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Investigating the Causal Relationship Between Railroad Rates and Carloadings on Rural Branch Lines

*Victor E. Eusebio and Stephen J. Rindom**

ABSTRACT

This study explores the different causal relationships between railroad rates and carloadings on six rail branch lines in Kansas. The Granger causality test and Geweke measures of feedback are used to differentiate "rate-caused" from "service-caused" abandonment applications so that a determination can be made if loss of business is due to refusal of shippers to use rail service or refusal by railroads to provide rail service or both.

Four of the lines exhibited one-way causality: branch lines A and B show rail rates to be a function of carloadings; and branch lines C and D show carloadings to be a function of rates. Two other lines show independence between rates and carloadings. Lastly, none of the lines exhibit bi-directional causality between rates and carloadings. Degree of feedback for the different causal relationships can be substantial especially when measuring the extent of instantaneous feedback between rates and carloadings.

While maximum rate guidelines protect shippers from rate abuse, the apparent lack of a precise guideline to cover the common carrier obligation in covered hopper car allocation procedures suggest the need for more specific "car service adequacy and reasonableness" measures to protect small shippers from (car) service abuse. The methodology presented in this paper may prove useful for developing alternative threshold levels to protect shippers against potential rate and/or service abuse from the railroads in the future.

INTRODUCTION

On specific rail abandonment cases tried before the Interstate Commerce Commission (ICC), burden of proof is placed on railroads to show that present or future convenience and necessity require or permit abandonment (49 USCA 10903). This standard requires the ICC to weigh the potential harm to affected shippers and communities against the burden of continued operations on the railroad and on interstate commerce. Class I railroads have used, with a great deal of success, the long standing argument that there is little demand for rail service by shippers on the line. The shippers contend that when railroads want to discontinue service on a line, they either set uncompetitive rates or refuse to supply shippers with rail cars for a period of time then go to the ICC and say, in effect, "See, there's no business on this line." In defense of the Class I railroad industry, truck competition on short hauls contributes to low traffic levels (and marginal profits) on many of these rail branch lines. Further, published reports (Norton and Klindworth, 1988 and 1989) of a growing car-supply problem have made it a priority for railroads to manage their dwindling supply of cars in a way that is most profitable for them.

Class I railroads regard grain transportation as two distinct markets: the country (elevator) market and the (inland) terminal market. Differences in size of shipments, length of haul, and other cost related factors separate these markets. The country market is seen by most Class I's as the less profitable market because of lower traffic volumes and higher rail operating costs associated with less efficient utilization of equipment. Conversely, the terminal market is the more profitable market by virtue of higher traffic volumes and lower costs connected with more efficient equipment usage.

As chronic shortages of hopper cars continue, railroads have and will continue to look at market-oriented pricing and supply management strategies that maximize system-wide profits and promote better utilization of their covered hopper car fleet. The result is greater priority for terminal markets at the expense of country markets.

This study explores the causal relationship between railroad rates and carloadings, a major point of contention in branch line abandonment applications by Class I railroads before the Interstate Commerce Commission. Firstly, it seeks to empirically resolve the issue, "Do (higher) rates cause (lower) carloadings or do (lower) carloadings cause (higher) rates or both? Secondly, this study attempts to provide an economic basis for the need to differentiate between "rate-caused" and "service-caused" abandonment applications.

THE THEORY OF CAUSALITY

This study considers causality in the same sense as Granger (1969) in that Granger's approach is purely predictive in nature. As an illustration, let X and Y be two covariance stationary time series. Then X is said to cause Y if Y can be predicted more accurately using past values of X and Y than by using past values of Y alone. Using the symbol "->" to denote Granger causality, four possibilities can occur: (a) $X \rightarrow Y$, $Y \nrightarrow X$; (b) $Y \rightarrow X$, $X \nrightarrow Y$; (c) $X \rightarrow Y$ and $Y \rightarrow X$; and (d) $X \nrightarrow Y$ and $Y \nrightarrow X$.

The theory of Granger causality is used in this paper to empirically examine the relationship between railroad rates and carloadings on rural branch lines in Kansas.

ALTERNATIVE MODELS OF RAIL TRANSPORTATION

Alternative models are presented in this section to explain the nature of grain markets under a chronic grain car shortage situation.

Case 1: Rail Carloadings ↔ Rail Rates

Changes in rail rates, may trigger a subsequent change in total rail carloadings depending on the elasticity of demand for rail transportation at the branch line level. If the local demand for grain cars is moderately elastic, an increase in rail rates causes a more than proportional decrease in traffic and fewer cars are actually used. Railroad firms react to less traffic (and less revenue) by subsequently decreasing the number of rail cars offered to shippers on a particular branch line in hope of sustaining the rate increase and rebuilding traffic or, alternatively, increase rates further to restore profitability of remaining traffic.

Alternatively, a chronic shortage in the supply of hopper cars may result in a decrease in the number of rail cars offered by the rail carrier to shippers on a particular line. Grain shippers unable to acquire grain cars respond by switching to competitive truck service for their short-haul moves from the country to terminal elevators. If the demand for rail cars is moderately inflexible, a decrease in the quantity of rail cars demanded causes a less than proportional increase in rail rates. Rail shippers react to increased rates by subsequently decreasing the number of cars demanded and the cycle repeats itself.

Case 2: Rail Carloadings ← Rail Rates

A second possibility is that a change in rail rates causes a subsequent change in rail carloadings but there is no feedback from carloadings to rates. Why? The answer may lie in grain transportation market conditions characterized by highly elastic grain transportation demand for rail service (highly inflexible demand). Under a system-wide shortage of grain cars, the railroad carrier may actually increase (not decrease) local rates which causes a more than proportional decrease in local carloadings (and revenues). Thus, a significant number of grain cars can alternatively be placed into more productive (more profitable) use elsewhere. Under conditions of highly inflexible demand, decreased carloads will cause little or no upward pressure on local rates.

Case 3: Rail Carloadings → Rail Rates

A third possibility is that a change in rail carloadings causes a change in rail rates but there is no feedback from rates to carloadings. Why? A possible explanation may again lie in the nature of grain transportation demand characterized by grain shippers with more expensive alternative means of transportation (highly rate inelastic, highly rate flexible grain demand condition). In a system-wide shortage of grain cars, railroads may decrease the local supply of grain cars to shippers. Local excess demand for grain cars creates upward pressure on local rates. Railroads allow local rates to increase with little or no change in grain car demand.

Case 4: Rail Carloadings and Rail Rates are Independent

Rail rates and carloadings may be independent of each other through the use of contracted rail service at the country where both rates and minimum volume requirements are set in advance for a specified period of time. Advantages to Class I railroads include improved equipment planning, better short run demand forecasts, and increased market share by tailoring price and service packages to local shipper needs (Klindworth, et.al., 1985).

MODELLING THE RELATIONSHIP BETWEEN RAIL RATES AND CARLOADINGS

The Model

The rail-pricing model for specific origin-destination movements on a given branch line is represented as follows:

$$REVPTM = A_1(L)REVPTM + A_2(L)RAILCAR + \in_1; \ \ var(\in_1) = \Sigma_1 \qquad (1)$$

where REVPTM denotes monthly branch line revenue in dollars per ton-mile; RAILCAR is monthly carloadings; and $A_i(L)$ are convergent polynomials in the lag operator, L ($L^i x_t = X_{t-i}$).

The potential impacts of branch line viability on the availability of rail service can be represented as:

$$RAILCAR = B_1(L)REVPTM + B_2(L)RAILCAR + \in_2; \ \ var(\in_2) = T_1 \qquad (2)$$

Considered together, (1) and (2) can be re-written as the following joint system:

$$\begin{bmatrix} REVPTM \\ RAILCAR \end{bmatrix} = \begin{bmatrix} A_1(L) & A_2(L) \\ B_1(L) & B_2(L) \end{bmatrix} \begin{bmatrix} REVPTM \\ RAILCAR \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix}; cov \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} = Y_1 = \begin{bmatrix} \Sigma_1 & C \\ C' & T_1 \end{bmatrix} \qquad (3)$$

Hypothesis Tests

In this context, we can test the following hypotheses:

H_1: RAILCAR -↛ REVPTM, ($A_2 = 0$);
H_2: REVPTM -↛ RAILCAR, ($B_1 = 0$);
H_3: There is no instantaneous causality, i.e., no contemporaneous correlation between REVPTM and RAILCAR; and
H_4: H_1, H_2, and H_3.

Imposing H_4 reduces equation (3) to the following:

$$\begin{bmatrix} REVPTM \\ RAILCAR \end{bmatrix} = \begin{bmatrix} A_1'(L) & 0 \\ 0 & B_2'(L) \end{bmatrix} \begin{bmatrix} REVPTM \\ RAILCAR \end{bmatrix} + \begin{bmatrix} \upsilon_1 \\ \upsilon_2 \end{bmatrix}; cov \begin{bmatrix} \upsilon_1 \\ \upsilon_2 \end{bmatrix} = Y_2 = \begin{bmatrix} \Sigma_2 & \Omega \\ \Omega' & T_2 \end{bmatrix} \qquad (4)$$

Before proceeding to estimate the unrestricted and restricted systems in (3) and (4), a finite lag parameterization must first be chosen. While longer lag lengths lessen the chance of misspecification, they also result in the loss of more degrees of freedom. Geweke (1978) argues that the number of lags on the lagged dependent variable in each equation should be kept generous in order to minimize the chance of serially correlated errors, while the number of lags on the other variables should be kept lower to retain power in the tests. Hence, the lag length is set at $p_1 = 42$ months for the lagged dependent variable in each equation [A_1 and B_2 in (3); A_1' and B_2' in (4)], and $p_2 = 18$ months for the other variables [A_2 and B_1 in (3)].

The Granger causality tests can be performed by estimating the unrestricted system, (3), and the restricted system, (4), and calculating the Wald F statistic for each hypothesis. These hypotheses can also be investigated by using the estimates of Y_1, Σ_1, Σ_2, T_1, and T_2 to calculate the Geweke measures of feedback:

$$H_1: \hat{F}_{RAILCAR \rightarrow REVPTM} = \ln(|\hat{\Sigma}_2| / |\hat{\Sigma}_1|) \overset{a}{\sim} (n^{-1})\chi^2_{2p_2};$$

$$H_2: \hat{F}_{REVPTM \rightarrow RAILCAR} = \ln(|\hat{T}_2| / |\hat{T}_1|) \overset{a}{\sim} (n^{-1})\chi^2_{2p_2};$$

$$H_3: \hat{F}_{RAILCAR \cdot REVPTM} = \ln(|\hat{\Sigma}_2| * |\hat{T}_2| / |\hat{Y}_1|) \overset{a}{\sim} (n^{-1})\chi^2_2;$$

$$H_4: \hat{F}_{RAILCAR, REVPTM} = \hat{F}_{RAILCAR \rightarrow REVPTM} + \hat{F}_{REVPTM \rightarrow RAILCAR} + \hat{F}_{RAILCAR \cdot REVPTM} \overset{a}{\sim} (n^{-1})\chi^2_{2(2p_2+1)};$$

where n is the sample size. The Geweke approach measures the degree of dependence or the extent of feedback present. A readily usable theory of inference for all these measures and their decompositions is described in Geweke (1982).

The Data

Data on REVPTM and RAILCAR for selected branch lines in Kansas have been obtained from the annual ICC Carload Waybill Sample tapes. The sample period begins in January, 1981 and continues through December, 1992.

The data for REVPTM and RAILCAR often display trends and systematic seasonal movements, implying nonstationarity. To address this problem, a time trend and eleven seasonal dummies have been included in equations (3) and (4). The resulting models then represent the hypothesized relationship between rail rates and carloadings, holding constant the systematic movements in each variable due to trend and seasonality.

EMPIRICAL RESULTS

Historical grain shipments by rail in Kansas are shown in Table 1. Small country houses are elevators with less than 1.5 million bushels of storage capacity. Large country houses are elevators with capacities of 1.5 million bushels or more. Both elevators receive most of their grain from farmers and have access to mostly local rail service. Terminals are large elevators that receive most of their grain from other elevators. They serve as storage points for grains in transit and have access to unit train service to major grain markets.

TABLE 1

Grains Shipped by Rail from Kansas Elevators - 1982, 1987 and 1992

Crop Year/Type of Elevator	Grain (Percent of Total Shipments)			
	Wheat	Corn	Milo	Soybeans
1992				
Small Country Houses	52	9	33	17
Large Country Houses	69	47	44	74
Terminals	99	97	100	92
1987				
Small Country Houses	65	22	47	10
Large Country Houses	78	17	25	62
Terminals	98	93	97	96
1982				
Small Country Houses	68	33	38	17
Large Country Houses	84	38	54	7
Terminals	98	88	92	51

Source: Kansas Grain Marketing and Transportation, Data for 1992 Crop and Historical Data 1982-91. Kansas Department of Agriculture and the U.S. Department of Agriculture. Topeka, Kansas. December 1993.

Although a large portion of shipments from Kansas elevators continue to move by rail, we can observe declining rail market share particularly at small country houses, and increased share at terminals for the four major grains.

Granger Test Results

Table 2 shows causality test results for six rail lines in Kansas. Four of the lines exhibit one-way causality: branch lines A and B show rail rates to be a function of carloadings while branch lines C and D show carloadings to be a function of rates. Two other lines (E and F) show independence between rates and carloadings. Lastly, none of the lines exhibit bi-directional causality between rates and carloadings.

TABLE 2

Granger Causality Tests on Kansas Branch Lines

Branch Line	Granger Test			Causality Condition
	H_1	H_2	H_4	
A	2.00**	0.93	1.47*	HOPCAR → REVPTM
B	2.41***	1.45	1.92**	HOPCAR → REVPTM
C	1.25	1.87**	1.57*	HOPCAR ← REVPTM
D	1.27	3.49***	2.57**	HOPCAR ← REVPTM
E	1.29	1.38	1.40	HOPCAR & REVPTM are independent
F	0.67	1.52	1.11	HOPCAR & REVPTM are independent

*** significant (rejection of H_i) at .01 level
** significant at .05 level
* significant at .10 level

Source: Empirical Results.

Using branch lines A and B as example, rejection of hypothesis 1, i.e., RAILCAR causes REVPTM, and acceptance of hypothesis 2, i.e., REVPTM does not cause RAILCAR, imply that changes in local rail carloadings will trigger changes in local rail rates, but not vice-verca. In a grain car shortage situation, the implications are obvious: restricting the supply of grain hopper cars on a line will cause upward pressure on rail rates as local shippers compete for a smaller allotment of cars.

Hypothesis 4 provides for joint-testing of hypotheses 1 and 2 and serves as "back-up" hypothesis that either reinforces or contradicts hypotheses 1 and 2. Intuitively, if one or both of the previous hypotheses are accepted, hypothesis 4 must also be accepted. Conversely, if both the previous hypotheses are rejected, then hypothesis 4 should also be rejected.

With lines C and D, the opposite takes place: acceptance of hypothesis 1, i.e., RAILCAR does not cause REVPTM, and rejection of hypothesis 2, i.e., REVPTM causes RAILCAR, imply that local changes in rail rates will trigger changes in rail carloadings, but not vice-verca.

In a car shortage situation, increasing rates will cause decreased carloadings as shippers switch from rail to truck service.

Lastly, with lines E and F, acceptance of hypotheses 1 and 2 implies no causal relationship between rail rates and cars. A closer examination of both lines confirms the presence of big shippers with grain contracts and access to trainload service to the grain export market.

Geweke Measures of Feedback

The Geweke measures for direction and degree of causality on six Kansas branch lines are shown in Table 3. The measure of linear dependence is the sum of the measure of linear feedback from the first time series (carloadings) to the second (rates), linear feedback from the second (rates) to the first (carloadings), and instantaneous linear feedback. The measures of linear feedback from one series to another can be additively decomposed by frequency.

TABLE 3

Geweke Measures of Feedback on Kansas Branch Lines

Branch Line	Geweke Test			
	H_1	H_2	H_3	H_4
A	55.4*	3.7	46.1***	105.2**
B	59.0**	28.8	102.2***	190.0***
C	13.7	51.0*	54.4***	119.1**
D	8.4	72.0***	172.8***	253.2***
E	15.8	14.4	12.9***	87.8
F	20.2	22.6	26.2***	69.0

*** significant (rejection of H_i) at .01 level
** significant at .05 level
* significant at .10 level

Source: Empirical Results.

Both the Granger test and Geweke measures show identical causal relationships for the six branch lines. Moreover, the Geweke measures allow us to compare the degree of causality (feedback) among the lines. For example, feedback results (under hypothesis 2) indicate that an increase in rates will lead to a greater decrease in carloadings for line D than line C. Interestingly, the Geweke results also indicate (statistically) significant instantaneous causality and feedback under hypothesis 3. (The Granger test assumes no instantaneous feedback between rates and carloadings.) This is indicative of relatively "quick" responses by railroads and shippers to changes in rates and carloadings due to periodic changes in grain supply and demand.

REGULATORY IMPLICATIONS

Certain provisions of the Staggers Rail Act of 1980 allow railroads to reduce rates more easily to meet truck and barge competition. Rate setting jurisdiction by the ICC is limited to those rates where railroads exercise market dominance and charge above a threshold rate level set initially at 160 percent (now at 170 percent) of variable cost. Zones of rate flexibility are established which allow rates to be raised up to 4 percent per annum above the cost recovery index without prior ICC approval.

MacDonald (1989) concluded that both a decline in demand for grain export and increased unit train usage lowered per bushel shipping costs and exerted downward pressure on rates. Under a more competitive grain transportation environment, railroads can have uncompetitive rates that are below the rail variable cost threshold. The end result may be declining rail market share of local grain traffic, financial insolvency and rail line abandonment.

Although under a more market-oriented rail pricing environment since 1980, rail carriers still have a common carrier obligation to the allocation and distribution of covered hopper cars. The Interstate Commerce Act states that rail carriers must provide "adequate car service" and have "reasonable rules and practices on car service." In recent years, several railroads have developed covered hopper car allocation procedures that primarily allot cars to heavy/frequent users. Oftentimes, these users are the bigger grain elevators and terminals. While maximum rate guidelines govern abuse of rates, the apparent lack of a precise guideline to cover the common carrier obligation in actual covered hopper car distribution procedures suggest the need for more specific "car service adequacy and reasonableness" measures to protect small grain shippers on rural branch lines.

CONCLUSION

This paper presents empirical evidence concerning the different causal relationships that may exist between rail rates and grain carloadings. It provides a useful tool for the Interstate Commerce Commission in future rail abandonment applications in determining if loss of business may be due to refusal by shippers to use rail service or refusal by railroads to provide rail service or both. In addition, this study suggests a "level of feedback" procedure which may prove useful for developing alternative threshold levels to protect shippers against potential rate and/or service abuse from the railroads.

This paper represents a preliminary report of progress on causality and feedback analysis. More testing and verification on a larger sample of branch lines have to be done before we know if the procedure proves reliable and manageable for regulators.

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ENDNOTE

* The authors are with the Kansas Department of Transportation, Bureau of Rail Affairs.