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Research report

Measuring the financial impact of environmental regulations on the trucking industry

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ABSTRACT

Since 2002, the Environmental Protection Agency has enacted federal regulations aimed at reducing pollution caused by diesel engines. This study provides an empirical examination of the effect of EPA regulations on the financial performance of firms in the trucking industry. The findings are relevant to regulators, practitioners, and academics because it addresses the impact of environmental regulations as well as the financial accounting standards process.

1. Introduction

The transportation industry impacts nearly every American in terms of traveling from one location to another, shipping products throughout the country, or working in a transportation-related occupation. One important component of the American transportation system is the trucking industry. By 2018, 80% of all communities in the U.S. will be served exclusively by the trucking industry, and 70% of all tonnage will be moved by commercial trucks (American Trucking Association, 2009).

With the onset of deregulation, the Environmental Protection Agency (EPA) also increased its regulatory oversight of the trucking industry. The EPA established new requirements for the industry that included new engines and new types of diesel fuel. Three waves of regulation significantly impacted trucking companies, with one deadline established in 2002, and another in 2007. The third phase of the EPA mandates was integrated in 2010. With record-high fuel prices and asymmetric response to oil prices (Valadkhani, Smyth, & Vahid, 2015) along with lower rates because of an increasingly competitive industry, trucking firms found themselves examining the impact of becoming a “green” industry. While previous research has examined the impact of disclosure requirements (Fogel, El-Khatib, Feng, & Torres-Spelliscy, 2015) and compliance programs (Martin, Sanders, & Scalan, 2014), few researchers have examined the relationship between environmental factors and financial (or firm) performance (Ashcroft & Smith, 2008; Clemens, 2006; Pugliese, Minichilli, & Zattoni, 2014). Moreover, this paper is the first to focus on the financial impact of EPA mandates on the trucking industry.

As such, the objective of this paper is to provide an empirical examination of the effect of EPA regulations on the financial performance of firms in the trucking industry. The measure of financial performance employed is the operating ratio, which is the ratio of operating expenses to operating revenues. Management, investors, creditors, regulators, and analysts most commonly use the operating ratio as an indicator of efficiency and profitability of trucking industry firms (Cassidy, 2013).

The research documented in this report is of potential relevance to the readership of this journal (regulators, practitioners, and academics) because it addresses two different types of regulations: the environmental regulations whose trucking industry impact is assessed, and the financial accounting standards regulation process of the FASB, which could consider requiring trucking firms to disclose their operating ratios on a supplemental basis to enhance external users’ ability to assess the impact of environmental and other regulations on the financial performance of those firms.

2. Background and relevant literature

The trucking industry as it exists today was created at the beginning of the 20th century. With the increase in number of firms entering the industry in the 1920s, railroads, as well as trucking companies, petitioned Washington for protective regulation. The existing firms in both industries wanted restrictions on both entry into the industry as well as constraints on prices (Stigler, 1971). The Interstate Commerce Commission (ICC) began regulating the

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trucking industry in 1935 and restricted both entry into the industry by new firms and prevented the expansion of existing firms. This process continued until 1980 when regulatory reform was enacted. These actions effectively removed barriers to entry and price restrictions for new firms, leading to increased competition in the for-hire trucking industry (Silverman, Nickerson, & Freeman, 1997).

Prior to the 1980s, the number of carriers remained relatively stable since the ICC had to approve new carriers entering the industry as well as local price bureaus setting price floors for freight and routes (Corsi, Grimm, Smith, & Smith, 1992; Silverman et al., 1997). Under this system, carriers earned substantial margins, with a portion paid to unionized labor (Silverman et al., 1997). As the number of carriers increased because of the removal of entry barriers, profit margins were reduced substantially, attributable to the downward pressure on price (Corsi et al., 1992).

The trucking industry predominantly uses diesel engines for a number of important reasons (Kilcarr, 2010); however, diesel engines are inherently pollutant as they emit large quantities of particulates in engine exhaust and nitrous oxide (NO_2). Therefore, it is not surprising that the EPA focused on the industry, as such focus is also consistent with the recent regulation to raise the Corporate Average Fuel Economy (CAFE) standards from 35.5 mpg to 54.5 mpg for 2025 model year vehicles (Ullman, 2016).

In 2001, a landmark case highlighted the extent of the EPA's investigative and enforcement powers. The American Trucking Association, the U.S. Chamber of Commerce, and nearly twenty trucking companies and other industry groups filed a lawsuit against the EPA, challenging the limits of the Agency's authority. In the landmark case, *Whitman versus American Trucking Associations*, the Supreme Court overruled an appellate court ruling restricting the EPA's enforcement abilities to only those that entailed a substantial cost/benefit analysis. In this unanimous decision, the Supreme Court upheld the EPA's authority to establish and enforce air quality standards under the new law, regardless of any costs imposed by the Agency's policies (The Oyez Project, Whitman v. American Trucking Associations). After the Supreme Court ruling, new regulations specifically aimed at the trucking industry have increased.

The relatively recent set of new regulations centered around two primary issues. These issues included the diesel motors that power the trucking industry and the fuel that has historically been used in these engines. The new rules required trucks to use more environmentally friendly engines and ultra-low-sulfur diesel fuel to achieve a marked reduction in the amount of pollutants created by on-highway engines. According to the EPA, the new mandates will cut harmful pollution by 97% over the course of three specified implementation stages. The EPA allowed a phase-in approach between 2002 and 2010 for these changes to occur, with each phase requiring more stringent standards for air pollution levels (Hannon, 2005).

In addition to the changes in engine design, the diesel fuel itself underwent a major transformation to meet new EPA requirements. The Agency required a 97% reduction in the sulfur content of diesel fuel. In essence, this reduction cuts levels of sulfur in diesel fuel from 500 parts per million to 15 parts per million. These changes are estimated to reduce NO_2 by 2.6 million tons per year and particulate matter by 110,000 tons (Kilcarr, 2010). To complicate the situation for the trucking industry, the use of old diesel fuel will cause major structural damage to the newly mandated engines.

Most of these changes that the EPA enacted were motivated by health-related issues. However, there is a cost to these changes. Some of the additional expected costs are higher priced engines and increased fuel costs. Other (indirect) costs may not be as obvious. For example, catalytic reduction technology (SCR), already used in over half a million trucks in Europe, will be one of the major changes in the EPA-compliant engines. Trucks equipped with SCR technology will reduce NO_2 to near-zero levels using special diesel exhaust fluid. This exhaust fluid is injected into the engine's exhaust stream. The process converts truck exhaust to nitrogen and water, which are normal, non-pollutant elements in the atmosphere (Hartenstein, 2008).

Aside from the additional costs of the diesel exhaust fluid that has to be carried in separate storage tanks on the truck, the new engines will have special exhaust filters to process the truck's emissions. These filters hold a limited amount of soot. Thus, a process for burning off the pollutants using the special exhaust fluid must be incorporated into the engine's technology. This scenario creates several cost-related problems. To periodically burn off the material trapped in the exhaust filter, the temperature of the exhaust must be increased to temperatures exceeding 600 °C, causing serious problems with current docking facilities (Carey, 2005). Trucks could literally cause fires by backing up to loading docks with elevated exhaust temperatures. Costly changes will have to be made to delivery docks to avoid these types of potential problems.

Another significant cost relates to the particulate filter. For the filter to function properly, it must include high cost materials such as platinum and palladium. The more platinum that coats the filter, the less fuel needed to burn the soot from the filter. Therefore, a trade-off exists between production costs for these filters and efficient truck fuel usage. Third, aside from the inherent additional maintenance costs related to the newer engines, the industry also will face increased maintenance costs because of the new filtration systems (Carey, 2005). Some unique features of its operating structure exist. Trucking companies have some options for their organizational structure that are unavailable to other transportation sectors. For example, trucking firms can choose to use independent contractors who own their own trucks to haul freight. Alternatively, it is highly unlikely that the airline industry could contract outside pilots who own their own jumbo jets. Of course, the way a trucking company is organized can play a role as to the impact of deregulation and newly imposed EPA rules.

Two types of carriage exist in trucking: less-than-truckload (LTL) and truckload (TL). LTL carriage encompasses shipments of under 10,000 pounds, while TL comprises loads over 10,000 pounds and normally involves shipments from initiation points to specified destinations (Silverman et al., 1997). LTL and TL firms have markedly different operating characteristics because of the way each type of trucking company delivers its goods. The main difference lies in the manner that goods are delivered. LTL firms make extensive use of hub systems to collect and further distribute goods from single to multiple locations, and vice versa. This type of structure requires a significant investment in terminals that enhance breaking down large shipments. Since the choice of carriage significantly impacts a firm's investment in fixed assets, the additional costs of capital investment also impact the profitability of that company (Silverman et al., 1997).

Prior to deregulation in the1980s, the Interstate Commerce Commission (ICC) used operating ratios to raise or lower freight rates. Under regulation, a rate increase/decrease was based on an operating ratio of approximately 93%. Trucking companies used an operating ratio in excess of 93% to support a request for rate increases. However, these rate increases were typically not granted until the entire regional rate bureau experienced similarly higher costs (Giordano, 1989). As noted in the introduction, even though the trucking industry was deregulated in the 1980s, most trucking companies continue to evaluate efficiency in terms of the operating ratio percentage as a measure of profitability. While the operating ratio is of practical importance to the industry, minimal research has been conducted in this area.

The empirical research to date focuses on three primary areas of study, including deregulation issues, use of owner-operators, and the effectiveness of the EPA in drafting environmental guidelines. Regarding deregulation, Silverman et al. (1997) addressed

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Table 1
Variable definitions.

OperRatio	(Operating Expenses x 100) / Operating Revenues
Environmental	
Contamination	1 if company has Superfund or toxic waste site on property; 0 otherwise
Maintenance	1 if higher maintenance expenses from compliant engines; 0 otherwise
FuelEff	1 if lower fuel efficiency from compliant engines; 0 otherwise
ChangeInDieselxFuelEff	Interaction of *FuelEff* and the annual percentage change in the average price of diesel
EquipSales	Total capital expenditures and sales (in thousands)
PriorCapExp	Last year's capital expenditures (in thousands)
CapExp2002	Total amount of capital expenditures in the last 3 years (back to the 2002 model year)
CapExp2007	Total amount of capital expenditures in the last 3 years (back to the 2007 model year)
Accounting	
LTDebt/TA	Long Term Debt / Total Assets
WC	Working Capital (Current Assets – Current Liabilities)
ROA	Return on Assets (Net Income / Total Assets)
Size	Total Assets
Industry Specific	
OwnerOper	Percent of independent contractors that own trucks

the failure of a large number of trucking companies after deregulation and found that bankruptcy of these firms was a function of actions taken at the firm level as well as attributes of the industry in general. In addition, Silverman et al. (1997) contended that newer firms were more likely to withstand the effects of heightened competition attributable to deregulation than were older firms, but larger firms were more likely to maintain their overall profitability than smaller companies.

Han, Corsi, and Grimm (2008) employed a cross-sectional regression analysis to identify factors that impact the decision to use owner-operators. The authors identified two variables that were significant in helping to explain the use of outside contractors by a trucking company. They found that if a firm had a significant investment in specialized trucking equipment, a much higher probability existed for these types of trucking firms to use their own in-house drivers. Alternatively, if a firm's commerce primarily involved LTL services, owner-operators normally were not used in the transport function. Likewise, in times of high uncertainty and high asset specificity, owner operators may be more expensive than company drivers based on transaction cost economics (Han et al., 2008).

Using data about vehicle ownership and driver employment for 354 trucking companies, Nickerson and Silverman (2003) addressed owner-operator issues in the trucking industry and concluded that how much LTL trucking was performed by the firm as well as the degree of coordination of multiple hauls were factors impacting the decision to use company personnel rather than outside drivers. As the extent of LTL trucking for a firm increases and the need for more coordination of multiple hauls rises, trucking companies tend to rely more on in-house drivers rather than owner-operators for transport (Han et al., 2008)

Additionally, one component of the present research effort addresses both the long-term and short-term effects of debt, while another component relates financial leverage to profitability. Since trucking firms are asset heavy, the present study defines leverage in terms of assets. Just as financial leverage measures long-term financial health and efficiency, working capital is a short-term measure. Positive working capital is required for a firm to be able to cover its daily operational expenses and to be able to service maturing short-term debt. Previous studies have noted that a significant trade-off exists for a conservative working capital policy, which is defined as a greater investment in current assets (Gardner, Mills, & Pope, 1986; Nazir & Afza, 2009; Weinraub & Visscher, 1998). A conservative working capital policy lowers risk but also lowers potential profitability.

The sample for this study was the years 1999–2009 to ensure that the model reflected the effects of the EPA-mandated engines and the EPA-mandated low-sulfur diesel fuel established during this time frame. An increase in capital expenditures would be expected in 2001 as trucking companies tried to beat the environmental rules aimed at diesel engines by buying less expensive, noncompliant engines (Ball, 2002; Lam & Bausell, 2007). However, given the success of the transition to new engines in 2002, as well as the unavailability of older, less expensive non-compliant engines, an increase in sales in 2006 was not expected and failed to occur (Hannon, 2005). Using a trucking company's operating ratio to reflect profitability, this study identifies a number of variables that are useful in explaining the financial impact of recent EPA regulations.

3. Data and methodology

The data were extracted from 10-K reports for all publicly listed trucking companies in the SEC's EDGAR database using the Standard Industry Classification Code of 4213 (Trucking non-local) for the years 1999–2009. Prices for diesel fuel are calculated using the weekly prices of national diesel prices as reported by the Energy Information Administration. The database includes 31 firms with 274 data points. Trucking companies not in existence in 2002, the first year of the implementation of the EPA emission standards, are excluded from the sample. A panel data methodology was employed to incorporate various environmental, accounting, and industry-specific variables.[1] The environmental variables reflect concerns the firms address in their 10-K filings. The accounting variables reflect various financial dimensions of the firm such as size, leverage, and liquidity. Finally, the industry-specific variable reflects owner-operator status. Table 1 describes and defines the variables used in the analysis.

Environmental concerns expressed in the 10-K are of five forms: 1) contamination costs related to the Superfund Act; 2) rising maintenance costs related to the use of the compliant engines; 3) higher fuel costs because of lower fuel efficiency attributable to the use of compliant engines; 4) lower resale value for older trucks;

[1] See appendix for discussion on panel data analysis and model specification.

and 5) higher costs for trucks with compliant engines. The effects of these concerns were reflected in the following environmental predictors: *Contamination, Maintenance, FuelEff, ChangeInDieselxFuelEff, EquipSales, PriorCapExp, CapExp2002* and *CapExp2007*.

Trucking companies routinely deal with hazardous waste disposal. Most companies also own underground and above ground fuel tanks. The Comprehensive Environmental Response, Compensation and Liability Act ("Superfund Act") was enacted by Congress in December 1980. The Superfund Act authorized the EPA to identify and impose a liability on a potentially responsible party (PRP) found guilty of releasing hazardous substances into the environment (http://www.epa.gov/superfund/policy/cercla.htm). A PRP may be required to pay more than its proportional share of the costs of environmental clean-up remediation. *Contamination* is coded 1 if a company has a Superfund or toxic waste site on company property, 0 otherwise. Trucking companies that have been identified as a PRP are expected to have a higher operating ratio than companies without contamination problems.

Another concern expressed by the trucking companies in their financial statements addresses rising maintenance expenses related to the 2002 and 2007 engines that complied with EPA standards. Most trucking companies do not separate their maintenance expenses from other operating expenses. A trucking company will not be coded as having concerns with higher maintenance expenses (*Maintenance* = 1) unless those expenses are specifically related to maintaining engines with designs dictated by the 2002 and 2007 EPA standards. Companies that state they are experiencing higher maintenance expenses associated with the use of compliant engines are expected to have a higher operating ratio than firms that are not experiencing higher maintenance expenses associated with compliant engines.

Similar to *Maintenance*, lower fuel efficiencies (*FuelEff*) are addressed in this study only when they relate to the use of 2002 and 2007 compliant engines. Diesel fuel is the single largest variable cost for trucking companies according to the 10-K filings. As with maintenance expenses, most firms do not separate fuel expenses from other operating expenses. If a firm states that its trucks are experiencing lower fuel efficiencies because of the adoption of compliant engines, *FuelEff* is coded 1, otherwise as a 0. Firms experiencing lower fuel efficiencies along with rising fuel expenses are expected to have a higher operating ratio than those firms that are not experiencing problems with lower fuel efficiency. Trucking companies with fuel efficiency problems may also be more sensitive to changes in diesel fuel prices. To study this interaction, *FuelEff* was multiplied by the annual percentage change in the average price of diesel over the past two years, *ChangeInDieselxFuelEff*. A priori reasoning suggests that as the price of fuel rises, firms experiencing lower fuel efficiency are expected to have an increase in their operating ratio.

The final environmental cost measures relate to capital expenditures including declining resale values and rising truck prices. Managers control the amount and timing of capital expenditures. Even though most trucking companies in the study do not separate the cost of buying and selling trucks from the purchase and sale of other capital assets, total capital expenditures and sales can be used as a proxy for the purchase and sale of trucks because trucks account for the majority of purchases and sales of capital assets. While the companies also do not provide details about the value of individual model years of their trucks, they do note that, on average, they keep their trucks approximately three years. While the EPA allowed non-compliant trucks to be sold for a short period after 2002, the majority of those trucks sold during this time period were manufactured with compliant engines (Lam & Bausell, 2007). Despite these constraints, we believe that total capital expenditures and sales may reasonably be used as a proxy for the purchases and sales of trucks.

Capital expenditures then were lagged by one year to capture the effect of the first full year of use of the trucks. *PriorCapExp* is defined as last year's capital expenditure (in thousands of dollars). Compliant trucks are expected to cost more because of higher maintenance costs and lower fuel efficiency than non-compliant trucks. As a firm's previous year capital expenditures increase, its operating ratio also is expected to increase.

To isolate the effect of the 2002 trucks and 2007 trucks, *CapExp2002* and *CapExp2007* are defined as the total amount of capital expenditures in the last three years (back to the 2002 or 2007 model year). We use a time period of three years to track model years because trucking companies on average keep their trucks for three years.[2] Given this definition, for example, in the year 2002, *CapExp2002* would be capital expenditures made in the year 2002, and *CapExp2007* would be zero (no 2007 trucks were available for sale). In 2007, *CapExp2002* would include capital expenditures for the years 2005 and 2006, and *CapExp2007* would include capital expenditures for 2007. By 2009, *CapExp2002* would be zero (all 2002 compliant trucks would be over three years old), and *CapExp2007* would include capital expenditures for the years 2007–2009 inclusive. While this proxy is not perfect for tracking the amount of 2002 and 2007 compliant trucks owned by the companies, it provides a reasonable approximation regarding the impact of the different model years of compliant engines. As *CapExp2002* and *CapExp2007* increase, the operating ratio also is expected to increase.

4. Results and discussion

The results of the fixed effects for the environmental, accounting, and industry specific variables are reported in Table 3. With regard to the differences between TL carriers and LTL carriers, few significant differences exist between the variables and how they affect the operating ratio. Contamination-related problems have a substantial impact on the operating ratio of TL firms. However, not enough evidence exists to suggest that it has a statistically significant impact on LTL firms. On the other hand, LTLs that experienced a decrease in fuel efficiency because of using compliant engines had a significant decrease in their operating ratio - a 3.19% decrease. One would ordinarily expect that a decrease in fuel efficiency would result in an increase in the operating ratio. The reason for this unusual result is explained by YRC in its 2008 financial statements: YRC disclosed that the company earns income on fuel surcharges in times of increasing fuel prices. In essence, surcharges more than compensated for the increase in fuel prices and decrease in fuel efficiency.

A very significant difference exists in the effect of ROA on operating ratio for a TL carrier as compared to a LTL carrier. A 1% increase in ROA decreases the operating ratio of a LTL carrier by 30.55%, more than twice the 14.71% decrease in the operating ratio of a similar TL carrier. This result is expected, as LTLs are riskier than TL because of specialized equipment and warehouses. In summary, an operating ratio for a TL carrier is more sensitive to contamination problems, while a LTL carrier is more sensitive to a decrease in fuel efficiency because of compliant engines. LTLs are getting a better return on their investments in assets than TLs, a compensation for the additional risk.

Likewise, a significant change did occur in operating ratios for trucking companies in 2002 and 2007. Results are reported

[2] Based on footnotes to the financial statements, the average age of tractors that trucking companies in our sample report is 3.06 (untabulated). The weighted average (using percentage of Fixed Assets for the companies in our sample) of age of tractors is 3.14 years. According to the American Transportation Research Institute (https://www.glostone.com/wp-content/uploads/2012/09/ATRI-Operational-Costs-of-Trucking-2012.pdf) for 2011, for the trucking industry, tractors were an average of 4.1 years old.

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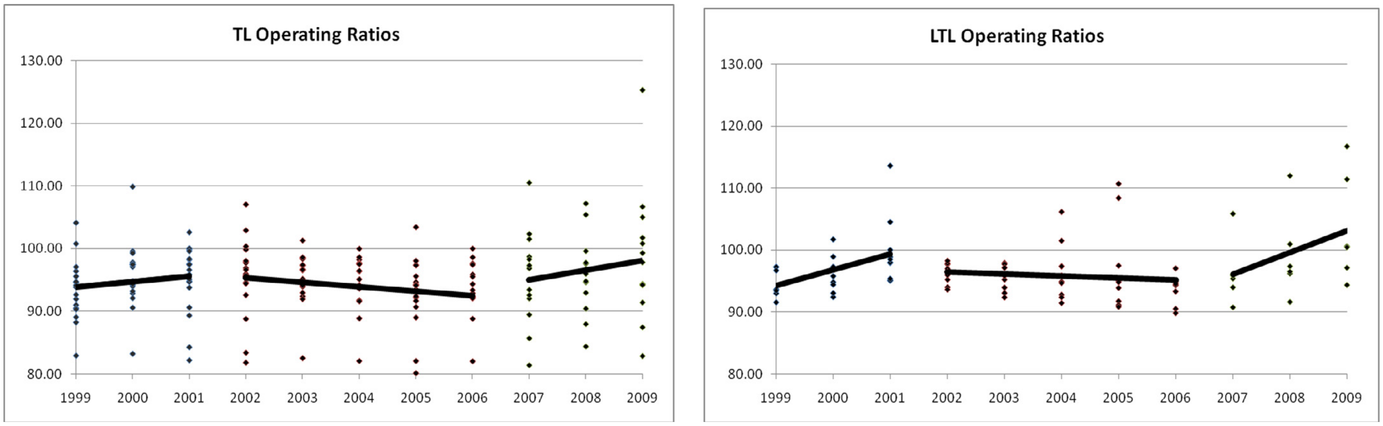

Fig. 1. Operating ratios for TL vs. LTL firms.

in Table 4. Contamination results in a rise in operating ratios in 1999–2001 as compared to 2002–2006 (where it actually resulted in a decrease). As such, contamination problems are becoming less of an issue for trucking companies. However, rising maintenance costs from compliant engines are more of a concern for trucking companies as shown in the increase from 2002–06 (where mangers were able to profit from the extra costs) to 2007–09. Lower Fuel efficiency is also becoming more of a problem, resulting in a significant 5.5% increase in operating ratio over the 2007–2009 period.

All variables related to capital expenditures are either statistically or economically insignificant. Size and the percentage of owner-operators are not statistically significant when examined over the different periods. In 2007–2009, leverage was extremely important to the operating ratio, whereas return on assets was the critical driving force in the operating ratio for both the 1999–2001 and 2002–2006 periods. A downward trend in operating ratios from 2002–2006 can be observed (Fig. 1), while an upward trend occurs in both the 1999–2001 and 2007–2009 periods.

5. Discussion and conclusions

Operating ratios for LTL and TL companies are sensitive to the various effects of environmental legislation but in different ways. As expected, because of their use of specialized equipment and warehouses, LTL's generally have higher, more rapidly increasing operating ratios than TL's. The results indicate that the 2002 and 2007 environmental regulations have had more of an impact on the LTL carriers than on the TL carriers. For instance, contamination issues (Superfund) are more problematic for TL's than LTL's. Specifically, having a contamination problem resulted in a 4.55% increase in operating ratios for TL's and only a 0.18% increase in operating ratios for LTL's, even though all companies that had a contamination problem noted they could estimate the costs and that these costs were not material. The Superfund legislation is resulting in an increase in operating ratios for trucking companies that have contamination issues.

No evidence exists to suggest that maintenance costs from the use of compliant engines have a differential impact on operating ratios for TL or LTL companies. In addition, this study assessed the effect of lower fuel efficiency from the use of compliant engines and its reaction with higher fuel prices. Lower fuel efficiency is more problematic during the 2007–2009 period than in prior years.

While statistically significant, costs associated with capital expenditures that included declining resale values and rising truck prices had little impact on operating ratios. While firms are able to pass on some of the effect of higher truck prices, they are experiencing lower returns on assets. The coefficient for Return on Assets (ROA) is negative and significant through 2006. As expected, because of the extra risk involved when using specialized warehouse and equipment for LTL's, the coefficient is more than twice the size as for TL firms.

For the most part, environmental regulations have induced operating ratio declines from 2002–2006 and increases from 2007–2009. The trucking industry is a vital industry that touches the lives of essentially every American. As such, understanding how various aspects of environmental regulations impact the operating ratio of trucking companies may help shareholders, politicians, and regulators understand the factors most responsible for the profitability of trucking firms and also help the trucking industry recoup its costs of "going green."

In summary, this paper addresses both environmental and financial accounting standard regulations. Specifically, in addition to assessing the impact of environmental regulation on trucking firms' financial performance, this research suggests that because of its widespread use (Cassidy, 2013), the FASB might consider issuing a reporting standard requiring firms in the trucking industry to disclose their operating ratios (based on a standardized calculation) on a supplemental basis. Such information should meet the decision usefulness criterion of financial reporting because external users (including regulators) would have enhanced ability to assess the impact of environmental and other types of regulation on the performance and efficiency of those firms. Such assessments are useful to those regulators in determining the relative costs and benefits of existing regulations and formulating decisions to adopt new regulations.

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Appendix

Panel data methods adjust for the covariance structure without assuming the independence of the data. According to Baltagi (1995), panel data have several advantages: 1) the dynamics of change are better explained by panel data; 2) panel data can measure and detect some effects that cannot be ob-

Table 2
Descriptive statistics.

Variable	Mean[a]	Std. Dev.	Minimum	Maximum
OperRatio	95.49		78.42	125.33
Environmental				
Contamination	0.23		0	1
Maintenance	0.15		0	1
FuelEff	0.23		0	1
ChangeInDieselxFuelEff	3.50	11.05	−35.12	32.68
EquipSales	26,278.00	37,827.00	−640.00	213,644.00
PriorCapExp	94,500.00	171,752.00	3.00	2,235,221.00
CapExp2002	95,453.00	171,012.00	−798.00	973,871.00
CapExp2007	37,028.00	114,631.00	0.00	1,019,949.00
Accounting				
LTDebt/TA	0.21	0.32	0.00	3.95
WC	52,702.00	119,286.00	−397,500.00	812,551.00
ROA	0.08	0.14	−0.47	1.59
Size	13.46	1.17	8.34	16.11
Industry Specific				
OwnerOper	26.60	34.74	0.00	100.00

[a] Proportions are presented for indicator variables and means and standard deviations are presented for continuous variables.

served when using only time series or cross-sectional data. Thus, the combination of time series and cross sections enables the regression analysis to be more robust. However, correlated data (autocorrelation) and unequal variances (heteroscedasticity) are common occurrences in situations where repeated measurements occur (panel data). We find evidence of both and correct for them to generate robust panel data estimates.

With fixed effects models, the impact of time-invariant omitted variables is controlled for by allowing the firm-varying intercepts. As such, we used a fixed effects model to estimate the operating ratio percentage for the *i*th firm in period *j*. The μ_i and γ_j are the fixed firm and time period effects, respectively, and account for the variation in the operating ratio percentage after all other independent variables have been included in the model.

(1) $\text{OperRatio}_{ij} = \alpha_1 + \alpha_2\ \text{Contamination} + \alpha_3\ \text{Maintenance} + \alpha_4\ \text{FuelEff} + \alpha_5\ \text{ChangeInDieselxFuelEff} + \alpha_6\ \text{EquipSales} + \alpha_7\ \text{PriorCapExp} + \alpha_8\ \text{CapExp2002} + \alpha_9\ \text{CapExp2007} + \alpha_{10}\ \text{LTDebt/TA} + \alpha_{11}\ \text{WC} + \alpha_{12}\ \text{ROA} + \alpha_{13}\ \text{Size} + \alpha_{14}\ \text{OwnerOper} + \mu_i + \gamma_j + \varepsilon_{ij}$

where $i = 1, \ldots, 31$ (firm number) and $j = 1, \ldots, 11$ (the years 1999–2009).

To test the effect of environmental legislation on the profitability of the trucking industry, environmental, accounting, and industry-specific variables are used. Dummy variables for *Firm* and *Year* are not shown. Means and standard deviations are reported in Table 2. A firm's operating ratio percentage is used as the signal for the costs of compliance with the U.S. Environmental Protection Agency's (EPA) stricter emission standards of 2002 and 2007 (the dependent variable). An operating ratio (operating expenses times 100 divided by operating revenues) measures the cost of operations (excluding debt-related expenses and taxes) per dollar of sales. Thus, a lower operating ratio indicates higher profit and a greater ability at handling increasing operational costs. In addition, we include accounting (e.g., *LTDebt/TA, WC, ROA, Size*) and industry-specific control variables.

Table 3
Results for TL and LTL.

Variable	β_i (SE) $n = 274$	TL β_i (SE) $n = 185$	LTL β_i (SE) $n = 89$
Environmental			
Contamination	2.76***	4.55***	0.18
	(0.87)	(1.53)	(0.87)
Maintenance	−0.21	0.21	1.18
	(0.72)	(0.78)	(1.74)
FuelEff	−0.93	−0.45	−3.19**
	(0.77)	(0.88)	(1.46)
ChangeInDieselxFuelEff	0.06*	0.06**	0.08
	(0.03)	(0.04)	(0.05)
EquipSales	0.00***	0.00**	0.00**
	(0.00)	(0.00)	(0.00)
PriorCapExp	0.00***	0.00	0.00***
	(0.00)	(0.00)	(0.00)
CapExp2002 −0.00**	−0.00	−0.00**	
	(0.00)	(0.00)	(0.00)
CapExp2007	0.00**	0.00	0.00
	(0.00)	(0.00)	(0.00)
Accounting			
LTDebt/TA	1.65**	1.74*	−3.65
	(0.83)	(0.92)	(2.87)
WC	−0.00	−0.00	0.00
	(0.0)	(0.00)	(0.00)
ROA −18.87***	−14.71**	−30.55***	
	(5.86)	(6.41)	(5.54)
Size	−3.36***	−2.47	−3.41**
	(1.09)	(1.53)	(1.47)
Industry Specific			
OwnerOper	0.08***	0.14***	−0.01
	(0.03)	(0.04)	(0.04)

Notes: For Total, F(53, 220) = 52.57, Prob > F = 0.0000; For TL, F (42,142) = 50.88, Prob > F = 0.0000; For LTL, F(33, 55) = 19.66, Prob > F = 0.0000.
Coefficient significant at 1% ***, 5%**, 10%*.

Table 4
Comparison of 1999–2001, 2002–2006, 2007–2009.

Variable	1999–2001 β_i (SE) $n=80$	2002–2006 β_i (SE) $n=136$	2007–2009 β_i (SE) $n=58$
Environmental			
Contamination	6.61	−1.05**	0.92
	(4.48)	(0.46)	(2.80)
Maintenance	–	−0.83***	4.33
		(0.30)	(2.76)
FuelEff	–	−0.31	5.50*
		(0.40)	(2.69)
ChangeInDieselxFuelEff	–	0.04*	0.02
		(0.02)	(0.04)
EquipSales	−0.00	0.00	−0.00
	(0.00)	(0.00)	(0.00)
PriorCapExp	0.00**	0.00	0.00*
	(0.00)	(0.00)	(0.00)
CapExp2002	–	−0.00**	−0.00
		(0.00)	(0.00)
CapExp2007	–	–	0.00
			(0.00)
Accounting			
LTDebt/TA	2.01	−0.10	42.00***
	(1.34)	(1.30)	(11.83)
WC	0.00	0.00	0.00
	(0.0)	(0.00)	(0.00)
ROA	−24.88**	−44.57***	−5.09
	(9.57)	(1.87)	(3.33)
Size	−1.49	−0.50	1.39
	(2.83)	(0.56)	(5.18)
Industry Specific			
OwnerOper	−0.01	0.03	0.23
	(0.14)	(0.02)	(0.20)

Notes: For 1999–2001: F(37,41) = 7.63, Prob > F = 0.0000; For 2002–2006: F (45, 89) = 161.66, Prob > F = 0.0000; For 2007–2009: F(34, 23) = 1504.75, Prob > F = 0.0000. Coefficient significant at 1%***, 5% **, 10% *

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