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Grains exhibit seasonal and other variations in production and sales. The derived demand for transportation services to move these bulk commodities usually follows these marketing patterns as well. Seasonal variations in grain production, when coupled with year-to-year variations in foreign demand, can create rather severe disturbances in the grain marketing system. One example is the 1972-73 period. The transportation system's adjustment to demand shifts for transportation services can be costly. Shippers pay higher carrying costs if their shipments do not move in a timely manner. Carriers may invest in capacity that is underutilized during off-peak periods or use existing capacity so intensively that costs increase in greater proportion than output. Depending on the elasticity of demand for the product, some of these costs are passed on to consumers or back to farmers.

Railroads are particularly vulnerable to shifts in demand for equipment. Rails carried over a fifth of the total grain tonnage in 1970 (U.S. Senate, 1974, p. 62). Rail rates on bulk grain movements are regulated whereas barge and truck rates vary according to demand and supply for equipment. Therefore, during peak demand periods rail rates may be below barge rates and attract shipments from other modes, reinforcing the peaking problem.

The seasonality and other variations in demand for transportation

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services are expected to remain, if not intensify, in the future. Several developments now evident in grain marketing have significance to the transportation industry, and to rail in particular. For example, grain production increased by almost 80 million tons in the 1970-75 period compared to a 23 million ton increase between 1960-70. Since much of these production increases have moved off-farm, the overall need for transportation has also increased. Shifts in world markets have increased the demand for U.S. grains and soybeans. Finally, recent increases in on-farm storage may allow farmers to alter the timing of traditional marketing patterns, creating surge movements in response to price expectations.

The Railroad Revitalization and Regulatory Reform Act of 1976 (RRRR Act) addresses the problems associated with the seasonal and peak-demand for rail services by permitting greater flexibility in rail rates. The Act states: "Within 1 year after the date of enactment of this paragraph, the Commission shall establish, by rule, standards and expeditious procedures for the establishment of railroad rates based on seasonal, regional or peak-period demand for rail services. Such standards and procedures shall 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..." (Public Law 94-210, Title II, Section 202).

Given the seasonality of most rail agricultural traffic, rates based on these fluctuations are expected to have an important impact on agriculture. To determine the appropriate level as well as range of these flexible rates requires a thorough analysis of the extent of peaking that occurs in rail grain movements. But the questions arise, how can peak demand be measured? What savings are possible through the smoothing out of demand?

This paper focuses on a preliminary attempt to measure the seasonality of demand for railcars in grain movements by analyzing the distribution of weekly carloadings of grain during each of the past six years. Car shortages existed from late 1972 until early spring 1974. Some would argue that carloadings during this period were more a reflection of car supply than of demand, since if more empty cars had been delivered they would have been loaded. There were several years during which car supply was apparently adequate in most seasons and areas. From data for the years since 1970, it is possible to gain a perspective on the peak seasonal demand problem that confronts rail grain transportation. Several aspects of the peak-load problem will be examined as well as trends in grain production and marketing. Finally, some estimates of the investment savings to railroads by smoothing peak seasonal demand will be presented.

Trends in Grain Marketing

Grains are bulky and semi-perishable and originate at widely dispersed points. These elements affect the level of demand for transportation as well as the type of equipment and services. Depending on such factors as length of haul, rates and availability of alternative modes, grains may be economically handled by rail, truck, and barge or some combination of these modes. Thus, the total transportation demand by grains is composed of the individual and in some cases highly substitutable demand for rail, truck, and barge transportation services. Generally, railroads and barges handle the long distance movements where these modes have a competitive advantage over trucks. For example, the average length of haul by rail for grain is 435 miles (U.S. Senate, 1975, p. 77).

Quantities of grain sold from farms indicate demand for transportation since it requires movement between production and consumption or processing points. Farm sales of grain increased by over 40 million tons during the 10-year period, 1960-70, and by 75 million tons from 1970-75. Corn and wheat sales during the 1970-75 period both increased by over 60 percent (USDA, 1975).

Export grain movements have a significant impact on the grain transportation system, particularly rail and barge because export points are generally some distance from production areas. A modal split of grain arriving for export reveals that the share carried by rail varied from 60 to 69 percent, barge varied from 17 to 23 percent, with trucks carrying the remaining share, in the 1969-74 period (U.S. Senate, 1975, p. 77). At different stages of the grain handling system the modal split may change. For example, all farm to first market movements use trucks.

Grain exports, using inspection figures, increased by 22 million tons between 1960 and 1970, and have jumped by 73 percent (39 million tons) since 1970. Corn exports, in particular, have increased six times over the 1960 figure of six million tons and have more than doubled in the 1970-75 period. Wheat exports also experienced dramatic gains during the 1960-75 period. Soybean exports, on the other hand, have not experienced much increase in exports since 1970 (USDA).

These overall marketing trends still obscure the seasonal element of sales and exports that are important in understanding the peaking phenomenon.

For example, if local storage facilities become filled during harvest, movements to other stages of the marketing chain are necessary. In some areas, corn can compete with spring wheat and other grains for storage and/or transportation equipment. Export commitments may be of such magnitude that they cause peaking problems at other than harvest periods. It is precisely these ebbs and flows that cause difficulties for rail transportation.

The Peak-Load Problem

The dramatic shifts from year to year in the demand for rail transportation services has added to the seasonal peak-load problem. For our purposes no differentiation will be made between a peak demand due to seasonality of production or because of a sudden increase in export commitments. It is the magnitude of shifts in demand from week to week and the process by which adjustments to these shifts occur that are relevant for development of a peak-load pricing system.

Oort sees three factors in transportation services as necessary for a peaking problem to arise; the use of durable or fixed factor of production, dramatic shifts in demand and inability to store or transfer supply from one period to another (Oort, p. 239). All three elements are present in the transportation of grains by rail. For example, rail equipment such as covered hoppers and narrow-door 40-foot boxcars are durable and fixed within the period of demand fluctuations. It is not possible to inventory transportation services from one time period to another, but by storing the commodity at the appropriate locale, the peaks in transport demand can be smoothed out. Commodity storage incurs costs nonetheless.

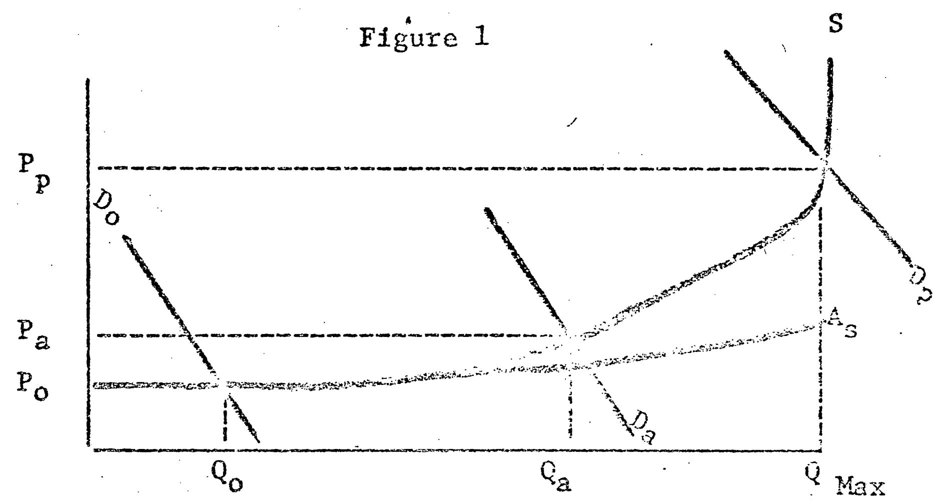
From the viewpoint of economic efficiency, the pricing of peak and off-peak demand should reflect the marginal costs of providing the service.

By considering costs of speeding up car movement and congestion, the pricing analysis is more relevant. The curve S illustrates increasing costs of additional capacity and A_s reflects average costs (Figure 1). At D_o, any small shift in demand would not result in different costs because there is sufficient underutilized capacity. However, to supply the demand D_a, requires the use of perhaps older, more inefficient equipment, faster movement of cars, and more intensive use of other inputs. Therefore, the marginal cost is above the average cost, A_s. Finally, at demand D_p, and any shifts in demand beyond, there is a marginal scarcity rent because all available capacity is being used (Oort, p. 241).

Grain can be stored and demand for railcars can be shifted to other than the peak period when price P_p prevails. Therefore, shippers can determine whether the costs of storage locally versus storage costs at terminals are offset by lower transportation rates during slack periods. However, it is price flexibility that encourages the choice of efficient combinations.

Since rail equipment must be adequate to handle surges in demand and yet be underutilized at other periods, there is a cost in providing a car fleet to handle these peaks. Flexible pricing would allow these costs to be allocated among those requiring a larger fleet, or alternatively lead to efficient storage decisions. In the short run, the flexible pricing of services could perform a rationing function, allocating the fixed supply of equipment and services to their most efficient use. These prices act as signals, and as they increase, demanders of rail service may be able to transfer some of their demand to off-peak periods. Thus, in theoretical terms, flexible prices can ration the supply of cars and services as well as smooth the peaks. If nothing else, flexible pricing

Figure 1



will give railroads equality of pricing opportunity with barges and trucks. Both Berglund and Felton present the theoretical underpinnings for a competitive general freight car market that deals with many of these issues.

It is important to note that the language of the RRRR Act suggests that flexible pricing as such is not allowed, rather fixed seasonal differentials in rates are intimated. If the Act is so interpreted by ratemaking authorities, then it is necessary to determine the extent of peaking that occurs in grain transportation in order to frame an efficient seasonal pricing policy. However, the problem of measuring the seasonal demand for equipment is difficult. At present, only one imperfect indicator exists--the weekly carloadings of grain.

Demand for Railcars to Move Grain

Weekly carloadings of grain reflect peaks and troughs of rail movements. As such, they are not strict measures of grain shippers' demand for freight cars since they reflect only the cars loaded; demand for cars may have been much higher. Also, some shippers who wished to use rail may have used alternative modes or stored grain because they felt that cars were not available; again understating railcar demand (Felton, p. 16). However, weekly carloadings of grain represent the best available indicator of the use of rail equipment if not of the demand for such equipment.

By plotting the carloadings as a weekly time series for one year, considerable seasonality in loading of grain in freight cars is apparent. However, a frequency distribution of the 52 weekly carloadings of grain in a year reveals other aspects than just the seasonality of demand for freight cars. Relatively simple statistics such as average weekly carloadings, range of carloadings, and the relative frequency of the distribution can provide valuable insights into the intensity and the duration of the demand for freight cars in a particular year. It is also possible to compare these statistics with those of other years.

One problem with using this measure to compare carloading activity among years is the change in the type and capacity of rail equipment that has occurred (Hammond and Reinsel). For example, in 1970 there were 207,000, 40-foot narrow-door boxcars with a 2,000-bushel capacity. By 1975, only 131,000 of these cars remained (a 37-percent decrease). In the same period, 3,400-bushel or larger capacity covered hoppers showed a 34-percent increase from 170,000 to 228,000 cars. However, these latter car types are not all used for grain transportation.

Total grain carloadings for the year (no distinction is made among cars of varying capacities) have varied from a low of 1,278,000 carloads in 1971 to a high in 1973 of 1,682,000 carloads (Table 1). Fluctuations in total carloads occur from year to year. For example, an increase of 322,000 carloads between 1972-73 and reductions of approximately 200,000 carloads between 1970-71 and 1973-74 are shown. These yearly carload figures reflect the impact of variations in freight car demand on the rail system over the longer term.

The range of carloadings in a particular year reveal the difference between the peak and trough weeks. Within years, carloadings have fluctuations between low week to high week of from 15,000 to 23,000 carloads. Between 1970 and 1975, the lowest week had 13,700 carloadings and the highest had 38,100. Holidays tend to reduce the carloadings for the week; this influence has not been eliminated in these calculations.

It is these various highs and lows in demand that occur within and among years that are of significance since service capacity must fluctuate

Table 1.--Railcars Loaded with Grain 1970-75[a]

Year	Total 52 weeks	Change from previous year	Mean for 52 weeks	Minimum value	Range	Maximum value	Coefficient of variation
	(Thousands of cars)						
1970	1,469	---	28.2	20.0	15.4	35.4	14
1971	1,278	-191	24.6	16.4	17.1	33.5	16
1972	1,360	+82	26.2	16.1	17.7	33.8	18
1973	1,682	+322	32.3	23.3	14.8	38.1	9
1974	1,471	-211	28.2	19.0	15.9	34.9	13
1975	1,343	-128	25.8	13.7	22.6	36.3	22

[a]Calculated from Association of American Railroads, Car Service Division. Cars of Revenue Freight Loaded, CS54 Record, various issues, Wash., D.C.

accordingly to handle these peaks and troughs. There likely are costs to the railroads involved in these fluctuations since it is unlikely that they only reflect car supply variability as some would claim. At present, with a rigid pricing system, it may also be argued that peak users pay less than the marginal cost for the capacity they use while off-peak users pay more than both marginal and average costs (although they may receive benefits from a higher capacity car fleet in the form of quicker service and other characteristics).

The variability of carloadings in the peak weeks among years is less than that of the trough weeks among years. The difference between the highest and lowest trough week carloading, which occurred in 1973 and 1975, was about 10,000 carloads (Table 1). The peak week carloadings among the years varied from the lowest to the highest by about 4,600 carloads. Carloadings in excess of 36,000 per week occurred in 1975 and 1973. However, relative frequency distributions for each year show that almost 12 percent of the 1973 weekly carloadings were in the 36,000+ class interval versus just 2 percent in 1975. Indeed, in 1973, almost 60 percent of the weeks showed loadings in excess of 32,000 carloadings per week, illustrating the intensity of carloadings that year. For the other years, only 20 percent of the weeks had carloadings in excess of this figure.

The coefficient of variation indicates the spread of the distribution relative to the number of carloadings. The coefficient value is smallest for 1973, a period of intensive use. The intensity of carloadings was less in 1975 which had a coefficient value of 22 percent (Table 1). Prolonged periods of intensive carloadings result in increased congestion costs for shippers and railroads, but they also reduce weekly variations. Thus, periods of less intensive carloadings may reflect the inherent seasonal demand variability of the grain industry.

Savings From Smoothing Out Peak Periods

The previous section showed that some peaking is evident in grain carloadings. While the transportation service cannot be shifted from one time period to another, the commodity can be stored and its shipments deferred to nonpeak periods. By averaging out the weekly carloadings, fewer railcars are needed in the grain fleet to move the same amount of grain, with reduced investment costs in equipment. Estimates of net savings would have to account for investment in storage facilities closer to production areas to allow a smoother distribution of movements. The focus here is on possible investment cost reductions due to a smaller grain car fleet.

Table 1 presented the yearly carload figures for grain. Assume that approximately two-thirds of the grain is moved by covered hopper, the rest by boxcar. Using the carloadings and the turnaround time for boxcars and covered hoppers, it is possible to estimate the size of the grain car fleet required to move the volume actually observed. The calculations proceed as follows:

1. 1/3 x annual grain carloadings = number of boxcar loadings
2. 2/3 x annual grain carloadings = number of covered hopper carloadings
3. $\frac{\text{365 days}}{\text{Turnaround time for boxcars}}$ = number of times a boxcar turns over/year
4. $\frac{\text{365 days}}{\text{Turnaround time for covered hoppers}}$ = number of times a covered hopper turns over/year
5. $\frac{\text{Boxcar carloadings}}{\text{Turnover rate for boxcars}}$ = number of boxcars needed
6. $\frac{\text{Covered hopper carloadings}}{\text{Turnover rate for covered hoppers}}$ = number of covered hoppers needed
7. Number of boxcars + number of covered hoppers needed = total grain car fleet that moved the grain

Berglund developed a technique to determine the number of freight cars that could be eliminated by smoothing peak periods in general freight movements (Berglund, p. 130). An important assumption is that the entire fleet of cars is used at the peak. These calculations proceed as follows:

8. $\frac{\text{Mean weekly carloadings for the year}}{\text{Peak weekly carloadings for the year}}$ = percentage mean is of peak

9. Percentage mean of peak x total grain car fleet = number of cars required to meet the average weekly carloads

10. Total grain car fleet - grain cars needed to meet the average weekly carloads = number of excess capacity cars

11. Total investment cost = excess cars x average cost of a freight car ($25,000)

For 1973, which had the smallest number of excess cars according to the analysis, a total investment cost savings of $374 million is possible. The investment cost of increased country storage facilities would reduce this amount.

Summary

According to the RRRR Act, the ICC must establish procedures to allow rail rates to reflect seasonal or peak demands. Theoretically, flexible pricing in the face of peaking problems is efficient. From an examination of carloadings of grain, some peaking is evident. Again, we reiterate that there is the possibility that this measure is a better reflection of the supply of cars, particularly in years of intensive grain movements, than it is of demand. Under these circumstances, information on carloadings must be supplemented by measures of excess demands and the cost of meeting those demands for an efficient pricing process to be developed.

This paper has also identified a way of estimating the car investment savings associated with a smoothing of seasonal demands. Since grains can be stored, they can be shipped at different time periods. Therefore, savings are possible if less rail cars are needed to move a smoothed out pattern of grain shipments. A trade-off exists, however, since such a pattern implies an increased investment in local grain storage facilities. The impact of fluctuating rail rates, whether positive or negative, will surely be felt in the grains area. Both of these questions should be examined closely.

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