ISSN 1046-1469
Indexed by PAIS

# *JOURNAL OF THE TRANSPORTATION RESEARCH FORUM*

Volume 37 Number 2 1998



**TRANSPORTATION RESEARCH FORUM**

# GRAIN DEPENDENT SHORT LINE RAILROAD PROFITABILITY

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## ABSTRACT

This paper is the first empirical analysis of U.S. short line railroad profitability using primary cost and revenue data. The paper develops profitability models for grain-dependent short line railroads and identifies the key factors influencing grain dependent short line profitability through empirical estimation of these models. In addition, the paper develops a quantitative profile of a grain-dependent short line railroad that is likely to be profitable in the long term. The models explain up to 86 percent of the variation in short line profitability and all the explanatory variables have the theoretically expected sign and are statistically significant. The key factors influencing short line profitability are identified through sensitivity analysis as well as the elasticities and t-statistics of the explanatory variables. The most important profitability determinant by all three of these criteria is the number of carloads per mile of main-line track.


## INTRODUCTION

The short line railroad industry has experienced tremendous growth since railroad deregulation in 1980. Between 1980 and 1993, a total of 339 short line railroads were created, operating a total of 34,385 miles of track. By 1996, short line and regional railroads operated 47,214 miles of track in the U.S. which is 27 percent of the national rail network.

Short lines are operating many thousands of miles of rural rail branchline that might otherwise have been abandoned. Abandonment has several potential negative impacts on rural areas such as:

- Lower grain prices received by farmers.
- Higher transportation costs and lower profits for rail shippers.
- Loss of market options for shippers.
- Lost economic development opportunities in rural communities resulting in less diversification of employment.
- Higher road maintenance and reconstruction costs.
- Loss of local tax base needed for basic governmental services.

Thus, the question of economic viability of short lines is important to rural areas. If short lines are an economically viable alternative to abandonment, then the above potential negative effects can be avoided. Also, as Class I railroad mileage continues to decline, rural communities, shipper groups, and railroad entrepreneurs may ask states for assistance in establishing short line railroads. Thus, state Departments of Transportation (DOTs) need to know if short line railroads offer an economically viable mode of transportation in order to properly evaluate the question of financial assistance for short lines.

Several researchers have investigated the economic feasibility of short line railroads. Some studies have estimated short line railroad cost functions (Sidhu et.al., 1977; Dooley, 1991). Others have identified some of the causes of short line success or failure (Due, 1984, 1987; Wolfe, 1988; Grimm and Sapienza, 1993; and Eusebio, 1993). Some investigators have employed a financial model approach to the question of short line viability (Wolfe, 1989a, 1989b; Walter and McNair, 1990; and USDOT, 1993). Dooley and Rodriquez (1988), ICC and USDOT (1989), USDOT (1989), and Babcock et.al. (1995a, 1995b) addressed the problem by comparing the prices and service of short line railroads to that of the predecessor Class I railroad and to motor carriers. Fitzsimmons (1991) and Eusebio (1993) examined the impact of intramodal and intermodal competition on short lines. Babcock, Prater, and Morrill (1994) identified a qualitative profile of a profitable short line railroad based on personal interviews of short line railroad executives, shippers located on short lines, and public officials.

While these studies made important contributions to our understanding of short line railroad profitability, no study has specified and empirically estimated a model of short line railroad profitability using proprietary financial information supplied by the short lines themselves. Also since short line railroads are not price takers for all their movements, a profitability study would reveal more about short line viability than previous cost studies. Furthermore some variables that are typi-cally employed in rail cost studies, such as traffic density, affect railroad revenue as well. Accord-ingly the objectives of this paper are as follows:

1. Develop profitability models of grain-dependent short line railroads.[1]

2. Identify the key factors influencing grain-dependent short line profitability by empirical estimation of the models developed in Objective 1.

3. Develop a quantitative profile of a grain-dependent short line railroad that is likely to be profitable in the long term.

## THE MODEL

The general form of the model is as follows:

$$Y_{it} = \propto + \sum_k \beta_k X_{itk} + \varepsilon_{it}$$

Where:

$Y_{it}$ = the profitability of firm i in year t.
$\propto$ = the intercept term which is the same for all firms.
$\beta_k$ = the effect of the independent variable k upon profitability.
$X_{itk}$ = the value of the independent variable k for firm i and year t.
$\varepsilon_{it}$ = the error term, $\varepsilon_{it} \sim$ iid $N(0, \sigma_e^2)$.

The profitability of short line railroads can be measured in several alternative ways and each of them has advantages and disadvantages. The dependent variable selected for this study is Gross Railway Operating Income (GROI) which is calculated as follows:

| | |
|---|---|
| Operating Revenues | $$$ |
| Operating Expenses | -$$$ |
| Operating Income | $$$ |
| Income From Lease of Track | -$$$ |
| Income From Lease of Equipment | -$$$ |
| Care Hire Income | -$$$ |
| Rent Paid for Lease of Track | +$$$ |
| Rent Paid for Lease of Equipment | +$$$ |
| Care Hire Costs | +$$$ |
| Gross Railway Operating Income | $$$ |

The objective of the study is to identify and measure the economic determinants of short line railroad profitability. Thus it is necessary to adjust the profitability measure for interfirm differences in profits that are due solely to accounting factors or to unusual, nonrecurring events.[2] The major advantage of using GROI to measure profit is that it does not include the effects of many non-operating items upon profitability. For example, in the sample short lines examined in this study, income tax rates vary from zero to 36 percent of income before taxes. However, since GROI is a before-tax measure of profitability, it is unaffected by interfirm variation in tax rates. Also interest expenses varied widely among the short lines in the sample, but since GROI is a before-interest measure of profits, it is unaffected by interfirm variation in interest expense. GROI also is unaffected by non-operating items such as extraordinary income or by unusual income.

In addition, car hire costs are a major operating expense for some short line railroads so failure to include car hire costs and income would result in a substantial source of error in measuring the profitability of short line railroads. Accordingly, GROI includes car hire costs and income.[3] The disadvantage of GROI is that it is affected by depreciation and track maintenance expenses which vary widely among short line railroads.

The nature of maintenance of way (MOW) expenses resulted in the formulation of alternative versions of the profitability models. MOW expenses include all expenses associated with maintaining track including track repair, weed control, snow removal, and depreciation of equipment used to maintain track.[4] These expenses vary widely among short lines due to differences in debt level, condition of the track, traffic density, miles of track and other factors.

Ideally railroad profitability should reflect MOW expense that measures all the costs associated with track usage during a given period of time. However, since MOW expenses are postponeable, this does not necessarily occur for all railroads in the sample. For example suppose Railroad X has very limited profitability and spends nothing on MOW while Railroad Y is highly profitable and its MOW expense is sufficient to maintain track quality. In this scenario, the combined MOW expense of the two railroads does not reflect all the costs of track usage. One way to avoid this potential distortion of profitability is to remove MOW expenses from the operating expense of the firm. This removes the potential distortion of short line profitability caused by interfirm differences in MOW expense that may or may not reflect all of the true costs of track usage. Since the significance of this is an empirical question we estimate models with MOW expense as an explanatory variable and models with MOW expense removed from the operating expense of the firm.

GROI is also adjusted to remove the effects of interfirm differences in government aid received which varied among the sample short lines from no aid to substantial amounts. To adjust GROI, an annual value is placed on the government aid received by each railroad. Next, the government aid is divided into interest and non-interest components where the interest benefits are those derived from reduced interest costs. Since GROI is a before-interest measure of profitability, it is adjusted only for the non-interest portion of government aid.[5]

The effect of the MOW expense and government aid adjustments is to create three different versions of the dependent variable, GROI. The first version (RGROI) is not adjusted for interfirm differences in MOW expense and government aid so both of these variables are in the model as explanatory variables. The second version (RGROI1) is GROI adjusted only for interfirm differences in MOW expense in the manner described above, while the third version (RGROI2) is GROI adjusted for interfirm differences in MOW expense and government aid.

The final adjustments are to measure GROI in real dollars and divide by miles of mainline track in order to better compare the profitability of short lines having different track miles. The latter adjustment also reduces the potential for statistical problems such as heteroskedasticity.

In the RGROI model, MOW is lagged one year to eliminate potential simultaneity. That is, one can hypothesize that MOW affects profitability and also that profitability affects funds available for MOW. Also MOW is lagged since it is reasonable to assume that increased MOW in the current period will improve profits in the next period due to improved service and safety.

A large number of potential independent variables thought to affect short line revenues and costs were examined.[6] After substantial statistical testing the following explanatory variables are employed in the model.

ERA1 = a dummy variable equal to 1.0 if the railroad was created before 1970.

ERA2 = a dummy variable equal to 1.0 if the railroad was created between 1970 and 1987.

GRP = number of railroad firms owned by a parent firm.

GRP2 = GRP squared.

SHIP = a dummy variable equal to 1.0 for railroad firms owned and managed by a shipper or shipper group.

CONN = the number of other railroad firms to which a short line connects.

GMIL = gross miles of main-line track operated by the railroad.

OWN = percentage of track owned by the railroad firm.

TOP3 = percentage of the railroad's total traffic in the top three Standard Industrial Classification (SIC) codes.

TOP32 = TOP3-squared.

GRAN = percentage of the railroad's total traffic which is grain.

GRAN2 = GRAN-squared.

POH = percentage of the railroad's total traffic which is overhead traffic.

DENS = number of carloads per mile of main-line track.

LGROTEXM = total real operating expense per mile minus real maintenance of way (MOW) expense per mile, lagged one year.

RHAUL = ratio of the railroad's length of haul to gross main-line miles operated.

LAGRMOWM = real maintenance of way (MOW) expense per mile, lagged one year.

RAIDNMI = real non-interest government aid per mile of track.

The theoretically expected sign for explanatory variable ERA1 is positive. Older, established short lines have characteristics that have a positive effect on profitability such as experience in the railroad business, a higher number of established marketing relationships, and lower depreciation costs on their assets.

It is difficult to determine an expected sign for ERA2. It could be negative due to the relatively higher prices paid for short lines in the 1970-87 period and the resulting negative effect on profitability. However, the sign of ERA2 could be positive since short lines spunoff by Class I railroads between 1970 and 1987 may have been structured to succeed in order to avoid criticism of using short line creation as a disguise for abandonment. The default for ERA is short lines created after 1987.

With regard to the variable GRP, it can be argued that the theoretically expected sign should be positive since railroad groups benefit from economies that are not available to independent railroads such as the ability to share labor, equipment, technology, management resources, and to diversify risk. However, it can also be argued that the sign should be negative since marginal railroads may be successful only when they are part of a rail group. Thus, marginal railroads are either purchased by a rail group or abandoned. In addition, many railroads in rail groups pay a management fee to the parent firm. If this fee is more than the individual railroad's share of parent firm expenses, then profits are transferred from the individual short line to the parent firm. It is hypothesized that GRP is quadratically related to GROI so the squared value of GRP is included in the model.

A negative relationship is expected between short line profitability and SHIP. A railroad is often owned by shippers if it has marginal traffic density and low profit potential. Since no other firms are willing to purchase these lines, their profitability may be inherently low. Thus, purchase of the line by shippers is the only option that will preserve rail service. Shipper groups may be willing to accept low profitability, in effect subsidizing the line to preserve rail service. Also since operating the railroad is not the shipper's primary business, it may be operated without professional railroad management. This can result in the short line's service not being aggressively marketed, producing a negative effect on profits.

The expected sign of CONN is positive since it reflects the bargaining power of the short line relative to Class I railroads with regard to revenue splits on joint movements, car hire fees, and switching charges. As the number of connections to alternative Class I railroads increases, short line revenues increase, costs decrease, and profits rise. The positive sign of CONN could also be partly attributed to access to additional rail cars that accompanies additional connections to Class I railroads, and the resulting ability to supply more service and increase profits.

A positive relationship is expected for GMIL and short line profitability, since an increase in the size of the railroad's network will produce economies of scale, increased access to markets, and increased potential for gains in local traffic. All of these factors have a positive effect on the short line's profit potential.

Short lines which own their track incur depreciation and interest costs. Depreciation increases operating expense but interest cost does not affect GROI. Railroads which lease their track incur leasing costs which include both depreciation and interest costs. The inclusion of interest in lease costs reduces GROI by increasing operating expenses. Thus, since operating expenses under ownership of track are lower than operating expenses under lease, one would expect the sign of OWN to be positive since GROI would be higher for short lines that own their track.

It is difficult to specify the expected signs of TOP3 and GRAN. It could be argued that TOP3 and GRAN have positive signs if there are significant economies that result from specializing in handling a few commodities in large volumes. Other things equal, this would reduce costs and increase profits. However, it can also be argued that TOP3 and GRAN have negative signs since the railroad's traffic may be seasonal, resulting in reduced efficiency and greater risk to the firm's profitability. Also, grain freight rates are low relative to those of other commodities, producing a negative effect on profits. The variables TOP32 and GRAN2 are the squared values of the above variables and are included in the model to measure potential nonlinear effects of TOP3 and GRAN. Both of these are expected to have negative signs since it is more likely that TOP3 and GRAN will have maximum values. That is, increasing values of these two variables will continue to increase GROI only up to a point, after which continued increases in TOP3 or GRAN will reduce GROI.

A negative relationship is expected between POH and profitability. Overhead traffic is received from a Class I railroad at one location on a short line and returned to the same Class I railroad at a different location on the short line. The Class I railroad has considerable bargaining power relative to the short line since it usually has the option of hauling the traffic a longer distance on its own network. As a result, the short line usually sets a price for overhead traffic that is slightly above its variable cost. Although any revenue in excess of variable cost will increase profits, the presence of traffic density (DENS) in the model may cause POH to be negative since overhead traffic is included in total traffic, but is priced at a below average level. Thus, the negative sign of POH may reflect the effects of price discounts on overhead traffic.

A positive relationship is expected between DENS and short line profitability. Since railroads have a high percentage of fixed costs and factor indivisibilites, an increase in traffic density will reduce costs per carload and increase profitability.



 

Previous short line studies have found that a key factor for the profitability of short line railroads is the ability of management to control expenses. To the extent that short line management is successful in this endeavor, LGROTEXM will fall and profits will increase. Thus the theoretically expected sign is negative. This variable is lagged to eliminate potential simultaneity bias. That is, one can hypothesize that reduced other expenses will increase profitability and also that increased profitability affects funds available for other expenses.

Railroads have a competitive advantage relative to motor carriers on longer distance hauls. Thus, the greater the length of haul, the higher the price that the railroad will be able to charge relative to its variable cost. In addition, the greater the length of haul, the larger the short line's share of revenue from joint movements with other railroads. Thus, the theoretically expected sign for RHAUL is positive since the greater the length of haul, the higher the profits of the short line railroad. The ratio of the length of haul to mainline miles of track is used to measure RHAUL, instead of actual length of haul, to reduce the potential for multicollinearity.

The expected sign of LAGRMOWM is positive since it is reasonable to assume that increased MOW in the current period (time, t) will increase profits in the next period (time, t+1) due to improved service and safety.

With the regard to RAIDNMI, the expected sign is theoretically indeterminate. One could argue that the sign of this variable is negative since government aid is usually given to less profitable railroads. However, government financial assistance is usually considered to be more likely to benefit a firm and thus increase profitability. The theoretically expected signs of the independent variables are summarized in Table 1.

The sample to empirically estimate the model of short line profitability includes 34 railroads operating in 17 states in the Midwestern region of the U.S. for the fiscal years 1986 through 1995. The sample is unbalanced since some of the short lines did not begin operations until after 1986 and other railroads discontinued operations prior to 1995. The number of years data for each railroad in the sample varies from 2 to 10 years. A total of 109 annual observations were obtained.

The principal reason that no previous study of this type has been conducted is that it requires proprietary financial information from short line railroads, which they are naturally reluctant to make available to researchers. However, 34 short line railroads participated in this study by completing questionnaires and submitting balance sheets and income statements for the relevant years. In some states, short lines are required to submit annual reports to state DOTs and these reports contain some of the data required in this study. On occasion we used data from *Profiles of American Railroads* published by the Association of American Railroads.

RGROI is converted to 1992 dollars using the Implicit Gross Domestic Product Deflator found in the *1996 Economic Report of the President*.

## EMPIRICAL RESULTS

The models are estimated by ordinary least squares (OLS) regression.[7] The standard errors of the estimates are computed in the usual manner and we use the Huber-White-Sandwich robust estimator of variance to detect the potential presence of heteroskedasticity. The models are initially estimated using TOP3 and TOP32 as explanatory variables. The same models are then re-estimated replacing TOP3 and TOP32 with GRAN and GRAN2. Since TOP3 and GRAN (and TOP32 and GRAN2) are highly correlated, multicollinearity occurs if both variables are in the same equation. Some of the independent variables are calculated on a per mile of track basis in order to reduce potential statistical problems such as multicollinearity and heteroskedasticity.

The estimated RGROI equations (with TOP3 and TOP32) are displayed in Table 2. An examination of the table reveals that the adjusted $R^2$'s of RGROI1 and RGROI2 are 0.83 and 0.86, respectively somewhat better than that of RGROI (0.78). The Durbin-Watson statistics of the RGROI, RGROI1, and RGROI2 equations are 1.87, 1.94, and 2.00 respectively, so autocorrelation is not a problem in the estimated equations.[8] In addition, the parameters and standard errors obtained by robust standard error estimation do not vary much from those of the OLS models, indicating that heteroskedasticity is not a problem with the estimated RGROI equations.

With respect to the RGROI equation, all the independent variables with a determinate expected sign have the theoretically expected sign. For independent variables with an indeterminate sign, ERA2 has a positive sign which is consistent with the hypothesis that the short lines spunoff during this period were those that had the best opportunity for success. GRP has a negative sign indicating that some of the railroads purchased by rail groups may be marginally profitable. The negative coefficient may also be partly attributable to the possible transfer of individual railroad profits to

**Table 1**

| Independent Variable | Theoretically Expected Sign |
|---|---|
| ERA1 | + |
| ERA2 | + or - |
| GRP | + or - |
| GRP2 | + or - |
| SHIP | - |
| CONN | + |
| GMIL | + |
| OWN | + |
| TOP3 | + or - |
| TOP32 | - |
| GRAN | + or - |
| GRAN2 | - |
| POH | - |
| DENS | + |
| LGROTEXM | - |
| RHAUL | + |
| LAGRMOWM | + |
| RAIDNMI | + or - |

the parent firm in the form of management fees. TOP3 and RAIDNMI have positive signs but neither variable is statistically significant.

With regard to statistical significance of the coefficients in the RGROI equation, the variables ERA1, GRP, GRP2, SHIP, CONN, GMIL, DENS, and LGROTEXM are significant at the .01 level, while ERA2, OWN, and RHAUL are significant at the .05 level. The variable POH is significant at the .10 level. The other 4 independent variables are nonsignificant including lagged real maintenance of way expenditures (LAGRMOWM).

The empirical results of the RGROI1 and RGROI2 equations are similar. The variables that are statistically significant at the .01 level in both equations are ERA1, ERA2, GRP, SHIP, CONN, GMIL, DENS, and LGROTEXM. In both equations the variable RHAUL is statistically significant at the .05 level. The variables GRP2 and POH are significant at the .01 level in the RGROI1 equation and at the .05 level in the RGROI2 equation. The variables TOP3 and TOP32 are statistically significant at the .05 level in the RGROI1 equation but are not significant in the RGROI2 equation. In both equations OWN is not significant.

The empirical results in Table 2 indicate that the there is relatively little difference in the statistical performance of the three equations. The $\bar{R}^2$ of RGROI1 and RGROI2 is slightly higher than that of RGROI. However all three equations have a similar number of statistically significant variables and the t statistics are similar as well.

It is interesting to note the quadratic nature of GRP and its relationship to short line profitability. When a dependent variable has a quadratic relationship to the explanatory variable, the value of the dependent variable is maximized or minimized at some value of the explanatory variable. This maximizing or minimizing value of the explanatory variable can be found by differentiation. For instance, if $Y=\beta_1X+\beta_2X^2$, then $\partial Y/\partial X=\beta_1+2\beta_2X$. Since $\partial Y/\partial X$ is the slope of the function, Y is maximized or minimized where the slope of the function equals zero. Thus, set $\beta_1+2\beta_2X=0$ and the Y is optimized when X has a value of $-\beta_1/2\beta_2$. Letting Y be RGROI1 and X be GRP and using the regression results in Table 2, RGROI1 is minimized (with respect to GRP) when GRP is 16 firms (-1361.19/2(42.61)). The corresponding values for RGROI and RGROI2 are 14.6 and 16.7 firms, respectively.

As GRP exceeds its profit minimizing value, profitability of the short line will increase as GRP increases. Profitability increases since the slope of the profitability function is positive when GRP exceeds its profit minimizing value. However profits as related only to GRP remain negative. Thus RGROI1 increases after GRP exceeds 16 firms, but RGROI1 remains negative since the negative effect on profits from GRP still outweighs the positive effects of GRP2. The profit maximizing values of TOP3 are 84.1, 80.7, and 81.8 percent for RGROI, RGROI1, and RGROI2, respectively.

Table 3 contains the empirical results of the models when TOP3 and TOP32 are replaced with GRAN and GRAN2. The adjusted $R^2$s of RGROI is 0.79 compared to 0.84 for RGROI1 and 0.86 for RGROI2. Thus these models explain about the same amount of variation in RGROI as the models using TOP3 and TOP32. The root mean square errors for these models are also about the same.

The Durbin-Watson statistics for the RGROI, RGROI1, and RGROI2 equations are 2.11, 2.20, and 1.95, respectively, indicating that autocorrelation is not a problem with these OLS equations. In addition, the parameter estimates and standard errors obtained by robust standard errors estimation do not vary greatly from those of the OLS models, indicating that heteroskedasticity is not a problem of the OLS equations.

Examination of Table 3 reveals that with regard to the RGROI equation all the variables with a theoretically determinate sign have the expected sign. With regard to the variables with a theoretically indeterminate sign, GRP has a negative sign while ERA2, GRAN and RAIDMI have positive signs. There is substantial similarity in the empirical results for the two versions of the GROI model. The RGROI (TOP3) equation has 8 independent variables that are statistically significant at the .01 level while the RGROI (GRAN) equation also has 8 variables in this category. In addition, the variables that are statistically significant at the .01 level are the same in both equations. The RGROI (TOP3) equation has 4 independent variables that are not statistically significant while the RGROI (GRAN) equation has 5 nonsignificant variables.

The empirical results of the RGROI1 and RGROI2 equations in Table 3 are very similar. Among the variables with a theoretically indeterminate sign, GRP has a negative sign while ERA2, GRAN and RAIDMI have positive signs. In both the RGROI1 and RGROI2 equations, the independent variables GRP, GRP2, SHIP, CONN, GMIL, GRAN, GRAN2, POH and DENS are statistically significant at the .01 level. The variables ERA1 and LGROTEXM are statistically significant at the .05 level in the RGROI1 equation and at the .10 level in the RGROI2 equation. The variable ERA2 is significant at the .05 level in the RGROI1 equation and not significant in the RGROI2 equation. The only variable that is non-significant in both equations is OWN.

It is interesting to note the quadratic nature of GRAN and its relationship to short line profitability. RGROI1 is maximized (with respect to GRAN) when GRAN is 60.7 percent [-238.1/2(-1.96)]. The corresponding values for RGROI and RGROI2 are 74.2 and 62.1 percent, respectively.

As GRAN exceeds its profit maximizing value, profitability of the short line will decline as GRAN increases. Profitability decreases since the slope of the profitability function is negative when GRAN exceeds its profit maximizing value. However profits as related only to GRAN remain positive. Thus RGROI1 decreases after GRAN exceeds 60.7 percent, but RGROI1 remains positive since the positive effect on profits from GRAN still outweighs the negative effects of GRAN2. The profit minimizing values of GRP are 14.3, 15.3, and 14.9 firms for RGROI, RGROI1, and RGROI2, respectively.

Like the TOP3 equations, the empirical results of the adjusted models (RGROI1 and RGROI2) are similar to those of the unadjusted model (RGROI). The adjusted $R^2$s of the RGROI1 and RGROI2 equations are slightly higher than that of RGROI. However the number of statistically significant variables as well as the t statistics are similar in all three equations.

Table 4 contains the elasticities (calculated at the mean) for the various independent variables. The top row of numbers for each variable are the elasticities pertaining to the models using TOP3 as an independent variable and the bottom row of numbers are the elasticities for the models using GRAN. The elasticity of RGROI with respect to the various independent variables is important in evaluating the relative impact of the independent variable on RGROI. In general, changes in those independent variables having larger elasticities will produce larger changes in RGROI than changes in those independent variables having lower elasticities.

An examination of Table 4 reveals that the elasticities of the RGROI model are higher than those of the RGROI1 and RGROI2 models for most of the explanatory variables. The elasticities of the independent variables for the RGROI1 and RGROI2 models are similar for both the TOP3 and GRAN versions of the model. The variable with the highest elasticities is DENS with the elasticity ranging from a low of 1.030 to a high of 1.511. With the exception of DENS, no independent variable has an elastic coefficient (i.e. >1.0) with respect to RGROI1 and RGROI2. However for the unadjusted RGROI model, three independent variables have elastic coefficients including GRP, DENS, and LGROTEXM. In general, the high elasticities of DENS for all versions of the models indicate that short line profitability is more responsive to traffic density than any other variable in the model.

**Table 2**
**Real Gross Railway Operating Income Per Mile (RGROI)[a]**
**TOP3 MODEL**

| Independent Variable | RGROI (Unadjusted) | RGROI1 (Before MOW) | RGROI2 (Before MOW and Aid) |
|---|---|---|---|
| ERA1 | 9150.37 | 9473.21 | 9564.54 |
| | (3.002)*** | (2.983)*** | (3.114)*** |
| ERA2 | 4537.52 | 5498.90 | 5297.06 |
| | (2.536)** | (2.962)*** | (3.035)*** |
| GRP | -1374.27 | -1361.19 | -1307.47 |
| | (-3.755)*** | (-3.561)*** | (-3.453)*** |
| GRP2 | 46.92 | 42.61 | 39.05 |
| | (3.132)*** | (2.729)*** | (2.509)** |
| SHIP | -9480.09 | -9590.99 | -9796.35 |
| | (-5.289)*** | (-5.128)*** | (-5.431)*** |
| CONN | 636.63 | 571.07 | 561.89 |
| | (4.930)*** | (4.414)*** | (4.503)*** |
| GMIL | 12.61 | 13.69 | 13.84 |
| | (5.192)*** | (5.441)*** | (5.817)*** |
| OWN | 29.91 | 21.24 | 20.43 |
| | (2.094)** | (1.443) | (1.405) |
| TOP3 | 803.55 | 1370.96 | 1117.04 |
| | (1.447) | (2.395)** | (1.640) |
| TOP32 | -4.78 | -8.49 | -6.83 |
| | (-1.351) | (-2.327)** | (-1.616) |
| POH | -64.95 | -109.12 | -104.61 |
| | (-1.669)* | (-2.801)*** | (-2.597)** |
| DENS | 77.81 | 123.53 | 132.73 |
| | (4.174)*** | (7.510)*** | (8.464)*** |
| RHAUL | 5659.63 | 5830.54 | 5438.40 |
| | (2.303)** | (2.303)** | (2.265)** |
| LGROTEXM | -0.2909 | -0.2493 | -0.2349 |
| | (-3.68)*** | (-3.219)*** | (-3.214)*** |
| LAGRMOWM | 0.1768 | ------ | ------ |
| | (0.536) | | |
| RAIDNMI | 0.3279 | 0.6804 | ------ |
| | (1.056) | (2.203)** | |
| CONSTANT | -35586.68 | 55854.56 | -47586.42 |
| | (-1.647) | (2.503)** | (-1.739)* |
| Number of obs. | 109 | 109 | 108 |
| Adj. $R^2$ | 0.7767 | 0.8303 | 0.8644 |
| Root MSE | 3556.3 | 3714.2 | 3690.8 |
| Durbin-Watson | 1.87 | 1.94 | 2.00 |

[a] t statistics in parentheses; *** (**, *) significant at the 1 (5, 10) percent level.

**Table 3**
**Real Gross Railway Operating Income Per Mile (RGROI)[a]**
**GRAN MODEL**

| Independent Variable | RGROI (Unadjusted) | RGROI1 (Before MOW) | RGROI2 (Before MOW and Aid) |
|---|---|---|---|
| ERA1 | 7795.67 | 6505.32 | 5229.29 |
| | (2.995)*** | (2.399)** | (1.971)* |
| ERA2 | 3068.46 | 3702.43 | 2080.26 |
| | (1.780)* | (2.062)** | (1.256) |
| GRP | -1416.72 | -1392.48 | -1660.00 |
| | (-4.082)*** | (-3.835)*** | (-4.797)*** |
| GRP2 | 49.61 | 45.42 | 55.54 |
| | (3.431)*** | (2.997)*** | (3.866)*** |
| SHIP | -9566.24 | -9123.53 | -9201.7 |
| | (-5.468)*** | (-5.030)*** | (-5.114)*** |
| CONN | 555.56 | 443.68 | 433.34 |
| | (4.579)*** | (3.790)*** | (3.937)*** |
| GMIL | 11.43 | 12.83 | 13.30 |
| | (4.978)*** | (5.400)*** | (6.042)*** |
| OWN | 26.50 | 17.16 | 20.30 |
| | (1.921)* | (1.214) | (1.460) |
| GRAN | 158.79 | 238.10 | 307.84 |
| | (1.995)** | (3.099)*** | (4.190)*** |
| GRAN2 | -1.07 | -1.96 | -2.48 |
| | (-1.506) | (-2.948)*** | (-4.017)*** |
| POH | -61.14 | -112.05 | -138.12 |
| | (-1.526) | (-3.004)*** | (-3.846)*** |
| DENS | 68.91 | 109.27 | 105.23 |
| | (4.031)*** | (7.117)*** | (7.370)*** |
| RHAUL | 3595.35 | 4177.11 | 3461.47 |
| | (1.562)** | (1.735)* | (1.592) |
| LGROTEXM | -0.2056 | -0.1336 | -0.1069 |
| | (-2.845)*** | (-2.002)** | (-1.701)* |
| LAGRMOWM | 0.1685 | —— | —— |
| | (0.460) | | |
| RAIDNMI | 0.3957 | 0.6373 | —— |
| | (1.294) | (2.032)** | |
| CONSTANT | -5518.89 | -6004.42 | -6416.20 |
| | (-1.986)** | (-2.063)** | (-2.271)** |
| Number of obs. | 109 | 109 | 108 |
| Adj. $R^2$ | 0.7859 | 0.8362 | 0.8599 |
| Root MSE | 3481.7 | 3648.6 | 3573.3 |
| Durbin-Watson | 2.11 | 2.20 | 1.95 |

[a] t statistics in parentheses; *** (**, *) significant at the 1 (5, 10) percent level.

**Table 4**
**Elasticities of Real Gross Railway Operating Income per Mile (RGROI)**

| Independent Variable | RGROI (Unadjusted) | RGROI1 (Before MOW) | RGROI2 (Before MOW and Aid) |
|---|---|---|---|
| GRP | 1.021[1] | .559 | .660 |
| | 1.041[2] | .562 | .800 |
| CONN | .963 | .460 | .547 |
| | .841 | .358 | .422 |
| GMIL | .791 | .458 | .558 |
| | .717 | .429 | .537 |
| OWN | .488 | .185 | .214 |
| | .433 | .149 | .213 |
| TOP3 | .134 | .461 | .257 |
| GRAN | .621 | .275 | .472 |
| POH | .117 | .105 | .122 |
| | .111 | .108 | .161 |
| DENS | 1.377 | 1.165 | 1.511 |
| | 1.220 | 1.030 | 1.198 |
| RHAUL | .656 | .360 | .405 |
| | .417 | .258 | .258 |
| LGROTEXM | 1.566 | .715 | .813 |
| | 1.106 | .383 | .270 |
| LAGRMOWM | .155 | .---- | .---- |
| | .147 | .---- | .---- |
| RAIDNMI | .071 | .078 | .---- |
| | .085 | .073 | .---- |

[1] The upper row of numbers for each variable are calculated from the models using TOP 3.

[2] The lower row of numbers for each variable are calculated from the models using GRAN.

The empirical results are consistent with those of other short line studies with regard to the importance of traffic density for short line success. Sidhu, Charney and Due (1977) found that railroads with traffic levels between 200,000 and 800,000 net ton-miles per mile were nearly certain to be successful and lines having as low as 50,000 net ton-miles per mile may be successful under certain circumstances. Wolfe (1989b) found that successful railroads averaged 304,000 revenue ton-miles per mile compared to an average of only 167,000 for failed railroads. Grimm and Sapienza (1993) found that traffic density is positively related to short line performance. Due (1984, 1987) estimated that 40 to 100 carloads per mile are required to have a good chance of successful operation. This study found that a short line needs to haul in excess of 75 carloads per mile to have a reasonable chance of success (see Table 6).

This study determined that the number of gross miles of main-line track operated by the railroad (GMIL) is one of the more important variables affecting the profitability of short lines. This finding agrees with that of Wolfe (1988, 1989b), Grimm and Sapienza (1993), and Due (1984, 1987).

The findings of this study are consistent with those of Wolfe (1989b) regarding the effect of commodity traffic concentration. The above discussion indicates that RGROI, RGROI1, and RGROI2 are maximized when TOP3 is 81 to 84 percent and GRAN is 62 to 74 percent. Wolfe (1989b) reported that successful railroads averaged 88 percent of their traffic in the top three SIC codes compared to 91 percent for failed railroads. He also found that successful short lines had an average single commodity concentration ratio of 69 percent compared to 77 percent for failed railroads.

According to Due (1984, 1987) management ability is one of the key factors for the success of short line railroads. Included in his description of management ability is the ability to control costs. In this study the variable LGROTEXM is used as a proxy for management ability to control costs and the empirical results confirm its importance for short line profitability

## SENSITIVITY ANALYSIS

The estimated short line profitability equations can be used to develop "rules of thumb" regarding the expected profitability of short line railroads. The data in Table 5 indicates how this can be accomplished. The table contains the non-dummy variables from the RGROI2, GRAN regression (see last column of Table 3). The top numbers in the first column of numbers in Table 5 is the RGROI2 of short line railroads assuming a given independent variable has its minimum sample value with all other variables assuming their sample mean values.[9] For example, if CONN has its minimum sample value of 1.0 and the other variables have their mean sample value, short line RGROI2 is $12,544. The second and third numbers listed in Table 5 for each independent variable are the lower and upper 95 percent confidence interval values. For CONN, these confidence interval values are $5,540 and $19,548, which means that we are 95 percent sure that RGROI2 is between these two values.

The middle column of numbers in Table 5 displays RGROI2 and 95 percent confidence interval values for each independent variable assuming a given variable has its maximum sample value while all other independent variables have their sample mean value. For example, if the value of CONN is increased to its maximum sample value, all other variables assuming their sample mean value, RGROI2 is $26,844.

Thus the data in Table 5 reveals the range of potential short line profitability at the minimum and maximum sample values of a given variable. The same exercise can be performed using any of the other profitability equations in Tables 2 and 3.

Examination of Table 5 reveals that DENS has wider variation of RGROI2 than any other independent variable, ranging from a low of $5189 (minimum sample value of DENS) to a high of $42,167 (maximum sample value of DENS). Given this variation and the high elasticity of DENS, it is clear that DENS has a greater impact on RGROI2 than any other variable.

Table 6 contains values of RGROI2 estimated at various values of DENS ranging from 20 carloads per mile to 100 carloads per mile. The values of the other independent variables are set at their sample means. Recall, RGROI2 is defined as real gross railway operating income and is adjusted to remove the interfirm differences in maintenance of way expenses (MOW) and non-interest government aid. Thus, the profit levels estimated for RGROI2 in Table 6 would be reduced by track maintenance, interest, and income taxes.

Various studies and state Departments of Transportation have estimated the minimum annual real MOW expenses at between $5,000 and $8,000 per mile of track.[10] Thus, a railroad with the mean density of traffic in the sample (74.41), and all other independent variables at the sample mean, is likely to receive a profit per mile slightly greater than needed expenditures for MOW, leaving little revenue to pay interest on its debt and income taxes.

**Table 5**
**Sensitivity of RGROI2 to Changes in Independent Variables[1]**
**GRAN MODEL**

| Independent Variable | At the Variable's Minimum Value | At the Variable's Maximum Value | Difference in GROI Between its max. & min Value |
|---|---|---|---|
| CONN | 12,543.93[2] | 26,844.10 | 14,300.17 |
| | 5,540.26[3] | 19,840.43 | |
| | 19,547.60[4] | 33,847.77 | |
| GMIL | 9,194.91 | 21,899.25 | 12,704.34 |
| | 2,191.24 | 14,895.58 | |
| | 16,198.58 | 28,902.91 | |
| OWN | 11,150.49 | 13,180.95 | 2,030.46 |
| | 4,146.83 | 6,177.28 | |
| | 18,154.16 | 20,184.61 | |
| GRAN | 3,363.78 | 12,934.73 | 9,570.95[5] |
| | (3,639.89)[6] | 5,931.06 | (GROI2 max |
| | 10,367.45 | 19,938.40 | at 62.18%) |
| POH | 13,593.50 | 5,582.59 | (8,010.91) |
| | 6,589.83 | (1,421.08) | |
| | 20,597.17 | 12,586.25 | |
| DENS | 5,188.51 | 42,166.61 | 36,978.10 |
| | (1,815.16) | 35,162.95 | |
| | 12,192.18 | 49,170.28 | |
| LGROTEXM | 14,569.24 | 6,507.98 | (8,061.26) |
| | 7,565.58 | (495.69) | |
| | 21,572.91 | 13,511.65 | |
| RHAUL | 11,265.27 | 14,319.66 | 3,054.39 |
| | 4,261.60 | 7,316.00 | |
| | 18,268.93 | 21,323.33 | |

[1] Each independent variable is evaluated at its minimum and maximum values while holding all other variables at their mean values. See Endnote 9 regarding the values of the variables not in the table.

[2] The top number for each variable is the estimated RGROI2.

[3] The middle number for each variable is the lower 95 percent confidence interval value of RGROI2.

[4] The bottom number for each variable is the upper 95 percent confidence interval value of RGROI2.

[5] The profit minimizing and profit maximizing sample values of GRAN are used for the minimum and maximum values, respectively.

[6] Numbers in parentheses are negative values.

**Table 6**
**Sensitivity of RGROI2 to Changes in DENS[1]**

| Density of Railcar Traffic[2] | Estimated Value of RGROI2 | Lower 95% CI of RGROI2 | Upper 95% CI of RGROI2 |
|---|---|---|---|
| RGR012 Model Using TOP3: | | | |
| 20 | $1,626.33 | -$5,607.64 | $8,860.30 |
| 40 | $4,280.97 | -$2,953.00 | $11,514.93 |
| 60 | $6,935.60 | -$298.36 | $14,169.57 |
| 74.41[3] | $8,848.54 | $1,614.57 | $16,082.50 |
| 80 | $9,590.24 | $2,356.27 | $16,824.21 |
| 100 | $12,244.88 | $5,010.91 | $19,478.85 |
| RGROI2 Model Using GRAN: | | | |
| 20 | $6,818.03 | -$185.64 | $13,821.70 |
| 40 | $8,922.68 | $1,919.01 | $15,926.35 |
| 60 | $11,027.32 | $4,023.66 | $18,030.99 |
| 74.41 | $12,543.93 | $5,540.26 | $19,547.60 |
| 80 | $13,131.97 | $6,128.30 | $20,135.64 |
| 100 | $15,236.62 | $8,232.95 | $22,240.28 |

[1] Calculated based on the predictive equation of RGROI2. All values assume the railroad is established after 1987, is independent of other railroads, is not owned by shippers, and connects to only one other railroad firm. It is further assumed that all other independent variables are at the mean values of the sample.

[2] Density is measured in rail cars per main-line mile of track.

[3] This is the mean density of the sample.

Also, Table 6 indicates it takes in excess of 100 carloads per mile to be 95 percent certain of receiving RGROI2 high enough to cover MOW, interest and income taxes.

Three of the 34 railroads in the sample of this study had traffic densities of less than 20 carloads per mile and six of the railroads in the sample had traffic densities between 20 and 40 carloads per mile. Thus, about 25 percent of the short line railroads in this study have a high probability of requiring governmental financial assistance in order to continue operating.

## CONCLUSION

One of the principal objectives of this paper was to develop models of profitability for grain-dependent short line railroads. This objective was accomplished through the specification of models that explain up to 86 percent of the variation in short line railroad RGROI. These models incorporate explanatory variables which in every case had signs that are in accordance with theoretical expectations.

Another important objective of the paper was to identify the key factors influencing grain-dependent short line profitability. This objective was achieved through the sensitivity analysis of RGROI2 (GRAN version) and the elasticities and t statistics of the explanatory variables. Although DENS was the most important factor by all three of these criteria, the other important variables according to each of these criteria are discussed in the order mentioned above.

In the sensitivity analysis of RGROI2 (GRAN version), DENS was by far the most important variable. The variation in RGROI2 between the sample minimum and maximum values of DENS was $36,978 which was more than 2.5 times greater than that of the second most important variable, CONN (Table 5). Other variables which have high variation in the sensitivity analysis were GMIL ($12,704) and CONN ($14,300).

The elasticity of RGROI with respect to the various independent variables was another good indicator of the relative importance of these variables. The variable with the highest elasticities was DENS with the elasticity ranging from a low of 1.03 to a high of 1.51 (Table 4). With respect to RGROI1 and RGROI2 no other explanatory variable had an elastic coefficient. However with respect to RGROI several variables had elastic coefficients including GRP, DENS, and LGROTEXM. In general, the elasticity analysis indicated that RGROI was more responsive to DENS than any other variable in the model. DENS had the highest t statistic in 4 of the 6 equations in Tables 2 and 3. The variables GRP, CONN, SHIP, GMIL and DENS were statistically significant at the .01 level in all 6 equations.

The empirical results of the study indicate that the profitability (RGROI) of the grain-dependent short lines in the sample was not very high. A short line with the mean traffic density (all other variables at their mean values) was likely to receive RGROI2 slightly greater than MOW, interest, and income taxes. The analysis of the paper also indicated that about 25 percent of the sample short lines had a high probability of requiring government assistance to continue operating. This study will help state DOTs to allocate assistance to those short line railroads which need aid and are most likely to be profitable, and thus avoid the negative impacts of abandonment on rural areas.

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**ENDNOTES**

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1. A grain-dependent short line railroad is defined as a line haul short line whose grain carloadings are at least 25 percent of total annual carloadings.

2. Net profit (income) is the most commonly cited measure of profitability. We chose not to use net profit because it is much harder to obtain comparability between different firms since net income includes unusual and extraordinary income, income taxes, and interest which vary greatly between firms. Return on assets and return on equity are often used to compare profitability of firms. These variables were not selected since they do not remove tax rate variation between firms and are based on accounting values of the assets which vary quite widely according to the year in which the assets were purchased. In addition, there are substantial differences in the asset base between those firms which own their assets and those firms which lease. Return on equity cannot be used since some firms in the sample show negative equity. Thus, return on equity cannot be calculated for those firms. Also, some of the firms showing negative equity were subsidiaries of rail holding firms which have positive equity. Thus, the negative equity position of the rail firm is misleading.

3. A short line railroad receives car hire income by making its cars available to other railroads through car hire agreements.

4. Maintenance of way expense does not include depreciation on the track itself.

5. For more details regarding the adjustment of GROI for interfirm differences in government aid, see Prater (1997: 73-77).

6. Since transportation demand is derived from the demand for products it is appropriate to include variable(s) in the model that reflect the strength of the economy. In the model specification phase of the research we tested the empirical strength of several

measures of product demand including the following:

- A grain production index in which each state's grain production was weighted by the proportion of the short line railroad's mileage operated in each state.
- A manufacturing production index in which each state's manufacturing production index was weighted by the proportion of the short line railroad's mileage in each state.
- A weighted average of the grain production and the manufacturing production index which was weighted by the percentages of grain and non-grain commodities hauled by each short line.
- An index of grain exports.

These variables were always statistically non-significant. The likely reason is multicollinearity with traffic density. While the above mentioned measures of the economy's strength are not explicitly included in the model we think they are included implicitly. Changes in product demand would be reflected in changes in the variable DENS (number of carloads per mile of main-line track).

7. Fixed effects models were estimated to ascertain the effects on profitability due to individual firm differences. Unfortunately, the firm dummy variables are collinear with the other independent variables. Thus, very few of the independent variables are significant and the firm effects are significant for relatively few firms. Thus, fixed effects models are rejected for estimating RGROI. Also since the Durbin-Watson statistics of the estimated equations indicate no statistically significant autocorrelation and the robust standard error estimations indicate no heteroskedasticity for the OLS models, the random effects panel models are not used to estimate RGROI.

8. The RGROI2 equations in both Table 2 and Table 3 are corrected for autocorrelation using the Cochrane-Orcutt procedure.

9. The assumptions regarding the variables not in Table 5 are that the firm was established after 1987, is independent of other railroads, is not owned by shippers, and connects to only one other railroad firm (except when CONN is varied).

10. The amount of MOW required to keep the track in its present condition will vary greatly depending on the density of traffic, terrain, number and size of bridges, and many other factors.