 7, the average prices and associated SI ratios for HRS wheat are listed by month.

There is a slight variation in average prices from month to month. In Table 8, SI ratios are listed by month since 1967. Analysis of Variance was used to determine if the differences in monthly prices are significant (i.e. if the seasonality effect is significant). The calculated F statistic is 1.881 which is greater than the theoretical value at the 5% level but less than the theoretical value at the 1% level.

TABLE 7. AVERAGE MONTHLY PRICES RECEIVED BY FARMERS AND SI RATIOS FOR HRS WHEAT, NORTH DAKOTA, 1967-77.

Month	Average Price for HRS Wheat*	Unmodified SI Rates**
	($/bu.)	
January	2.43	103
February	2.43	102
March	2.38	100
April	2.27	97
May	2.24	97
June	2.29	97
July	2.34	98
August	2.42	100
September	2.47	102
October	2.49	103
November	2.48	102
December	2.49	102

*The average monthly prices are averaged by month over the years 1967-77.

**The average monthly SI ratios are averaged by month over the years 1967-77 and is the percent of the moving average.

In Table 9, the monthly indexes are reproduced for the series. Examination of the data indicates that from 1967 to 1973 the higher prices were received in winter months, the lower prices in the period during and immediately following harvest. But since 1974/75 the trend has changed with higher prices received during harvest.

TABLE 8. SI RATIOS BY MONTH FOR HRS WHEAT PRICES, NORTH DAKOTA, 1967-77.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1967	102	100	104	99	103	99	98	95	96	102	101	100
1968	102	101	103	101	102	99	98	94	98	101	103	100
1969	102	101	102	101	102	98	100	93	98	101	102	103
1970	102	101	100	101	100	99	98	93	99	102	105	102
1971	102	102	99	98	97	100	98	94	97	103	104	105
1972	105	103	98	96	97	94	92	98	103	105	104	118
1973	113	99	97	95	87	89	82	128	121	105	100	106
1974	110	110	100	82	78	91	103	99	100	109	111	107
1975	100	98	97	100	96	92	102	104	105	105	97	95
1976	93	103	101	97	98	105	109	99	102	99	97	95
1977	97	101	102	100	103	102	101	100	103	100	100	93
Average	103	102	100	97	97	97	98	100	102	103	102	102

Conclusions

1. Rail movements of HRS wheat are seasonal with peaks occurring during and immediately following harvest. This seasonality effect is statistically significant.

2. The truck movements of HRS are seasonal with peaks and valleys similar to those in the rail movement. However, the difference between peak and off-peak truck movements is not as great as the difference in rail movements.

TABLE 9. MONTHLY SEASONAL INDEXES FOR HRS WHEAT PRICES, NORTH DAKOTA, 1967-77.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1967	101.8	100.7	102.2	100.1	101.7	99.0	98.3	(94.0)	97.6	101.3	102.3	100.9
1968	102.0	100.9	101.9	100.0	101.3	99.1	98.3	(93.8)	97.6	101.5	102.6	101.3
1969	101.9	101.1	101.4	100.6	101.3	98.2	99.2	(93.0)	98.2	101.1	102.5	102.7
1970	102.3	101.3	101.3	99.9	100.5	98.9	97.8	(93.9)	98.1	101.8	103.2	102.2
1971	104.9	101.5	99.6	98.2	97.1	96.5	97.5	(95.3)	99.9	103.3	103.3	104.2
1972	106.1	101.1	98.9	97.1	95.4	(94.9)	98.3	97.0	101.0	104.3	102.5	104.4
1973	106.1	100.8	98.6	96.4	94.5	(94.0)	99.5	98.6	101.9	104.8	101.5	103.4
1974	105.0	100.4	98.7	96.5	94.6	(94.1)	101.2	100.0	102.7	104.5	100.2	101.4
1975	103.4	100.4	99.3	96.9	95.4	(95.1)	102.8	100.6	103.0	103.8	99.5	99.3
1976	101.4	100.4	99.7	97.6	96.6	(96.4)	103.6	100.8	103.0	103.0	99.0	97.4
1977	100.2	100.7	100.0	98.2	97.5	(97.3)	103.8	100.7	103.0	102.4	98.7	96.2
Average	103.3	100.8	100.0	98.1	97.5	(96.5)	100.1	97.5	103.1	101.3	101.3	101.1

Annual high ____

Annual low (   )

3. The seasonal movement of HRS wheat from North Dakota to Duluth became more pronounced during the 1967-1977 period. This confirms the railroads' contention that their attempts to reduce the peak load problem by seasonal prices were ineffective.

4. Prices for HRS wheat are significantly different throughout the year at the 5% level of significance but not at the 1% level. In latter years, prices received during and immediately after harvest have increased relative to the rest of the year. This would explain the trend in rail movements for more amplified peaks in recent years.

Storage Considerations

Grain Storage Facilities

It has been postulated that new grain storage would be constructed in country points to accommodate the shift in grain shipments prompted by the introduction of seasonal rail rates. The purpose of this section is to explore this hypothesis. Prior to the introduction of seasonal rates, farmers were motivated to build on-farm storage to take advantage of non-harvesttime prices and to speed up harvesting operations.

Little data are available concerning on-farm grain storage capacity in the state, with the exception of a 1978 USDA survey (16). However, data are available concerning the amount of new storage facilities financed under the government farm program (ASCS) and the amount of commercial storage in existence by year.

Grain storage space in the state in April 1978 totaled 830 million bushels--sufficient capacity to store one and one-half years of the state's small grain production. (16) Approximately 45% of existing farm storage facilities have been built with low interest ASCS loans, according to ASCS officials. The amount of capacity constructed with ASCS financing in North Dakota has been variable from year to year--ranging from 1.3 million to 61.4 million bushels (Figure 2). Farmers typically have constructed grain storage facilities in times of grain surpluses and low prices. The correlation coefficient (r) describing the linear relationship between the amount of farm storage constructed annually and the corresponding calendar year average price of hard red spring wheat is relatively weak (significant at the 15% level).

Total storage capacity was estimated to be 577 million bushels in 1966 by Egge and Anderson (2). Grain storage capacity in each succeeding year was estimated by calculating the annual change in commercial and on-farm storage (Figure 3). The estimate of annual increase in on-farm storage was calculated by dividing the annual new storage financed with ASCS loans by the estimated percentge that ASCS financed storage was of total new on-farm storage. Steel bin dealers in the state estimated the percentage of on-farm storage built with ASCS loans to be 80, 50, and 90% for the years 1967-73, 1974-76, and 1977-78, respectively.

Commercial storage capacity has remained relatively constant over the years at approximately 140 million bushels. Total storage capacity has increased 46% over the 12-year period, due almost entirely to an increase in on-farm storage. The percentage of total storage capacity composed of

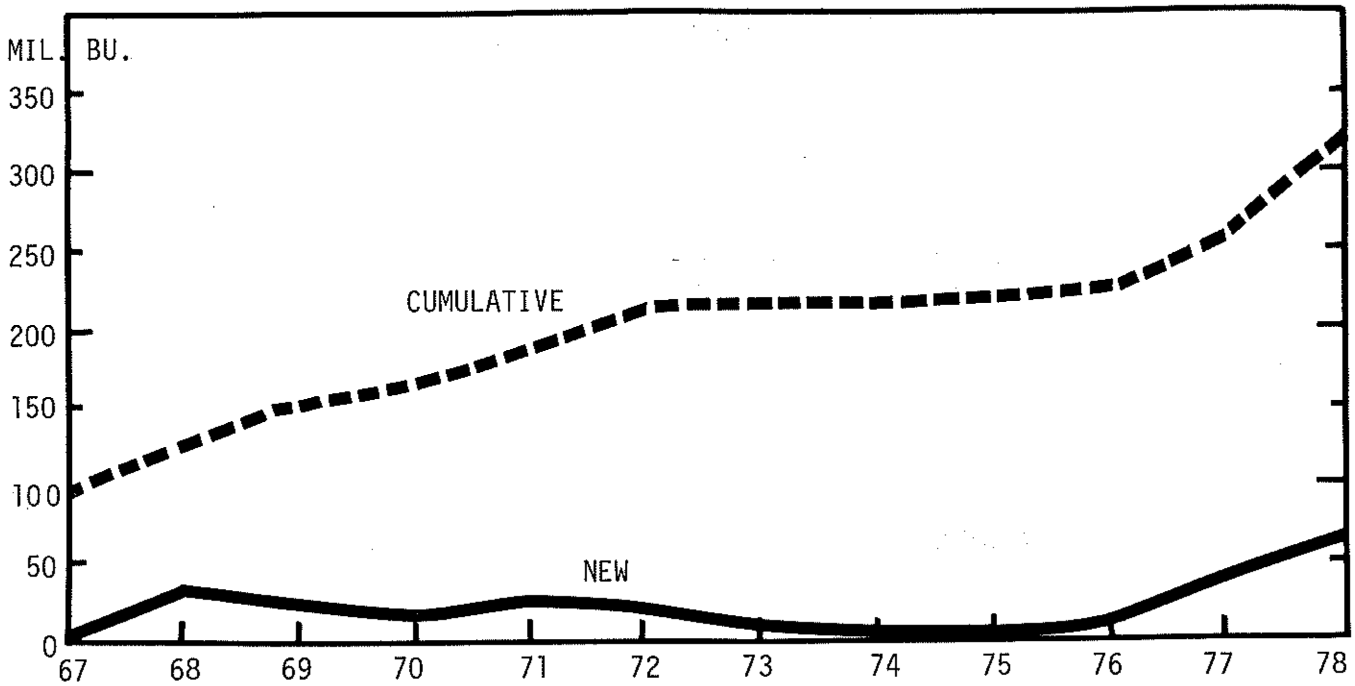

Figure 2. ASCS Financed Construction of On-Farm Storage in North Dakota, 1967-78.

Source: Agricultural Stabilization and Conservation Service, North Dakota State Office, Fargo, North Dakota.

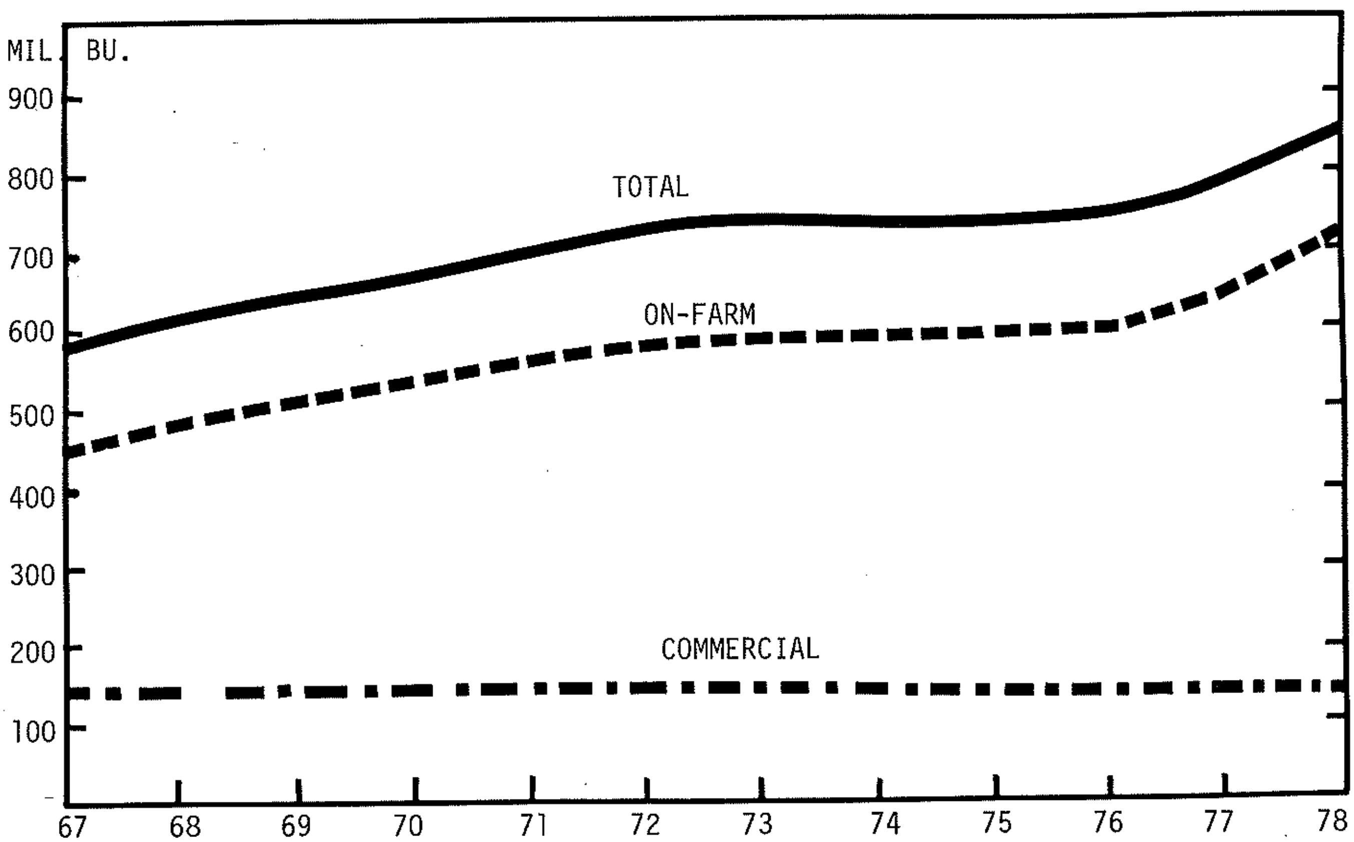

Figure 3. Estimated North Dakota Grain Storage Capacity, 1967-78.

on-farm storage increased from 75% in 1967 to 83% in 1978. Total storage capacity increased at an annual rate of 3¼% during the study period.

Total estimated storage capacity increased at an annual rate of about 20 million bushels each year during the 8 years when seasonal rates were in effect, compared to 29 million bushels each of the 4 years after the seasonal rates were canceled. Thus, construction of storage was not visibly related to seasonal rates. However, there could have been a relationship but it was not discernable from existing data.

Inventories

Quarterly stocks of all wheat[5] in North Dakota (October, January, April, and July) for the study period are shown in Figure 4. In all years stocks peaked during harvest (October) and decreased in the following quarters. There is a statistically significant difference in wheat stocks among years and quarters at the 1% level when the data are tested using Analysis of Variance. Seasonality does exist with respect to wheat stocks.

Relationships Between Movements, Prices, and Rail Rates of Wheat

An econometric model describing seasonal grain movements from North Dakota is specified and estimated in this section. Employing the estimated model, the effect of alternative levels of seasonal freight rates on grain movements in general and rail movements specifically is analyzed.

Regression analysis, using binary dummy variables to indicate the month as well as other independent variables, was used to examine the

[5]Quarterly stocks of hard red spring wheat were not available for all years during the 1967-78 study period.

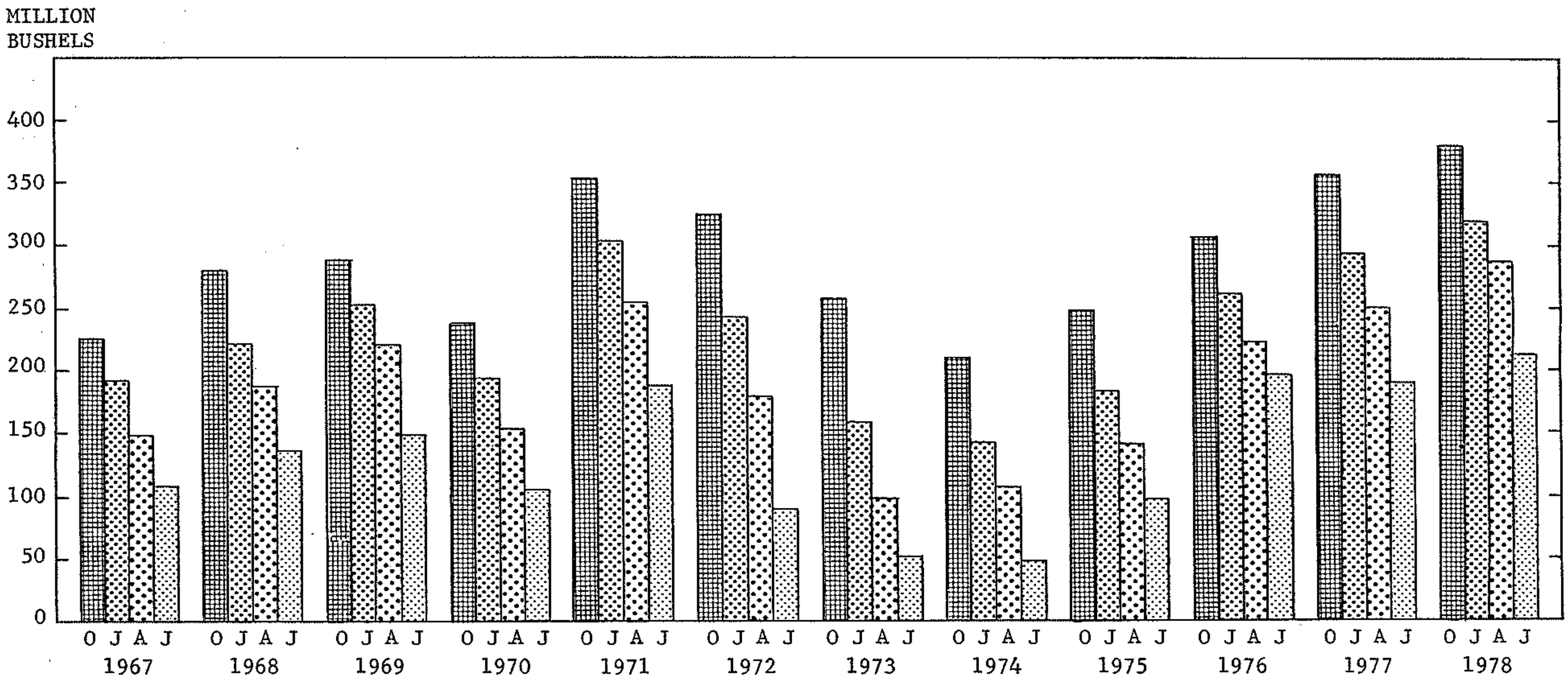

Figure 4. Quarterly Stocks of North Dakota Wheat, 1967-78.

Source: (10)

effects of seasonal demand. The essential differences between the time series decomposition procedure reported in a previous section and the model used here is in the nature of the information obtained. In both cases a seasonal index can be derived indicating the seasonal movement relative to the annual average. The seasonal indexes derived from the moving average method are a gross measure of seasonal variability. Coefficients so derived combine the effect of all the factors which influence grain movements. The binary dummy variable approach has the flexibility to hold constant the other independent variables which affect grain movements. It is, therefore, a net measure of seasonality. The differences between the moving average index and those derived from regression analysis indicate the amount of variability which can be attributed to the other exogenous variables.

Model Specificaiton and Empiricial Procedures[6]

The demand for transportation is influenced by many variables. Of particular importance are the price of the commodity received by producers, the quantity of the commodity available for transportation (inventories), expectations of future prices, and the seasonality effect. This, in turn, could be interpreted as a function explaining the delivery behavior of producers.

Individual modal demands are affected by the above variables as well as their relative prices, transportation equipment availabiltiy, and service quality. Conceptually, grain transportation demand can be interpreted as a recursive system. Total transportation demand is explained first, and modal

---

[6]The conceptual and econometric issues for this procedure are discussed in (19).

demands are specified in the subsequent equations. The following model demonstrates the system:

1.a $Q_T = f(Y_1, Y_2, \ldots, Y_m)$

1.b $Q_{RR} = f(X_1, X_2, \ldots, X_n; Y_1, Y_2, \ldots, Y_m)$

1.c $Q_{TR} = f(X_1, X_2, \ldots, X_n; Y_1, Y_2, \ldots, Y_m)$

where Q_T is total transportation demand and Q_{RR} and Q_{TR} are the individual modal demands for railroads and trucks, respectively ($Q_T = Q_{RR} + Q_{TR}$). $Y_1, Y_2, \ldots, Y_m$ are exogenous variables affecting total transportation demand and $X_1, X_2, \ldots, X_n$ are variables reflecting intermodal competitiveness. The latter includes prices for each mode. The above model is recursive and can be reformulated as follows:

2.a $Q_T = f(Y_1, Y_2, \ldots, Y_m)$

2.b $Q_{RR} = f(X_1, X_2, \ldots, X_n; Q_T)$

2.c $Q_{TR} = f(X_1, X_2, \ldots, X_n; Q_T)$

The conceptual logic underlying the recursiveness of the model is that given the total demand for transportation, individual modal demands are influenced by their relative competitiveness. There are important exogenous variables affecting the total demand which simultaneously affect individual modal demands.

The first question in the empirical application of the model explains the variability in the total demand for transportation. The dependent variable is the movement of Hard Red Spring (HRS) Wheat from North Dakota to Duluth, which is the primary outlet for that grain. These statistics were taken from unpublished data from the North Dakota Public Service Commission as reported to them by all licensed elevators. Output is measured in bushels as opposed to ton-miles or bushel-miles which is the normal output unit in cross-section transportation studies. Data were aggregated across the state and since they were time series, inclusion of distance was necessary. Exogenous variables included in the total transportation equation were production, monthly average prices received by producers, and 11 binary dummy variables to isolate monthly effects. Quarterly estimates of grain inventories were initially included and were collinear with production. The latter proved superior as a demand shifter and, consequently, inventories were excluded from the model. Various lags of prices were tested but the model without lags produced superior statistical results.

The dependent variables in the individual modal equations were measured in bushels transported by the respective mode. The purpose of the exogenous variable in the modal demand functions (other than Q_T) is to reflect intermodal competitiveness through time. Of particular importance is the price charged for each of the modal services. The rail rate was included as one of the exogenous variables. Its value in a given month was an average rate from North Dakota--averaged across representative shipping points from each of the nine crop districts in the state and weighted by the movements from each. The rates so derived represent typical monthly rates applicable from North Dakota shipping points.

Throughout the study period, the rail rates varied because of experimentation by the railroads with peak-load pricing and rate cutting to meet motor carrier competition.

The rates charged by unregulated motor carriers are not published and, consequently, could not be included. As a proxy for this, an index of motor carrier costs was used. The index is a good approximation of Class I and Class II motor carrier cost structures and was used as a proxy for the changing competitiveness of the motor carriers through time. It was derived by Glenn Fast and presented at a University of Wisconsin Motor Carrier Costing Seminar, April 1979.

Other variables, such as transportation equipment availability and quality of service factors (e.g., frequency of service, loss and damage experience, etc.) logically should be included in the modal specifications because they affect intermodal competitiveness. Data depicting these variables were not available and the model was estimated without them.

Various forms of the equations were estimated and only the results using the logarithmic form discussed below are presented in this paper. The model was estimated using both Q_T and Q_T in the modal demand equations. The results in each case were similar and only the results using the former are presented here. The following model was estimated:

3.a $\log Q_T = (\gamma_0 + \gamma_i S_i) + \gamma_{12} \log P_f + a_{13} \log PR + \log e$

3.b $\log Q_{RR} = \beta_0 + \beta_1 \log Q_T + \beta_2 \log P_{RR} + \beta_3 \log P_{MC} + \log e$

3.c $\log Q_{TR} = \delta_0 + \delta_1 \log Q_T + \delta_2 \log P_{RR} + \delta_3 \log P_{MC} + \log e$

where S_i represents 11 monthly dummy variables ($i = 1, 2, \ldots, 11$); P_f is monthly prices received by North Dakota farmers for HRS wheat; PR is production of HRS wheat in North Dakota; P_{RR} is the representative rail rate from North Dakota to Duluth, Minnesota; and P_{MC} is the index of motor carrier costs. The parameters to be estimated are $\gamma_0, \gamma_1, \ldots, \gamma_{13}$; $\beta_0, \beta_1, \ldots, \beta_3$; and $\delta_0, \delta_1, \ldots, \delta_3$.

Equation 3.a was estimated using data from August 1967 through December 1978. The modal demand equations were estimated with data through December 1977 as some of the data were not available for 1978.

The Durbin-Watson procedure was used to test for positive first-order autocorrelation. In all cases it was significant, indicating the residuals are temporally related. The Cochrane-Orcutt procedure was used to adjust the data (9, pp. 206-210). Tests were also used to confirm the conceptual logic of the model and are discussed in the following section. A covariance test was used to ensure that the addition P_{RR} and P_{MC} significantly improved the explanatory power of the equation. A test also was used to ensure that the summation of the individual modal demands equaled total demand.

Results

Results of the estimated equations are listed in Tables 10 and 11.

All the coefficients in the general equation reported in Table 10 have the expected sign. The seasonal coefficients which are insignificant are not significantly different than the December movement. Nevertheless it would be incorrect to exclude them (11, p. 206). The first

TABLE 10. COEFFICIENT ESTIMATES FOR EQUATION 10, QUANTITY OF GRAIN SHIPPED FROM NORTH DAKOTA, 1967-78.

Variable	Coefficient	Standard Error
constant	10.483	1.610*
S1 (Jan)	-0.207	0.101**
S2 (Feb)	-0.191	0.130
S3 (Mar)	-0.070	0.145
S4 (Apr)	-0.061	0.154
S5 (May)	-0.013	0.159
S6 (Jun)	0.367	0.160**
S7 (Jul)	0.259	0.157
S8 (Aug)	0.632	0.150*
S9 (Sep)	0.600	0.141*
S10(Oct)	0.282	0.125**
S11(Nov)	0.304	0.097*
log P_f	0.339	0.171**
log Prod	0.568	0.367***

* indicates significant at 1% level
** indicates significant at 5% level
*** indicates significant at 15% level

TABLE 11. EQUATION COEFFICIENT ESTIMATES FOR MODAL DEMAND FOR WHEAT SHIPMENTS, NORTH DAKOTA, 1967-78.

	Rail Equation		Truck Equation	
Variable	Coefficient	Standard Error	Coefficient	Standard Error
constant	-5.938	1.468*	8.707	2.511*
log Q_T	1.166	0.041*	0.722	0.077*
log P_r	-0.629	0.227*	1.344	0.413*
log M_C	1.038	0.366*	-2.084	0.638*
First order autocorrelation coefficient	0.70027		0.66071	
R^2	.9524		.7731	
F	806		137	

*indicates significant at the 1% level

equation should be interpreted at: given a level of annual production and a particular month, grain movements increase with the prices received by producers. The coefficients estimated should be interpreted as the elasticities and are constant. A 10% increase in production results in a 5.7% increase in shipments; a 10% increase in the farm level price results in a 3.4% increase in shipments assuming everything else is constant. The peak months, as indicated by the coefficients, are June and August through November.

Because the variables affect each other multiplicatively, the interpretation of the seasonal coefficients is not readily apparent. Seasonal indexes for monthly movements were computed using the average value of the independent variables and are reported in Table 12 along with the actual values. The average values were 151.22 million bushels and $2.46/bu. respectively for production and farm level prices.

TABLE 12. ACTUAL AND ESTIMATED AVERAGE MONTHLY MOVEMENTS OF HRS WHEAT FROM NORTH DAKOTA TO DULUTH/SUPERIOR, 1967-78.

Month	Movements		Index	
	Actual	Estimated	Actual#	Estimated§
	(million bushels)			
Jan	3.388	3.249	65	67
Feb	3.398	3.299	66	68
Mar	3.726	3.723	72	76
Apr	3.768	3.760	73	77
May	4.313	4.049	83	83
June	6.020	5.769	116	118
July	5.658	5.178	109	106
Aug	8.210	7.519	159	154
Sept	7.827	7.283	151	149
Oct	5.628	5.294	109	109
Nov	5.930	5.411	115	111
Dec	4.235	3.997	82	82

#(actual movement ÷ average monthly movement) x 100
§(estimated movement ÷ average estimated monthly movement) x 100

The estimated movements and indexes are relatively close to the actual values. Peak-period movements were June through November with the highest peaks in August and September when shipments are 154% and 149% of the average shipments, respectively. The off-peak period is the remainder of the year and the trough is during January and February. Coefficients for the modal demand equations in Table 11 have the expected sign and are significant at the 1% level. The coefficients indicate that a 10% increase in grain movements results in a 11.6% and 7.2% increase in rail and truck shipments, respectively. The price elasticities indicate that rail demand is rail rate inelastic, but elastic with respect to motor carrier costs. For example, a 10% increase in the rail rate results in a 6.3% reduction in rail shipments. A 10% increase in motor carrier costs results in a 10.4% increase in rail movements. The demand for motor carrier shipments is elastic with respect to both their own costs and rail rates.

Because of the highly significant relationship between the dependent variable in the modal demand equations and Q_T, any relationship containing the latter would be significant. An Analysis of Variance test was used to determine whether the inclusion of the additional explanatory variables (P_r and MC) significantly increased the explanatory power of the equations (Table 13). The ordinary least squares equations were used for this test instead of autoregression equations since, due to data transformation, the sum of squares in the latter were nonadditive. In both cases, F is significant at the 1% level indicating that the additional variables significantly increase the explanatory power of the equation. The above procedure is another way to insure that the intra-modal and inter-model elasticities are significant and have the expected sign.

In order for the model to be logically correct, the summation of the estimated rail and truck movements should equal the total movements. To test this, estimated market shares were calculated using the two modal demand equations at the average value for the independent variables.[7] The estimated rail and truck shipments are 3.34 and 1.57 million bushels, respectively or 68% and 32% which is the same as the average modal split throughout the study period.

TABLE 13. ANALYSIS OF VARIANCE STATISTICS REGARDING ADDITIONAL VARIABLES IN THE MODAL DEMAND EQUATION.

	Source	Sum of Square	D.F.	MSE	F*
Rail					
	Q_t	47.222	1		
	Q_t, P_r, MC	49.059	3		
	Additional	1.837	2	.9185	
	Residual	5.660	120	.0472	19.47*
	Total	54.719			
Truck					
	Q_t	5.9217	1		
	Q_t, P_r, MC	12.127	3	3.10	20.33*
	Additional	6.2053	2	0.1526	
	Residual	18.311	120		
	Total	30.438			

*Significant at the 1% level.

[7] The average values for P_r and MC were 28.31 and 127.26, respectively.

Limitations of the Estimated Model

Several limitations of the model are summarized here. First, equation 3.a is not truly a demand function for grain transportation in that the price of transportation is not an explicit explanatory variable. The relationship explaining grain movements is logically and statistically correct if it is accepted that changes in the freight rate structure are reflected in prices received by farmers. This assumption is supported by the Interstate Commerce Commission (7):

> The producer's country price is generally said to be the market cash price minus the freight and handling charges into the market. On such a basis, it follows that a reduction in the inbound rate to the market would benefit the producer, if the market price remained stationary.

Using this assumption, the effects of peak load pricing on seasonal grain movements are simulated in the next section.

The second limitation is that data on some important explanatory variables were not available. Particularly important are railcar availability and storage capacity. The model, as estimated, assumes these variables are random and do not systematically affect the dependent variables. Finally, the model is stated in nominal dollar terms. The model also was estimated using price variables deflated by the wholesale price index. The results were similar to the results reported here which use nominal values (see the Appendix).

Implication for Peak Load Pricing

The estimated equations were used to evaluate the effect of peak load pricing of rail services on monthly movements. The purpose of peak load pricing is to increase the utilization of the railways' inherent fixed capacity by leveling out the demand for transportation throughout the year. Relatively high rates are to be charged during peak periods and relatively low rates during the off-peak period. In agriculture, terminal market prices also pay an important role in grain movements since the gathering rates are subtracted from them.

The following assumptions were made in the analysis:

1. Changes in the seasonal pattern of transportation rates are reflected in prices received by producers.

2. The estimated relationship in equation 3.a is indicative of the nature of seasonal movements.

3. Alternative rate structures were evaluated at average values of the independent variables. These values were:

Variable Specification	$/bushel
production 151.22 million bushels farm level price	2.46
average transportation rate	.30
farm price plus grain rates	2.76

4. The rate structures evaluated incorporated $.20, $.09, and $.60/bu. differences between peak (June through November) and off-peak period rates. The average prices received by farmers during peak and off-peak periods for the 3 scenarios are as follows:

Rail Rate Differential	Farm Level Prices: Peak Month	Farm Level Prices: Off-Peak Month
(---$/bu.---)		
.02	2.45	2.47
.09	2.41	2.50
.60	2.16	2.76

Estimated monthly indexes, as well as the monthly indexes under the 3 peak load pricing schemes, are shown in Table 14.

TABLE 14. INDEXES INDICATING SEASONALITY IN HRS WHEAT MOVEMENTS UNDER VARIOUS RATE STRUCTURE DIFFERENTIALS, NORTH DAKOTA, 1967-78.

	Seasonal Rate Structure Differential			
Month	none*	$.02	$.09	$.60
Jan	67	67	67	70
Feb	68	68	68	71
Mar	76	77	77	80
Apr	77	77	78	84
May	83	83	84	87
Jun	118	118	118	115
Jul	106	106	106	103
Aug	154	154	153	149
Sep	149	149	149	145
Oct	109	108	108	105
Nov	111	111	110	107
Dec	82	82	83	86

*estimated directly from equation 3.a without a rate structure differential.

An effective peak load pricing scheme would decrease the seasonal index in peak months and increase it in off-peak months. At the average level of prices and production, neither a $.02 or $.09 rate differential changed the seasonal nature of the demand for transportation. A $.60 differential would even out the transportation demand only slightly. Under a $.60 rate differential the monthly index for August decreased from 154 to 149 and the December index increased from 82 to 86. These estimates are based on the estimated model. Extrapolation beyond the range of data may be questionable. The results with the $.60 differential above were included to demonstrate the concept and to indicate that though the parameter has the expected sign it is not large enough to bring about an observable change.

The success of any peak load rate structure depends on the level of grain prices relative to grain transportation rates. Seasonal flows would be more sensitive to a given rate differential at lower grain prices. At higher grain prices, the same rate differential would be less effective.

Estimated equations also can be used to evaluate the effects of peak load pricing on modal market shares assuming average values for the independent variables. In Table 15 estimated monthly total movements and rail market share are shown. Also in Table 15 the effects of a $.60/bu. peak/off-peak rate differential is shown with respect to total and rail market shares. A peak load rate $.60/bu. greater than the off-peak rate results in more shipments during the off-peak period and less during the peak. Total movements increased in December through May (the off-peak period) as expected and decreased during the peak period (June through November). Rail market shares changed in some months because their demand, vis-a-vis the demand for truck movements, was slightly more sensitive to changes in total movements.[8] Specifically, estimated railway market shares increased (decreased) in some of the off-peak (peak) months because of corresponding changes in total movements.

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[8]The elasticities of rail and truck shipments with respect to total movements were 1.17 and 0.73, respectively.

TABLE 15. ESTIMATED EFFECT OF A $.60/BU. RAIL RATE DIFFERENTIAL ON TOTAL MOVEMENTS AND RAIL MARKET SHARE OF HRS WHEAT FROM NORTH DAKOTA TO DULUTH, MN., 1967-78.

Month	Estimated Total Movements		Estimated Rail Market Share	
	No differential	60¢/bu. differential	No differential	60¢/bu. differential
	(million bushels)		(%)	
Jan	3.25	3.38	59	59
Feb	3.30	3.43	59	61
Mar	3.73	3.87	61	61
Apr	3.77	3.91	60	61
May	4.05	4.21	61	62
Jun	5.77	5.52	65	64
Jul	5.18	4.95	64	63
Aug	7.52	7.19	68	68
Sep	7.28	6.97	68	67
Oct	5.30	5.06	64	64
Nov	5.41	5.18	64	64
Dec	4.00	4.15	61	62

Conclusions

The peak demand problem has worsened since 1967 despite efforts on the part of the railways to even out the demand for transportation using seasonal pricing.

Estimated equations in this section indicate that grain movements are seasonal, the peak months are from June through November.

The demand for rail transport is rail rate inelastic but elastic to motor carrier costs. The demand for truck transportation is elastic to both rail rates and motor carrier costs.

The railways are affected more by changes in total movement than are trucks.

The effect of different peak load price differentials was evaluated to determine their effect on the seasonal nature of grain movements. Even when the differential was $.60/bu., the demand for transportation was evened out only slightly.

Influence of Seasonal Rates on Producers

The rail car capacity problem could be improved by farm storage of wheat at harvest for marketing later in the year when demand for cars is typically less. The feasibility of farm storage of wheat from the producer's perspective is examined both with and without seasonal rates.

Although wheat prices are typically at a seasonal low during harvest, producers still market a substantial amount of wheat during the harvest period. Approximately 20% of the grain marketed in 1972 was sold during harvest according to a study of grain marketing strategies of North Dakota farmers (1). Approximately 30% of North Dakota HRS wheat shipments over the three year period of July, 1975 - June, 1978, occurred during the harvest months of August and September.

Farm Storage Without Seasonal Rates

Farmers are motivated to store wheat for later sale at a higher non-harvest price if the additional income covers risk and storage costs. Egge and Anderson concluded in a 1967 study that it was profitable for

North Dakota farmers to store HRS wheat on the farm at harvest for sale later in the marketing year (2). Analysis of the seasonal price movement for HRS wheat for the years 1951-64 showed a period of low prices during harvesttime with price increasing after harvest to a high during the winter months. The average per bushel price increased 12 cents from harvest until the high point of the year. Storage costs, not including interest on the value of the grain, were estimated to be 4.6 cents per bushel. The increase in the per bushel net return after deduction of storage costs was 7.4 cents.

The 1967-1977 seasonal index of HRS wheat prices, significant at the 10% level, is at a peak in October (103.1) and at a low in June (96.5). This index can be used to evaluate the profitability of farm storage of wheat. For example, in July 1978, when the previous 12-month price of HRS wheat averaged $2.93/bu., a farmer could, on the average, receive 19¢/bu. more by delaying the sale of wheat from June to October [($2.93 x 1.031) - ($2.93 x .965)]. The question faced by a farmer in this situation is: will the 19¢/bu. differential be sufficient to cover construction and variable costs of storage?

Farm storage costs for 1978 were estimated based on data collected from steel bin dealers and index adjusted farm storage costs reported by Egge and Anderson (2). Erection costs for selected sizes of circular steel bins are shown in Tables 16 and 17. The erection cost per bushel ranged from 46 to 83¢, declining with larger sized bins. The annual bushel costs of storage on North Dakota farms with the 4,721 bushel bin (a common sized bin) assuming 100% occupancy is 17.2¢ (Table 7). Interest on the value of the grain is included in the storage cost. Assuming an 80% occupancy rate, the total cost is 19.2¢/bu.--of which approximately one-half represents fixed annual cost. An 80% occupancy level was used because it reflects actual storage levels more accurately than does the 100% occupancy level (Table 17). A farmer would have to receive a price at least 19.2 cents per bushel higher for storing wheat (plus return for risk) in order to justify building new grain storage if the storage were used only for that crop.

The farmer's decision to construct new storage facilities for wheat in 1978 based solely on seasonality in wheat prices is unclear since the expected gain (19 cents) is approximately the same as the storage (costs) (19.2¢). However, 1978 was a "boom" year for construction of on-farm grain storage facilities. The case for farm storage becomes more encouraging given government farm storage payments and the fact that existing farm storage has a lower cost than the new storage facilities considered in this case. In recent years the government has payed from 20 to 26½ cents per bushel per year for wheat held under the reserve program when the price is below the reserve release price.

Seasonality in wheat prices may not be the major factor contributing to the decision to construct new grain storage facilities or store wheat in existing storage. The relationship between the price of wheat and production costs may be the key factor in the decision to store wheat. If the price is far below the farmer's production cost, the farmer may decide to store wheat on the farm until the price becomes more favorable.

Farm Storage with Seasonal Rates

What level of seasonal rates will be necessary for farmers to build additional storage facilities and store grain previously marketed at harvest? The results of a previous section of this report indicate that even with a 60¢/bu. rate differential between harvest and nonharvest periods, there sould be only minor changes in wheat shipments by month. This suggests that seasonal rates would have little effect on the storage decision of farmers. A farmer may ship wheat during harvest because of a need for payment of loans or operating expenses, a risk of quality loss, a feeling that prices will not follow seasonal patterns, full storage facilities, or a feeling of insecurity about obtaining a better price.

TABLE 16. ERECTION COSTS OF CIRCULAR STEEL BINS, NORTH DAKOTA, 1978.

Bin Capacity (bu.)	Total Cost[a]	Erection Cost (¢/bu.)
2,314	$1,918	82.9
2,700	1,958	71.4
4,721	2,889	61.2
10,444	5,446	52.1
16,757	7,712	46.0

[a]Includes all costs (materials, labor, concrete floor, etc.).

Certain cost savings may accrue to the farmer if seasonal rates are effective in promoting on-farm storage. These savings are mentioned for

TABLE 17. COSTS OF ON-FARM GRAIN STORAGE IN NORTH DAKOTA, ASSUMING A 4,721 BUSHEL BIN, 1978.

Item	Cost Per Bin	Cost Per Bushel 100% occupancy	Cost Per Bushel 80% occupancy
Fixed Costs			
Depreciation[a]	$144.45	3.06	3.83
Insurance on bin[b]	8.67	.18	.23
Interest on Investment[c]	130.01	2.75	3.44
Unloading Elevator[d]	83.87	1.78	2.23
Total Fixed Cost	$367.00	7.77	9.73
Variable Costs			
Repairs[e,k]	48.15	1.02	1.02
Insurance on Grain[f,l]	44.63	.95	.95
Pest Control[g,l]	18.88	.40	.40
Labor[h,l]	23.55	.50	.50
Elevator Operating Costs[i,l]	9.91	.21	.21
Interest on Value of Grain[j,m]	299.76	6.35	6.35
Total Variable Costs	44.88	9.43	9.43
TOTAL COST	$811.88	17.20	19.16

[a]Depreciation based on a 20-year life; bin cost of $2,889 and no salvage value.

[b]At $6.00/$1,000 of average investment; average investment = $2,889/2.

[c]At .09 of average investment.

[d]Depreciation and interest on investment at 9 percent. Elevator cost = $1,750; expected life = 15 years.

[e]At one-third depreciation.

[f]Based on harvest price, (July) of $3.11/bushel of wheat; 80 percent of value insurable at $3.80/$1,000 of value.

[g]At $4.00/1,000 bushels.

[h]At $3.75/hour; 80 minutes/1,000 bushels.

[i]Fuel and repairs.

[j]Based on harvest price (July) of $3.11/bushel of wheat. Assumes storage for 3.5 months. Interest charged at the rate of 7 percent, the interest rate farmers were charged in 1978 by the government when the farmer took out a loan on the grain.

[k]Variable with respect to time.

[l]Variable with respect to volume.

[m]Variable with respect to time and volume.

the sake of discussion as their quantification is beyond the scope of this study. Cost savings from changes in the farmer's harvesting operation are possible if more grain is stored on the farm at harvest. A farmer depending on a country elevator with queuing problems must either stop harvesting or pile the grain on the ground, risking weather-related losses. Less truck labor is needed during harvest by hauling wheat to the farm grainery. Farmers hauling grain to the elevator need expensive trucks to insure rapid and dependable transportation. Fewer and less expensive trucks may be required for on-farm storage. More farm storage may stabilize farm and income taxes by allowing the farmer to average sales of high and low income years. Also, certain grain storage facilities qualify for the investment tax credit.

Reactions to Seasonal Rail Rates by the Grain Trade

The cancellation of the lower winter rates in 1974 with the implementation of the higher summer rates year-round was protested by various groups including the Farmers Union Grain Terminal Association (GTA), the Minneapolis Grain Exchange, the North Dakota Wheat Commission, and the North Dakota Public Service Commission (4). Those protesting did not argue whether seasonal rail rates were effective in smoothing out wheat shipments. Instead, the arguments centered around what the year-round rates should be. The protestants felt that the railroads did not prove their case for a year-round rate at the higher summer level. They contended that the railroads were making adequate profits with the lower winter rates and that a switch to the higher summer rates year-round was unjustified. One protestant proposed a compromise whereby the rate charged would be the average of summer and winter rates. In the final analysis, the railroads were allowed to raise their winter rates to the summer level.

Selected individuals in the grain trade were contacted by telephone to get their opinions concerning seasonal rail rates since the discussion in I&S 8939 (4) did not question the effectiveness or ineffectiveness of seasonal rates. Those contacted included elevator managers, marketing agencies and processors.

Elevator managers preferred to have the same rate throughout the year. They indicated that the railcar shortage has been year-round and that there has been no surplus of railcars during the year. Elevator managers view seasonal rail rates as a "headache." One manager whose views were typical said that in the latter part of the period when lower rates are in effect, railcars mysteriously disappear. If he buys grain from a farmer based on the lower rates and is forced to ship the grain later at the higher rate, his margin diminishes. The manager felt that the small difference in the price the farmer received because of seasonal rail rates is "no big deal" since the market price often fluctuates 20 cents in one day. He went on to say that seasonal rail rates have little or no influence on storage decisions of farmers or commercial elevators.

A grain merchandiser said that seasonal differences in rates would not make a critical difference at termimal markets or at the farm in the amount of grain stored. He felt that seasonal rates were not justifiable today compared to five to ten years ago because the marketing patterns of farmers have changed. The merchandiser said that in some recent years grain prices have been at a peak during harvest, contrary to what is normally expected. He concluded that seasonal rail rates were one of many factors that influenced a farmer's marketing decision and that any one of these factors could easily outweight the seasonal rate factor.

A grain processor indicated that he desired even shipments throughout the year but preferred one rail rate year-round. He felt that seasonal rates would not substantially affect his business. Seasonal rates would have little effect on his storage decisions.

Summary and Conclusions

Increasing the productivity of the railroad's rolling stock would enhance both their profitability and the quality of rail service. Congress has directed the ICC to look with favor on seasonal rail rates as a vehicle to even out the flow of commodities subject to seasonal flows. This, it was hoped, would reduce tension during peak demand periods and would increase utilization of fixed plant during off-peak periods. The practical use of seasonal rail rates to achieve these results has been seriously questioned.

Reported in this bulletin is an analysis designed to examine the seasonal flows of hard red spring wheat from North Dakota and the impact of two levels of seasonal rail rates which were in effect for 7 years. The study was conducted by the Dept. of Agricultural Economics in cooperation with the Upper Great Plains Transportation Institute, both of North Dakota State University, with financial support from ESS, USDA.

North Dakota is the only grain originating area where seasonally differentiated rates have been in effect for more than a limited period. A reduced winter rate for November through June of 10% below the summer rates was implemented in 1963. This discount was increased to 25% in 1971. The seasonal rate was entirely discontinued in December 1974. Analysis of seasonality of grain flows and impact of seasonal rates is made possible by the existence of detailed grain flow data available since 1967 from the North Dakota Public Service Commission. These data are based on monthly reports by all shippers to the PSC which provide, along with other data, shipments by commodity, mode, and destination. This provides an unusual data base for analyzing the on-again/off-again seasonal rail rate structure.

Seasonality of grain flows was analyzed by using the U.S Bureau of Census X-11 program which was designed to separate the trend, cyclical, seasonal, and irregular components. The major conclusion was that rail movement of HRS wheat from North Dakota was seasonal with peaks occuring during and immediately following harvest. This seasonality is statistically significant and not due to chance.

Truck movements of HRS wheat were also seasonal with peaks and valleys similar to those in the rail movement. However, the differences between peak and off-peak truck movements, though statistically significant, are not as great as the differences in rail movements.

The nature of seasonality has been changing. Peak movements in June through September have increased. Evidence that seasonaltiy existed for average monthly prices of HRS wheat received by farmers was weak for the

1967-1978 period. In the latter years, prices received during and immediately after havest have increased relative to the rest of the year. This would help explain the trend in rail movements for more amplified peaks in recent years.

An effort was also made to identify trends in construction of grain storage facilities and seasonality of inventories. Grain storage in North Dakota totaled 830 million bushels as of April 1978--sufficient to store 1½ years of the state's small grain production. Other than the USDA survey which provided the capacity figure above the government-financed (ASCS) storage construction, no data are available on construction of new on-farm grain storage. Estimates of total new farm construction for the study period were gathered from estimates of the proportion of constructed storage attributable to ASCS financing. These estimates were obtained from major farm storage distributors. New construction of farm grain storage is quite variable and seems to be negatively correlated with grain prices. Commercial storage capacity has remained relatively constant ranging from 140 to 147 million bushels. Seasonal rates were apparently ineffective in stimulating construction of storage facilities. Wheat stocks peaked in October and decreased the following quarters. This seasonality, as expected, is statistically significant but did not seem to be influenced by seasonal rail rates.

Three statistical models were specified to test for seasonality in a second way and to evaluate the impact of seasonal rates on the seasonality in a second way and to evaluate the impact of seasonal rates on the seasonality of wheat flows. The first model related the flows of HRS wheat from North Dakota to Duluth, Minnesota, to month, to farm price, and to production. The second and third equations related rail and truck flows, respectively, to total wheat to be transported, rail rates, and truck costs. Other variables were tested and deleted. Major conclusions were that the peak problem became worse despite efforts of the railroads to even out flows using seasonal prices during the 1963 to 1974 period. The demand for rail transport is rail rate inelastic but elastic to motor carrier costs. The demand for truck transportation is elastic to both rail rates and motor carrier costs. Seasonal rail movements were unaffected by seasonal rail rates in force between 1967 and 1974. Even when substituting a 60¢/bu. differential, the demand was evened out only slightly when using parameters estimated from the 1967-1978 period data. These results support the contention that seasonal rates are ineffective as a single tool to even out grain flows. Variability in prices and other considerations seem to outweigh the influence of seasonal rates.

It would take at least a 19.2¢/bu. discount at the 1979 price level during off-harvest season to encourage new storage construction if prices were uniform throughout the year.

Grain merchandisers and other marketing intermediaries contacted were opposed to seasonal rates because it was felt that they would not work, would introduce an additional and unnecessary complicating factor into their work, and would be artificial because of the year-round shortage of boxcars.

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APPENDIX RESULTS OF ESTIMATING EQUATIONS 10 - 12 USING DEFLATED VALUES FOR THE PRICE VARIABLES*

Variable	Nominal Dollars	Real Dollars
(-------Equation 10--Total Demand-------------)		
P_f	0.34	0.47
Prod	0.57	0.69
S1	-0.21	-0.21
S2	-0.19	-0.19
S3	-0.07	-0.07
S4	-0.06	-0.06
S5	0.01	0.02
S6	0.37	0.37
S7	0.26	0.26
S8	0.63	0.63
S9	0.60	0.60*
S10	0.28	0.28*
S11	0.30	0.30
Constant	10.48	9.33
R^2	.78	.78
Autocorrelation coefficient	.68	.68

Con't

Appendix Con't

Variable	Nominal Dollars	Real Dollars
(--------Equation 11--Rail Demand-------------)		
Q_t	1.17*	1.16
P_r	-0.63*	-0.80
MC	1.04*	-0.12
Constant	-5.94*	-1.16
R^2	.95	.95
Autocorrelation coefficient	.70	.64
(--------Equation 12--Truck Demand --------)		
Q_t	0.72	.71
P_r	1.34	1.48
MC	-2.08	-0.17
Constant	8.71	-0.38
R^2	.77	.77
Autocorrelation coefficient	.66	.63

*Deflated by wholesale price index for all commodities, U.S. Dept. of Labor.