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The relationship between measures of operations efficiency and financial success of truckload motor carriers: An empirical analysis

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THE RELATIONSHIP BETWEEN MEASURES OF OPERATIONS EFFICIENCY AND FINANCIAL SUCCESS OF TRUCKLOAD MOTOR CARRIERS: AN EMPIRICAL ANALYSIS

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ABSTRACT

This research paper examines the statistical relationship between day to day performance and efficiency measures and financial performance in the motor carrier industry. Key findings are that carriers with more miles per tractor per year, a larger average length of haul, more revenue per mile, and more revenue per tractor per week tend to perform better financially as measured in three separate models by operating ratio, return on assets, or return on equity. Unexpectedly, for the eight publicly traded carriers included in the analysis, there was a negative relationship between empty mile percentage and financial performance, indicating that carriers with a higher empty mile percentage have better financial performance. Possible explanations for these counterintuitive results could be due to a focus on better customer service or driver satisfaction causing slight increases in empty miles. Therefore the increased costs resulting from empty miles could be offset by higher revenue or decreased costs in other aspects of the operation. These results suggest that managers should focus not on minimizing empty miles but rather on keeping them within an acceptable range.

INTRODUCTION

A commonly accepted measure of financial stability and general business health for a motor carrier is the operating ratio (OR). Operating ratio is defined as the ratio of operating expenses to operating revenue, and as such, a lower operating ratio signifies better profit margin for the firm (Coyle et. al, 2004). While operating ratio is an acceptable measure for evaluating motor carriers, it isn't necessarily the most effective tool for managers to measure the efficiency of a firm's day to day operations. For this reason, managers and dispatchers of motor carriers often rely on other measures such as average length of haul, empty mile percentage and revenue per mile to evaluate and manage day to day operations. The goal of most motor carriers is to increase length of haul and revenue per mile, while decreasing the empty mile percentage.

This study evaluated the statistical relationship between managerial measures of performance in daily operations and operating ratio. Specifically, a linear regression was conducted with operating ratio as the dependent variable and various managerial measures of performance as the independent variables. Return on assets (ROA) and return on equity (ROE) are also commonly used to measure a firm's performance, so two secondary analyses were conducted using return on assets as the dependent variable in one and using return on equity as the dependent variable in the other. While the relationship between operating ratio, return on assets, or return on equity and these explanatory variables seems fairly straightforward, an examination of the data resulted in some surprising and even counter-intuitive results. Potential reasons for these results, managerial implications, and directions for future research are also explored.

FINANCIAL AND PERFORMANCE METRICS

The operating ratio is a measure of the general financial health of a firm but does not indicate any kind of operating efficiency. It is a ratio calculated as operating expenses divided by operating revenue, and was used by the Interstate Commerce

Commission to set motor carrier rates from 1935 until 1978. Questions about the rationale for using this measure as a standard have been raised by many authors. Wilson (1966) showed that the Interstate Commerce Commission's regulatory standard of 93 percent operating ratio translated into a 21 percent return on capital, while the railroads were regulated based on the rate of return standard and restricted to a 6 percent return on capital. This would mean that the two different standards would allow motor carriers to earn a much higher return than railroads were allowed to earn. Wilson argued that both types of transportation providers should be held to the same standards.

Nevel and Miklius (1968) showed "that the output which minimizes the operating ratio neither maximizes the profits of the firm nor is the optimum output from the point of view of society." They go on to say that the operating ratio is an ambiguous and possibly meaningless criterion. Their rationale was that a firm could have a "reasonable" operating ratio and still be earning either a large or small return. There does not have to be a correlation between the two measures despite the fact that one may exist. Due to these and other concerns, the ICC switched from an operating ratio standard to a return on equity standard in 1978 (Giordano, 1989), but even today, 20 years after deregulation, the operating ratio is still regularly reported as a standard, and carriers, such as Knight Transportation, who regularly report below average operating ratios are widely considered to be better managed. This is contrary to the financial evaluation of most other business, where return on assets and return on equity are considered more important than operating profit margin, the inverse of operating ratio. Despite this issue, with the data used in this study, there is a strong correlation between both operating ratio and return on assets (-0.87) and operating ratio and return on equity (-0.60).

Besides measures of financial performance, there are a variety of performance metrics used by motor carriers to manage day to day operations, yet minimal research has been done with regards to their impact on measures of financial success. Baker (1989) examined the relationship between traditional measures of carrier performance and survivability of LTL firms after de-regulation. He defined the measures of success as operating ratio, average length of haul, average weight per load, percentage of LTL traffic, and rate per hundredweight. Baker found that operating ratio had an inverse relationship to survival and length of haul had a positive relationship with survival, as would be expected, but he found no strong relationships with the other measures of success.

Corsi, Barnard, and Gibney (2002) examined at the relationship between financial performance and safety ratings in the motor carrier industry. They defined measures of financial performance as being the operating ratio and return on assets. Results for general freight carriers revealed that carriers with satisfactory carrier reviews had lower operating ratios than carriers with non-satisfactory carrier reviews. However there was no significant relationship between financial performance and specific safety ratings. They also defined carrier operating characteristics as gross revenue, total ton-miles, average weight per load, average length of haul, and driver's wages and looked for relationships between these measures and safety ratings. For these measures, they found no significant relationship with satisfactory/non-satisfactory carrier reviews. However, a positive correlation between average length of haul and driver safety ratings and a negative correlation between driver's wages and both vehicle and driver safety ratings was found.

Cottrell (2008) wrote a descriptive paper on performance metrics uses by carriers based on surveys with Frozen Food Express, US Xpress, and USA Truck. Three measures that were reported as very important to the industry were operating ratio, average length of haul, and an empty miles factor. Other commonly used metrics reported by Cottrell were equipment utilization rate, revenue per loaded mile, and shipments per business day. Examples of measures of equipment utilization are loads per tractor per week and miles per tractor

per week. Other metrics commonly reported by carriers in annual reports are revenue per load, revenue per tractor per week, and revenue per mile. The independent variables for the current study were selected based on those performance metrics which are "very important" to the literature and those which are commonly reported.

The studies reviewed found that operating ratio is commonly used to evaluate the financial performance of carriers, yet its importance as a measure of financial performance has been called into question. Managers rely on performance metrics to run business operations, presumably, with the intention of improving the financial performance of the firm, yet there has been little or no research examining how these managerial performance metrics relate to measures of financial performance. This paper seeks to fill this gap in the literature.

DATA

ACT Research (2010) collects and reports operational metrics for publicly traded truckload carriers. The data is obtained from the annual reports of said carriers. Based on the data available and commonly used carrier performance metrics, six potential metrics were identified as potentially related to operating ratio and commonly measured by carriers: miles per tractor per year (MTY), average length of haul (ALH), empty mile percentage (EMP), revenue per mile (RM), revenue per tractor per week (RTW), and loads per tractor per week (LTW). Because average length of haul and loads per tractor per week were highly correlated (-0.89) only one of these metrics was used in the regression analysis. Because average length of haul is more commonly reported and available for more carriers in more years, it was used as an independent variable rather than loads per tractor per week. This resulted in five performance measures used as independent variables in the final model. Information for JB Hunt was reported incorrectly by ACT Research for some years; therefore, data for that carrier was obtained directly from annual reports submitted to the Securities and Exchange Commission (JB Hunt, 2005-2010).

Complete information was available for seven carriers from 1999-2009. However, data was available on some carriers from 1990-2009, and the particular model used for analysis did not require a balanced panel. Including all carriers for all years in which data was available resulted in 119 usable observations, rather than 77, and eight carriers in the final sample. These additional observations alleviated a problem with too few degrees of freedom which arose when the model was estimated using only 77 observations. While the eight carriers included in the sample represent a relatively small proportion of total truckload carriers, they represent a disproportionately large percentage of the revenue for this highly fragmented industry as detailed in Table 1 (US Census Bureau, 2010).

TABLE 1
SIZE OF SAMPLE RELATIVE TO INDUSTRY*

	2002	2007
Number of Carriers in Sample	8	8
Number of Carriers in Industry	30,043	0,759
Percent of Industry Carriers Represented by Sample	0.03	0.03
Revenue of Sample ($M)	5,909	9,013
Revenue of Industry ($M)	65,030	3,385
Percent of Industry Revenue Represented by Sample	8.63	13.86

*Source: (US Census Bureau, 2010)
Industry defined as general freight trucking long-distance truckload (NAICS code 484121)

For revenue per mile and revenue per tractor per week, each observation was divided by the implicit price deflator to convert all monetary observations into 2005 dollars (Bureau of Economic Analysis, 2010). Each carrier's average value of each variable as well as the entire sample's average values of each variable are reported in Table 2. Table 2 also reports the years for which each carrier's observations were included in the final sample.

Some correlation between the independent variables was found, but the highest correlation coefficient was 0.65, and all estimated coefficients were significant in the final model, so this was assumed not to be a significant factor in the analysis. However this could be the cause of the lower significance of some estimated coefficients in the model with return on equity as the dependent variable. The correlation matrix is reported in Table 3. Both

TABLE 2
AVERAGE VALUES OF VARIABLES LISTED BY CARRIER

Carrier	OR	ROA	ROE	MTY	ALH	EMP	RM	RTW
Celadon Trucking (1994-2009)	94.77	1.8	2.7	109,097	1052	9.0	$ 1.34	$ 2,794
Covenant Transport (1992-2009)	94.91	1.7	10.0	135,268	1306	7.6	$ 1.32	$ 3,435
J B Hunt (2004-2009)	89.79	6.3	10.1	94,564	518	11.9	$ 1.76	$ 3,320
Knight Transportation (1994-2009)	83.25	10.7	16.2	113,438	519	11.0	$ 1.46	$ 2,959
Marten Transport (1999-2009)	93.42	7.7	22.1	111,823	947	7.2	$ 1.64	$ 3,149
PAM Transportation (1990-2009)	94.02	3.6	7.5	120,545	761	6.1	$ 1.33	$ 3,250
USA Truck (1994-2009)	93.94	3.2	6.4	119,716	845	9.8	$ 1.36	$ 3,048
Werner Enterprises (1994-2009)	91.61	4.8	8.4	122,570	689	10.9	$ 1.39	$ 3,288
Overall Average	91.97	5.0	10.4	115,877	830	9.2	$ 1.45	$ 3,155

OR = Operating Ratio
ROA = Return on Assets
ROE = Return on Equity
MTY = Miles per Tractor per Year
ALH = Average Length of Haul
EMP = Empty Mile Percentage
RM = Revenue per Mile
RTW = Revenue per Tractor per Week

TABLE 3
CORRELATION MATRIX OF INDEPENDENT VARIABLES

	MTY	ALH	EMP	RM	RTW
Miles Per Tractor Per Year	1				
Average Length of Haul	0.561479	1			
Empty Mile Percentage	-0.53802	-0.56472	1		
Revenue Per Mile	-0.30121	-0.11134	0.165601	1	
Revenue/Tractor Per Week	0.652937	0.449323	-0.44288	0.287514	1

the correlation matrix and average variable values per carrier were very similar for both the complete data set used and the balanced data set from 1999-2009, further justifying the inclusion of the additional observations available back to 1990.

STATISTICAL MODEL

Analysis was conducted via a regression analysis using SHAZAM. The dependent variable was operating ratio and independent variables were miles per tractor, average length of haul, empty mile percentage, revenue per mile, and revenue per tractor per week. Firm specific dummy variables, Fi, for all carriers except Werner Enterprises were included to control for differences between firms, and year specific dummy variables, Yj, for all years except 2009 were included to control for any differences between years that were not accounted for by converting the monetary values into 2005 dollars. An intercept term was also included in the final model. This resulted in Equation 1 which was the final model estimated. The only change between this and the alternate models is that return on assets and return on equity are substituted for operating ratio in the two alternate models estimated. These substitutions are shown in Equation 2 and Equation 3.

Due to autocorrelation of most of the included variables, estimation by ordinary least squares was not feasible, so a pooled cross section model available in SHAZAM was used for analysis. This is a generalized least squares estimation that allows for autocorrelation, cross-sectional heteroskedasticity and cross-sectional independence. This model also allows for unbalanced panels. Tests for the assumptions of heteroskedasticity and independence were conducted using the balanced panel data from 1999-2009. There were no statistical differences between the estimated coefficients from a model using this balanced panel and one using the full data set, but there was a lack of degrees of freedom from the balanced panel which resulted in higher standard errors. Furthermore, estimating the model using the full data set resulted in superior goodness of fit measures. An iterative procedure was used to improve the estimates. See Whistler et al. (2004) for details of the Pool command in SHAZAM.

Hypotheses

Hypotheses for the study were developed based on the managerial measures of performance selected for inclusion as independent variables in the final models and the three measures of firm financial performance selected as dependent variables. Increased miles per tractor per year, an increase in average length of haul, and a decrease in empty mile percentage, should all correspond to better asset utilization and less non-revenue-generating time between shipments. This should result in lower operating costs without a corresponding decrease in operating revenue. If operating costs are reduced while operating revenue remains the same, and there is no change in assets or owners' equity, return on both assets and equity should increase. Based on this logic the following three sets of hypotheses were developed:

H1A: There is a negative relationship between miles per tractor per year and operating ratio.
H1B: There is a positive relationship between miles per tractor per year and return on assets.
H1C: There is a positive relationship between miles per tractor per year and return on equity.

1 $$OR = \alpha + \sum \beta_i F_i + \sum \beta_j Y_j + \beta_{MTY} MTY + \beta_{ALH} ALH + \beta_{EMP} EMP + \beta_{RM} RM + \beta_{RTW} RTW$$

2 $$ROA = \alpha + \sum \beta_i F_i + \sum \beta_j Y_j + \beta_{MTY} MTY + \beta_{ALH} ALH + \beta_{EMP} EMP + \beta_{RM} RM + \beta_{RTW} RTW$$

3 $$ROE = \alpha + \sum \beta_i F_i + \sum \beta_j Y_j + \beta_{MTY} MTY + \beta_{ALH} ALH + \beta_{EMP} EMP + \beta_{RM} RM + \beta_{RTW} RTW$$

H2A: There is a negative relationship between average length of haul and operating ratio.
H2B: There is a positive relationship between average length of haul and return on assets.
H2C: There is a positive relationship between average length of haul and return on equity.

H3A: There is a positive relationship between empty mile percentage and operating ratio.
H3B: There is a negative relationship between empty mile percentage and return on assets.
H3C: There is a negative relationship between empty mile percentage and return on equity.

Increasing revenue per mile or revenue per tractor per week should increase total revenue without a corresponding increase in operating costs, leading to a decrease in operating ratio. This should also lead to an increase in return on assets and equity, provided there is no change in either assets or owners' equity. This results in the following hypotheses:

H4A: There is a negative relationship between revenue per mile and operating ratio.
H4B: There is a positive relationship between revenue per mile and return on assets.
H4C: There is a positive relationship between revenue per mile and return on equity.

H5A: There is a negative relationship between revenue per tractor per week and operating ratio.
H5B: There is a positive relationship between revenue per tractor per week and return on assets.
H5C: There is a positive relationship between revenue per tractor per week and return on equity.

RESULTS

The final models as previously discussed were estimated to test the five Hypotheses for each of the three models. These models resulted in estimates, which each had a fairly high Buse R2, which is a goodness of fit measure for generalized least squares models (Buse, 1973). Final estimated coefficients of the primary variables and goodness of fit measures of all three final models are reported in Table 4, and the full estimation results are shown in Appendix 1.

Estimated coefficients of the dummy variables confirm what is relatively apparent from an examination of the descriptive variables. Knight Transportation and JB Hunt have lower operating ratios and higher returns on assets and equity than Werner Enterprises; Werner Enterprises, Celadon Trucking Services, Marten Transport, and PAM Transportation Services have very similar operating ratios, returns on assets, and returns on equity;

TABLE 4
ESTIMATED COEFFICIENTS

Variable Name	Estimated Coefficient OR Model	Estimated Coefficient ROA Model	Estimated Coefficient ROE Model
Miles per Tractor per Year	-0.00011*	0.00014*	0.00034*
Average Length of Haul	-0.00606*	0.00844*	0.02341*
Empty Mile Percentage	-0.66082*	0.76696*	1.53090**
Revenue per Mile	-5.19430*	4.86520*	10.56200
Revenue per Tractor per Week	-0.00203**	0.00214**	0.00644**
Buse R2	0.8876	0.8858	0.7620
Buse Raw Moment R2	0.9997	0.9788	0.9130

* Indicates significance at the 0.05 level
** Indicates significance at the 0.10 level

and Covenant Transport and USA Truck have higher operating ratios and lower returns on assets than Werner Enterprises, however USA Truck has a similar return on equity to Werner while Covenant Transport has a lower return on equity.

With regards to the impact of different years on the carrier's operating ratio, the operating ratio tended to be at the same level as in 2009 in 1992-1993, 1996, and 2000-2007; lower than 2009 levels in 1994-1995 and 1997-1999; and higher than 2009 levels in 1990, 1991, and 2008. Return on assets was lower than 2009 levels in 1990-1991, 1996, 2000-2001, and 2008 and not statistically different than 2009 levels for all other years. Return on equity was lower than 2009 levels in 1990-1991, 1996, 2001, and 2008. These periods of higher operating ratios and lower returns correspond fairly well to the July 1990 – March 1991 recession and the December 2007 – June 2009 recession. The March 2001 – November 2001 recession and 1996 near recession did not appear to increase operating ratios to levels above those of 2009 but did reduce returns on assets and equity.

Based on the results of the analysis, Hypotheses 1A-C, 2A-C, and 4A-B are strongly supported, and Hypothesis 4C is rejected. Increasing miles per tractor per year and average length of haul correlates to a lower operating ratio, higher return on assets, and higher return on equity. Increasing revenue per mile does correlate to a decrease in operating ratio and increase in return on assets but does not appear to correlate to any type of change in return on equity. While the coefficient is not significant, it is in the direction hypothesized (positive). The reason for this odd result is most likely due to the lower explanatory power of the ROE model ($R2 = 0.76$) compared to the OR and ROA models ($R2 = 0.89$). Hypotheses 5A-C are marginally supported. An increase in revenue per tractor per week does correlate with a lower operating ratio, higher return on assets, and higher return on equity. However, Hypotheses 3A-C are all rejected. Not only are these hypotheses rejected, but the estimated coefficients are significant in the opposite direction of that hypothesized. An increase in empty mile percentage correlates to a decrease in operating ratio, an increase in return on assets, and an increase in return on equity.

DISCUSSION AND IMPLICATIONS

These results, as reported in Table 3 are rather esoteric but can easily be translated into a form that managers of motor carriers could find useful. The estimated coefficient of miles per tractor per year is 0.000108, indicating that, on average, increasing miles per tractor per year by 1 unit and holding everything else constant should increase operating ratio by 0.000108, increase return on assets by 0.00014, and increase return on equity by 0.000336. When the scale of this result is increased by a factor of 1,000, it can be seen that an increase of 1,000 miles per tractor per year should result in a 0.108 point increase in operating ratio, a 0.140 point increase in return on assets, and a 0.336 point increase in return on equity. A similar process can be employed on the remaining independent variables to show the impact on the dependent variables resulting from changes to them. Increasing the average length of haul by 100 miles should result in a 0.605 point reduction in operating ratio, a 0.844 point increase in return on assets, and a 2.341 point increase in return on equity. An increase of $0.10 per mile should result in a 0.519 point reduction in operating ratio and a 0.486 point increase in return on assets. Finally, an increase of $100 per tractor per week should result in a 0.203 point reduction in operating ratio, a 0.214 point increase in return on assets, and a 0.644 point increase in return on equity.

The estimated coefficient of empty mile percentage in the operating ratio model is negative and highly significant. This indicates that carriers with more empty miles tend to have lower operating ratios and thus higher profit margins. Specifically, a one percent increase in empty mile percentage (e.g. going from four to five percent empty miles) should result in a 0.661 point reduction in operating ratio. Furthermore, a one percent increase in empty mile percentage should result in a 0.767 point increase in return on assets and a 1.53 point

increase in return on equity. These results seem counter-intuitive, but there are many potential explanations for them.

One potential reason for the inverse relationship between empty mile percentage and operating ratio could be that carriers with more empty miles are providing better customer service by being willing to drive additional empty miles in order to pick up a customer's load. Such a carrier would gain customer loyalty and, and as a result, be able to demand higher revenue per mile. However, looking at Table 1 makes it clear that Knight Transportation, with the lowest average operating ratio and one of the highest average rates of return, does not have the highest revenue per mile, so better customer service may only be part of the explanation.

An additional possible explanation for the apparent benefit of increased empty miles might be that the better performing carriers acquire more empty miles in an attempt to get their driver's home more often. This could result in more content and happier drivers, and having happier drivers might contribute to a reduction in driver turnover. Since it has been estimated that the cost to hire a driver is between $3,000 and $12,000 (Richard et al., 1994; Isidore, 1996), a reduction in driver turnover could result in a significant reduction in operating costs. However, with drivers not being paid for empty miles, it is possible that a shorter time between loads and more time home wouldn't provide enough benefit to the driver to offset his/her dissatisfaction with having excessive empty miles.

CONCLUSION

For the most part, this study confirms a correlation between commonly used measures of effectiveness in motor carriers and three commonly used measure of financial performance in motor carriers. The one surprising exception was the relationship between empty mile percentage and financial performance. The results of the study indicate that, among the eight publicly traded truckload motor carriers included, an increase in empty miles is related to a decrease in operating ratio, a corresponding increase in profit margin, an increase in return on assets, and an increase in return on equity. Possible reasons for this could be better customer service resulting in an increase in revenue that offsets the additional costs associated with more empty miles, lower driver turnover resulting from drivers being happier due to more loads and more time home, or some combination of these.

This result indicates that managers of carriers should not focus heavily on decreasing empty miles as long as they remain below a certain level. None of the carriers in this sample had more than 13.6 percent empty miles or less than 4 percent empty miles, so the results of this analysis may only hold true within this relatively narrow range. It may certainly be the case that an empty mile percentage higher than 13.6 percent would lead to a significant increase in operating ratio and decrease in returns. However, the results of this study do seem to indicate that carriers need not worry excessively about keeping a low empty mile percentage at the expense of customer or driver satisfaction.

The results of this study should not be used as justification for carriers to increase their empty miles without reason or discard empty miles as a performance metric because there is clearly some additional factor(s) involved in the relationship that has not been accounted for in this study. Whatever the reason for the relationship between empty miles and measures of financial performance may be, this study shows that carriers with good financial performance are somehow able to overcome and even offset the additional costs of increased empty miles. This indicates that motor carrier managers should attempt to keep their empty mile percentage within an acceptable range rather than trying to keep it as low as possible.

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APPENDIX 1
FULL ESTIMATION RESULTS

	Estimated Coefficient:		
Variable Name	OR Model	ROA Model	ROE Model
Constant	131.13000*	-37.52600*	-94.95800*
Celadon Trucking Services	1.06270	-3.04910	-5.13480
Covenant Transport	6.00350*	-9.69590*	-17.09700*
J B Hunt	-4.35610*	6.94390*	26.69500*
Knight Transportation	-10.56100*	7.31510*	13.80500*
Marten Transport	0.01505	-0.63418	0.65063
PAM Transportation Services	-0.09433	0.99695	3.96460
USA Truck	1.53470*	-2.20620*	-2.25060
1990	10.86600*	-22.65600*	-77.91000*
1991	6.77600*	-16.66000*	-60.88300*
1992	0.62539	-1.85370	30.03100
1993	-1.10570	-1.32160	20.64400
1994	-3.47250*	-1.17010	-5.30550
1995	-2.78660*	-0.71414	-3.96980
1996	-0.60214	-2.78390*	-10.76600*
1997	-2.55300*	-0.34976	-4.06440
1998	-3.48060*	-0.45585	-3.26450
1999	-2.25350*	-1.29600	-2.94250
2000	0.32259	-2.19710*	-5.39820
2001	0.80194	-2.85830*	-7.52380*
2002	-0.78241	-0.89149	-4.75730
2003	-1.08870	-0.75707	-4.08850
2004	-0.99857	-0.55248	-3.35250
2005	-0.93789	-0.02315	-1.76810
2006	-0.81417	-0.02873	-2.99260
2007	0.93360	-1.14120	-3.42490
2008	2.30030*	-2.99610*	-4.92870**
Miles Per Tractor Per Year	-0.00011*	0.00014**	0.00034*
Average Length of Haul	-0.00606*	0.00844*	0.02341*
Empty Mile Percentage	-0.66082*	0.76696**	1.53090**
Revenue Per Mile	-5.1943*	4.86520*	10.56200
Revenue Per Tractor Per Week	-0.00203**	0.00214**	0.00644**
Buse R2	0.8876	0.8858	0.7620

*Indicates significance at the 0.05 level **Indicates significance at the 0.10 level

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