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A Three Essay Examination Of Current Pay And Safety Issues In The Truckload Sector Of The Motor Carrier Industry

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A THREE ESSAY EXAMINATION OF CURRENT PAY AND SAFETY ISSUES IN THE TRUCKLOAD SECTOR OF THE MOTOR CARRIER INDUSTRY

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1. Introduction

Background

The Motor Carrier Act (MCA) of 1980 ushered in an era of profound changes in the motor carrier industry. The economic regulations that existed were replaced by market forces, whereby the common carrier general freight motor carrier industry fragmented into the truckload (TL) and less than truckload (LTL) industry sectors in a relatively short period of time. The removal of entry controls that resulted from the Interstate Commerce Commission's (ICC) new interpretation of the "public convenience and necessity" doctrine (Moore 1983), in conjunction with the ability of the new firms to now adjust prices and services in accord with market forces, unleashed a wave of new motor carriers into the industry.

A large number of the new entrants in the motor carrier industry were small TL carriers (McMullen 2005; Burks & Guy 2012) that owned one to a few trucks that were previously employed under an existing firm's route certificate (McMullen 2005; Grawe 2008). In 1981, following the enactment of the MCA, there was a surge of just over 4000 new entrants into the industry (Moore 1983, 1986), and by 1986 there was an increase of roughly 19,000 new carriers, in addition to the approximate 18,000 carriers that existed in 1980 (Corsi & Fanara 1989; Grawe 2008). The elimination of the patchwork of former route certificates enabled new entrants to "cream" TL shipments (Belzer 2000) from the existing common carrier sector, leaving primarily LTL shipments to the remaining firms. The LTL sector found fewer and fewer firms competing for carriage (Boyer 1993; Corsi 1993; Belzer 2000; Burks & Guy 2012); the TL sector saw a marked increase in competition for carriage and most nearly replicates a competitive market (Burks & Guy 2012). The new carriers aided by the ability of freight brokers to find carriage (McMullen 2005) enabled small motor carriers to effectively compete with the largest motor carriers where the marginal carrier's cost of production for the next shipment greatly influenced the price charged for carriage in the market.

The market segmentation into TL and LTL industry sectors (Belzer 1995, 2000; Burks & Guy 2012) that resulted from deregulation, coincident with the 1979 through 1982 recessionary period (Belman & Monaco 2001), lowered motor carrier freight rates (Moore 1983) whereby overall wages were reduced; moreover, the labor force was effectively segmented in the motor carrier industry. In conjunction with the labor market segmentation, the consolidation of the LTL sector and the burgeoning TL sector effectively reduced overall union coverage in the motor carrier industry (Rose 1987; Hirsch 1993; Belzer 1995; Belman & Monaco 2001). The level of unionization in the motor carrier industry has significantly declined after the passage of the Motor Carrier Act of 1980 (Belzer 2000; Belman & Monaco 2001; Henrickson & Wilson 2008; Burks & Guy 2012) and union density is currently 10.2% (Hirsch & Macpherson 2014). The decentralized nature of the TL segment, combined with the difficulty of organizing within the National Labor Relations Act as amended, precluded the union from actively recruiting new membership. As a result of deregulation, the current logistics of TL carriage places a significant level of disutility on TL drivers' work experience. The TL sector's driver disutility and overall lower driver wages have significantly increased driver turnover that is currently prevalent in the TL sector of the motor carrier industry.

In the decades since the passage of the MCA of 1980, turnover in the TL sector of the motor carrier industry has hovered around 100 percent (Rodriguez & Griffin 1990; LeMay *et al.* 1993; Stephenson & Fox 1996; Min & Lambert 2002; Suzuki *et al.* 2009). In 2015, turnover for large TL firms remains elevated at 96 percent; down slightly from a turnover rate of 98 percent in 2014 (Watson 2014); and significantly lower than the peak turnover level of 130 percent in 2005 (Watson 2013). Exacerbating the turnover problem for large TL motor carriers is the persistent perceived shortage of qualified drivers (Suzuki 2007). Currently the TL sector is experiencing a driver shortfall of approximately 35,000 drivers (Bearth 2013) and the Department of Labor projects that by the year 2020 the motor carrier industry will need 315,000 new drivers[1]. Compounding the turnover pressure for TL firms is the need for labor in the competing industries of construction and manufacturing that require comparable human capital characteristics (Burks *et al.* 2008). Turnover is a serious problem for TL motor carriers and has a deleterious effect for the firms and for society.

Turnover necessitates driver recruitment and the eventual replacement. The costs of driver replacement and recruitment have been reported to be between $3,200 and $29,000 per driver with conservative estimates given to be approximately $12,000, adjusted to 2014 dollars (Burks *et al.* 2008; Suzuki *et al.* 2009). Additionally, motor carrier firms that have high turnover rates have been linked to higher crash incidents, thereby increasing the costs experienced by the motor carrier (Corsi & Fanara 1988), as well as increasing the costs imposed on society (Saltzman & Belzer 2002). Increasingly, motor carriers facing labor shortages and excessive turnover will hire young, potentially inexperienced and unqualified drivers; further increasing costs for the carrier and on society. Young drivers are involved in more crash incidents than their older counterparts (Cantor *et al.* 2010; Green & Blower August 2011). Although this list is not exhaustive, the increase in costs due to crashes include vehicle down time, higher insurance rates, reduced customer service for the carrier (LeMay *et al.* 1993; Suzuki *et al.* 2009); and the external cost imposed on society resulting from property damage, productivity loss, and loss of life that exceed the limits of current insurance mandates (Saltzman & Belzer 2002).

Motivation

In TL motor carriage, driver turnover is directly affected by harsh working conditions that the drivers endure. A typical TL motor carrier driver can expect to work long and irregular hours in the delivery of freight. Although these hours are limited by hours of service (HOS) regulation,

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[1] Bureau of Labor Statistics, U.S. Department of Labor, *Occupational Outlook Handbook, 2014-15 Edition*, Heavy and Tractor-trailer Truck Drivers,
on the Internet at http://www.bls.gov/ooh/transportation-and-material-moving/heavy-and-tractor-trailer-truck-drivers.htm (visited *July 01, 2014*).

drivers frequently report working considerably more hours than allowed by the law (Stephenson & Fox 1996; Belzer 2000; Kemp *et al.* 2013). The demands of driving are exacerbated by the loading and unloading operations carried out by the drivers, often times without compensation similar to what they earn while driving (Belzer 2000). Drivers have reported that the compensation is not adequate for the long hours and extended periods away from home (Rodriguez & Griffin 1990).

In the movement of freight, TL motor carrier firms must choose the cost minimizing amount of capital and labor inputs in order to deliver shipments of freight in a manner that is most efficient and cost effective to the firm. This requires the firm to have equipment and drivers strategically located in order to affect these movements. The labor choice for motor carriers considers the overall price of "effective labor" that includes the total cost to the firm for hiring and employing labor (Burks *et al.* 2008). Effective labor consists of the original cost to recruit and train a driver; the operational costs of creating the best working conditions for the driver; the cost of insurance and crashes that the firm incurs from selecting certain types of drivers; and the actual compensation paid to the driver including any compensating differential for the drivers that operate under the worst of conditions. Effective labor has emerged in the TL sector as being characterized by high turnover levels, high rates of crash incidents, and low to non-existent compensating differentials being paid to the drivers (Burks *et al.* 2008). The entrenchment of the model in the TL sector of the motor carrier industry has witnessed few firms exploiting the cost tradeoffs that could be afforded in the price of their effective labor.

The cooperating firm changed its pay structure to become a world-class provider of transportation supplanting their tarnished image in the TL motor carrier industry. To fulfill this goal, the firm initiated a new managerial culture whereby managers and supervisors were to take responsibility for being more attentive to safety issues and recognizing the issues of their drivers, turning attention to turnover to stabilize their workforce. To accomplish this task, the firm raised the per mile rate of pay for the drivers that remained in their employ on the average of 37%, and substantially increased the per mile rate of pay for their new hires that were safe and experienced drivers. The underlying objective was to pay the drivers a compensating differential that was significant enough to attract and retain the most experienced drivers in the TL sector, where the increase in pay eroded the disutility of the TL driving job and thereby reducing turnover. In other words, the cooperating firm moved from the model of high turnover and low wages, to the untried model in the nonunion TL sector of low turnover and high wages[2].

In addition to increasing wages, to the highest in the TL industry, the firm completely remade the corporate culture by enhancing the benefit package of the drivers; increased the amount of home time earned with a 100% guarantee to be at the home terminal by the date requested by the driver with a minimum of fourteen days notice; implemented a new recognition program to restore driver dignity and accountability; and reduce tractor age and increase maintenance schedules, among many other remedies[3]. Given the intentions, the firm, as well as other motor carriers that are dedicated to increasing driver compensation, will retain valued employees longer and attract a larger pool of qualified applicants from which firms can hire drivers that possess the necessary human capital required to safely operate a large commercial motor vehicle and thereby reduce driver turnover.

To investigate whether the above strategy was effective, the current research will employ a Cox proportional hazards model to build upon the previous work of Belzer et al., 2002. The Cox proportional hazards model is appropriate when the dependent variable in the analysis is a measure of the time to an event; in this research the time until a driver exits the firm's employment is the variable of interest. Further, in research where the data are right censored, a significant number of drivers do not experience the event of interest, and interest only in the effect of the covariates on the time to the event warrant the utilization of the Cox proportional hazards model.

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[2] The cooperating firm's internal documentation acknowledges the tradeoff of effective labor and discusses appropriate remedies summarized in this paragraph.
[3] The cooperating firm's internal documentation.

To build upon the prior research employing the cooperating firm's data, the current research disentangles the affects of pay, the affects of driver experience, and the new management regime's affects on the driver turnover rate of the cooperating firm that was not considered in the prior research, controlling for various demographic and operational covariates. The authors' expectation is that a more experienced driver workforce who is earning a higher rate of per mile pay, in conjunction with an improved management team, will reduce turnover levels at the firm.

2. Literature Review

Compensation

Driver pay consistently has been found to be the primary reason that random over the road irregular route (OTR) drivers exit from the firm of their current employment (Jason *et al.* 1998; Belzer *et al.* 2002; Keller 2002; Min & Lambert 2002; Min & Emam 2003; Williams *et al.* 2011). Belzer et al. and Suzuki et al., employing survival analysis with firm level data, find that increasing a driver's mileage pay rate reduces the probability of driver turnover (Belzer *et al.* 2002; Rodríguez *et al.* 2006; Suzuki *et al.* 2009). In addition to reduced turnover, increasing a driver's pay creates a stable work environment with experienced drivers where customer relationships are positively fostered (Keller 2002). Caution is warranted, however, given the level of disutility that most drivers receive from being an OTR driver; pay is often cited as the reason that a driver intends to quit even when there are other underlying issues with the work, such as excessive waiting times at shipper docks (LeMay *et al.* 1993; Stephenson & Fox 1996). Each particular firm's overall situation should therefore be carefully considered when linking its pay to their individual turnover rate.

Management

Management plays a crucial role in the recruitment and ultimate retention of the motor carrier driver. It is important that executives perform the tasks of operating a motor carrier firm with some level of sophistication, given the nature of the business; in other words, the management is running the company competently (Richard *et al.* 1994; Richard *et al.* 1995). In the process, managers should improve the current corporate culture; consider driver suggestions, as well as driver well-being, in the decision process. The driver's direct supervisor, the dispatcher, must promulgate the corporate culture to the driver, while failure to do so increases the animus between the firm and the driver (Richard *et al.* 1994; Richard *et al.* 1995). When dispatchers fail at these tasks, drivers become alienated from the firm and customers, increasing the likelihood of driver turnover. Failure of motor carrier firms to have high quality dispatchers erodes customer and driver confidence that in turn leads to a poor reputation amongst clients and increased driver turnover (Keller 2002; Suzuki *et al.* 2009) (Williams *et al.* 2011).

Time Away From Home

The nature of the TL segment of the motor carrier industry requires that drivers be away from their home for extended periods of time, for as much as two weeks at a time (Burks *et al.* 2008). Drivers frequently state that the prolonged periods away from home influence their decisions to turnover (Rodriguez & Griffin 1990; LeMay *et al.* 1993; Shaw *et al.* 1998; Keller 2002; Williams *et al.* 2011). It is of great importance to the retention of drivers and reducing turnover rates that firm management become aware of the amount of time that drivers spend at home, and importantly on the road. The added stress of being away for extended periods, driving long hours, loading and unloading cargo are all factors which increase the driver's fatigue, thus decreasing overall driver performance. Time away from home plays a crucial role in retaining drivers and is the second most cited reason for turnover.

Driver Image

In the recent past, truck drivers have been negatively stereotyped (Rodriguez & Griffin 1990; Richard *et al.* 1994). The negative perception of drivers alters driver turnover in two distinct ways. First, when managers appear to have a general lack of respect for what the driver represents to the firm, drivers feel belittled and quit in hopes of finding respect in future employment (Stephenson & Fox 1996). Drivers want a sense of pride in the firm that employs them; one that carries the reputation of treating their drivers with dignity (Min & Lambert 2002). Second, when the firm's customers disregard the driver's importance by increasing downtime at their docks, a disrespect of time and person, the shippers promulgate a similar sense of worthlessness, thereby increasing driver turnover (Stephenson & Fox 1996). The promotion of the driver as a professional will play a significant role in retention and turnover strategies of motor carrier drivers (Min & Lambert 2002).

3. Model

To explore the relationship between the driver's pay rate and the rate at which a driver exits from the firm, the current analysis will employ time-to-an-event analysis, or survival analysis to estimate a driver's hazard function following Belzer et al. and Suzuki et al. (Belzer *et al.* 2002; Suzuki *et al.* 2009). The hazard function is semi-parametric as a direct result of the fact that the baseline hazard function, $h_0(t)$, the error component of the regression model, is not estimated following Cox (Cox 1972). The systematic component of the hazard function is parameterized to be the exponential function. The hazard function, measuring the instantaneous rate of driver exit from the firm, is required to take on only positive values and the choice of the exponential function as the parameterization assures that conditional requirement. With the exponential function chosen for the model's systematic component, the hazard function becomes,

$$h(t,x) = h_0(t)\exp(x(t)'\beta). \quad (1)$$

In the data set supplied by the firm, there are multiple observations on each of the individual drivers that are measured on monthly time intervals. Denote,

$$x_{lk}(t_i) = (x_{l1}(t_i), \ \dots, x_{lp}(t_i))', \quad (2)$$

to be the measured value of the K^{th} covariate, $K = (1, 2, \dots, P)$, for each of the individual l drivers where $l = (1, 2, \dots, n)$ at each time t_i. The given definition of $x(t)'$ above allows an individual's covariate to vary for each of the successive monthly measurements to accommodate the covariates that vary from month to month. To compare the exit rate of different drivers, or different groups of drivers, the hazard ratio, also known as the relative risk ratio, is formed from individual hazard functions as,

$$HR(t,x) = \frac{h_0(t)exp\beta_0 \exp(x_1(t_i)'\beta)}{h_0(t)exp\beta_0 \exp(x_2(t_i)'\beta)} \tag{3}$$

$$= \exp(\beta(x_1 - x_2)) \,. \tag{4}$$

The coefficient β is estimated by maximizing the partial likelihood function from the cooperating firm's data following Cox's work on equation one (Cox 1972).

To estimate the parameter β by maximizing the partial likelihood function it is assumed that the baseline hazard function, $h_0(t)$, is an arbitrary function of time. On the intervals for which there are no failure times, employee exit from the firm, the baseline hazard function may take on values equal to zero that do not contain any information on the parameter β (Cox 1972). Only at the ordered driver exit times r, where $r = t_1 < t_2 < \cdots < t_r$ is the set of exit times, is the probability of an individual driver exiting from the firm on the interval $[\, t_i, t_i + \Delta t_i)$ conditional on the fact that the exiting driver remained gainfully employed with the firm until the time just before he/she exited from the firm. Assuming that driver right censoring is independent, the probability that driver j exits from the firm at time t_i is given by,

$$L_j(\beta) = \frac{h(t_i, x_j)\Delta t_i}{\sum_{l \in R(t_i)} h(t_i, x_l)\Delta t_i}, \tag{5}$$

where $R(t)$ is the set of drivers at the firm that are still under observation (Kalbfleisch & Prentice 2002); the set of drivers at the firm that have not exited or are uncensored at the time that driver j exits from the firm. In the above equation, $h_0(t)\Delta t_i$ cancels and the simplified expression becomes,

$$L_j(\beta) = \prod_{j=1}^{r} \frac{\exp(x_j(t_i)'\beta)}{\sum_{l \in R(t_i)} \exp(x_l(t_i)'\beta)} \,. \tag{6}$$

The model is further stratified into s strata, where $s = (1, 2, \dots, q)$, by driver experience at hire, whereby the above expression becomes,

$$L(\beta) = \prod_{s=1}^{q} \prod_{j=1}^{r(s)} \Big[\frac{\exp(x_{j(s)}(t_{j(s)})'\beta)}{\sum_{l_{(s)} \in R_{(s)}(t_{j(s)})} \exp(x_{l(s)}(t_{j(s)})'\beta)} \Big], \tag{7}$$

the partial likelihood function to be maximized over β, from which the inferences will be made (Kalbfleisch & Prentice 2002). It is the partial likelihood function in the sense that the actual censored and uncensored survival times are not used in the estimation of β (Collett 2003).

4. Empirical Analysis

Data

The cooperating firm is a large TL motor carrier that hauls general freight in the U.S. The proprietary data supplied by the firm for the current research consists of 91,744 driver observation months that includes driver demographic and operational covariates, considering 11,509 drivers in their random over the road irregular route truckload division. In addition to the standard operational covariates of driver mileage and dispatches per month, information on a driver's prior driving experience before hire, crashes each driver sustained per month including the actuarial estimate or fact regarding the cost of each crash, and the month that a driver, if appropriate, exits the firm's employment is included in the data set.

The drivers are observed during two time periods; referred to henceforth as pay regime one for the first observation time period, and as pay regime two for the second observation time period. Pay regime one, thirteen months of observation, commenced on September 1, 1995 and ended on September 30, 1996, which corresponded with the firm's formal announcement of the aforementioned impending corporate changes. Observation for pay regime two continued from February 1, 1997, the month that the drivers remaining in the firm's employment received a per mile pay increase and newly hired drivers fulfilled the firm's new hiring objective, and completed on March 31, 1998, fourteen months of observation. No data, except the hire dates of the drivers hired in the intervening period for pay regime two employment, are observed during the intervening four month period. Selected statistics for the entire data set are shown in Table 1.

Table 1 Here

Methodology

The modeling approach employed in the current analysis fulfilled two primary objectives. The first objective is to build on the previous work of Belzer et al., improving on their model specification where similar data is utilized for use as a future reference; the second objective is to utilize the data in such a way that corresponded to the firm's intent, as gleaned from the supplied internal documentation on the data. The analysis will model time to a driver's exit from the firm, employing what is understood from past research on demographic and operational covariates constrained by the supplied data set. In this data, it is unknown if the reason for a driver's exit was a voluntary quit, or an involuntarily release from the firm. Research on similar data suggests that 76.4 percent of all drivers quit voluntarily and the remaining drivers are released involuntarily (Burks *et al.* 2008). All driver observations are included in this analysis and the results are for driver exits; however, given the magnitude of voluntary quits in similar data, it is reasonable interpreting the results of the analysis in terms of voluntary driver quits. The independent covariates were further categorized to fulfill the aforementioned objectives.

The categorization of the covariates in the current analysis accomplished several important functions. In the prior analysis of Belzer et al., the driver's pay rate entered into the model as a continuous covariate accompanied by a continuous covariate for the percent increase in the base pay level for those drivers that received a pay raise at the beginning of pay regime two; moreover, age and tenure were additionally included as continuous covariates with a specified functional form (Belzer *et al.* 2002). Although significant, no distinction can be drawn between the drivers that the firm targeted for hire in pay regime one and pay regime two. Separating the pay rate into the various categories allows for the comparison of exit rates for new hires in pay regime one to the exit rates of new hires in pay regime two, the primary intent of the firm, and similarly for other covariates. Further, categorization does not force a specified functional form on the covariate of interest, in particular age and tenure, affecting inference of the results if the incorrect functional form is chosen; and categorization aids in the correction of nonlinearities if the covariates appear nonlinear in the data. Importantly, categorization improves proportionality of the covariates of interest required during the modeling process, thereby improving the model specifications. Further, tenure was removed from the analysis simply because the model is specified as a tenure time model. For the aforementioned reasons, all of the covariates were categorized based on the details outlined in the supporting documentation and descriptive analysis.

The stated goals of the cooperating firm, in conjunction with the internal documents supplied by the firm, were utilized to further categorize the data to aid in correctly disentangling the affect of pay, the affect of the driver's experience at hire, and the affect of the managerial improvements on driver exit decisions. In pay regime one, the firm primarily paid drivers $0.23 per mile to $0.25 per mile. These were the rates paid to the predominantly inexperienced commercial motor vehicle drivers hired in pay regime one and are the pay rates that comprise the base pay category of pay rates utilized in the regression analysis. In pay regime two, the target pay rate of the firm was identified as $0.38 per mile; the pay rate according to the internal documentation that corresponds to the average experience level of drivers hired during pay regime two. In total, the driver's pay rate was separated into seven distinct pay categories based on the above information, the remaining distribution of the pay rate data, and proportionality in the model.

The operational covariates of mileage per month and dispatches per month were separated into four distinct categories that approximated 25 percent of the observations in each of the categories; the mileage category for 6,608 to 9,315 miles per month and the dispatch category for 13 to 16 dispatches per month were chosen as the base category in the regression analysis because the mean of those covariates fall within the categories, respectively.

Driver baseline age, the age of the driver when he/she was first observed in the data, is categorized into seven, five year, categories beginning with age 21, the minimum age at which a driver can become a commercial motor vehicle driver. The eighth, and final, age category represents all of the drivers that had a baseline age greater than 55 years old, the group of drivers most likely to give retirement as the reason for exit; age category of drivers aged 41 to 45 years of age is the base category in the analysis.

Driver race was categorized into the three groups; Caucasian, the predominant race in the data and the base category for analysis, African American, and other, which consists of Indian, Asian, and Latino drivers, among others. The remaining covariates of period, gender, marital status, pay raise, and winter (the months of December through March) are categorized as zero one indictor covariates.

In the resulting model, the period covariate is the control employed in the analysis for the change in the managerial practices in the two observation periods. The pay categories were then interacted with the period covariate to control for the affect that the management change had on a driver's pay rate during each of the observation periods. Further, it was found in preliminary analysis that the inexperienced drivers at hire have different baseline hazard functions when compared to the experienced driver at hire and the model was therefore stratified on the driver's prior experience at the time of their hiring.

5. Results

As hypothesized, Table 2 reveals the modeling result that higher rates of pay for a driver lead to lower exit rates, a result similar to the prior results of Belzer et al., and Suzuki et al. (Belzer *et al.* 2002; Suzuki *et al.* 2009). Further, these results coincide with the findings of Suzuki et al., whereby the operational covariates are more significant at predicting driver exit rates than demographic covariates (Suzuki *et al.* 2009) Unexpectedly, controlling for all available covariates in the analysis, the control for the managerial change indicates that drivers in pay regime two exit at a rate that is 63.5 percent more than the exit rate for drivers in pay regime one; management changes were found to be detrimental to driver exit rates.

Table 2 Here

A driver who experienced higher driving mileage per month exited the firm at lower rates than a driver with lower mileage per month. Belzer et al. and Suzuki et al. measured mileage differently than in the current analysis. Belzer et al. found that the accumulation of average mileage leads to higher exit rates (Belzer *et al.* 2002), contradictory to the current results; and Suzuki et al. find that drivers dispatched on longer runs exit at lower rates (Suzuki *et al.* 2009). Contradicting Belzer et al., when a higher number of dispatches are received by a driver each month, there is a decrease in the driver exit rate (Belzer *et al.* 2002). Further, a driver that received a pay increase exited at a rate that is approximately 39 percent lower than a driver not receiving a pay increase; Belzer et al. found similar results in the percent change in pay covariate they employed in their analysis.

The seasonal covariate for the winter months suggests that drivers exit at an approximately 24 percent lower rate during the winter. The important control of whether a driver sustained a crash incident in the driving period suggests that a driver experiencing a crash exited at a 60 percent higher rate than other drivers; Suzuki et al. had similar findings (Suzuki *et al.* 2009).

The primary demographic covariate controlled for in the analysis was driver age. Young drivers, age 21 to 25 years old, and drivers approaching retirement age above 55 years old exit at a statistically significant rate, 14 percent and 19 percent more respectively. The remaining driver age groups exit at rates that suggest they are not statistically different from the base age group of 41 to 45-year-old drivers. This result is comparable to Belzer et al.'s prior finding that a 43-year-old driver exits at a rate significantly lower than 25 and 65-year-old drivers (Belzer *et al.* 2002); and the results of Suzuki et al. are comparable where exit rates decline as a driver ages (Suzuki *et al.* 2009). Moreover, the current analysis supports the findings of Beilock and Capelle that drivers in their 30s through their early 50s exit at lower rates than their younger and older counterparts (Beilock & Capelle 1990). The effect of race on exit rates is significant; Caucasian drivers in this analysis exit at rates 20 percent higher than those drivers of other races, supporting Belzer et al.'s findings (Belzer *et al.* 2002). Single drivers' exit rates are slightly lower than their married counterparts, whereas there is no statistical difference between the male and female exit rates, contradicting Belzer et al.'s prior findings (Belzer *et al.* 2002).

6. Discussion

This research allowed the researcher to examine and compare the rate of exit from the firm of the various driver groups targeted by the cooperating firm. The current methodology departs from Belzer et al.'s in significant ways. Importantly, the current analysis created categories based on internal documentation to explore the relative risk of driver groups targeted by the firm. The categories chosen aided in smoothing any nonlinearities that may have existed in the data maintaining the integrity of the firm's objectives without forcing a specific functional form onto the data. As in the case of age in the analysis, the above methods have led to contradictions in the results. Further, categorizing the data restored proportionality to the key covariates of interest, pay and age, which was a key aspect of the current modeling process.

Table 3 shows the hazard ratios for drivers in the various pay levels in the top row compared to the drivers of other pay levels indicated in the column of the table during pay regime one only. The results estimated from the model for the various pay levels of the driver's pay rate indicate, with the exception of drivers earning $0.22 per mile and below, that a higher rate of pay per mile is associated with lower rates of exit for pay regime one drivers. Drivers that are paid $0.26 to $0.30 per mile exit at a rate that is approximately 15 percent less than the base wage driver that earns $0.23 to $0.25 per mile; drivers earning $0.31 to $0.33 per mile exit from the firm at a rate that is 34 percent lower than the base wage drivers; and drivers earning $0.34 to $0.37 per mile exit at a rate that is approximately 28 percent lower than the rate of the base pay drivers. Drivers earning the highest per mile rates, earning $0.38 and earning $0.39 and above per mile, exit at approximately similar rates that are respectively 63 percent lower and 65 percent lower than exit rate of the base wage driver. The pay level of $0.34 to $0.37 is not statistically different from the pay level of $0.26 to $0.30, indicating that those drivers exit at a similar rate; when higher paid drivers earning pay level $0.31 to $0.33 through the pay level of more than $0.38 are compared to the pay level of $0.26 to $0.30, a similar pattern emerges, higher paid drivers exit from the firm at a lower rate. Further, there is a weak statistical linkage that the highest paid drivers exit at lower rates than drivers that are paid $0.34 to $0.37; while the remaining levels for higher paid drivers are not statistically different.

Table 3 Here

In general, the expectation that higher levels of pay result in lower exit rates for drivers is upheld, except for the lowest paid drivers in pay regime one. Drivers earning $0.22 and less appear to be an anomaly; they exit at a lower rate than those drivers earning a pay level of $0.23 to $0.25 and drivers earning a pay level of $0.26 to $.030, and they are not statistically different from the remaining higher paid drivers. Observation of the data suggests that these particular drivers were hired with transfer promises to other departments within the firm of which the researcher is unaware, based on the fact that 98 percent of these drivers are right censored in the data, they do not exit from the firm.

In pay regime two, higher paid drivers exit at rates less than their lower paid counterparts; see Table 4 that is read similarly to Table 3. The one exception to this rule is that drivers earning the highest pay level of more than $0.38 per mile exit from the firm at a 42 percent higher rate than drivers earning $0.38 per mile. Intuitively this is reasonable. The highest paid drivers may be older drivers that are paid for their exceptional human capital who could obtain jobs at unionized carriers, which are the highest paid in the industry. Further, the lowest paid drivers continue to be an anomaly during pay regime two where analysis of the data reveals a similar explanation as the lower paid drivers in pay regime one. Comparison of drivers in the same pay regime reveals what was expected, is intuitively known, and has been presented in the prior literature. This research further demonstrates that exit rates across pay regimes were reduced by the cooperating firm's experiment.

Table 4 Here

To attract an experienced workforce, the cooperating firm paid newly hired drivers in pay regime two either $0.37 or $0.38 per mile, with an observed final target of $0.38 per mile. Comparison of the pay levels of new hires in pay regime two to that in pay regime one indicates that, on average, pay regime two new hires turnover at a rate that is 50 percent less than their pay regime one counterparts, (Table 5).

Table 5 Here

An interesting part of the firm's experiment is to compare the drivers in pay regime one who received a pay increase in pay regime two to their new counterparts in pay regime two. In Table 6, the pay levels in the row represent the drivers who received a pay increase and moved into the listed pay level as a result of the increase. They are compared to the newly hired pay regime two drivers in the column that would have been hired into the firm at that pay level. As an example, a retained driver now earning $0.38 per mile exits at a rate that is 39% lower than a new hire in pay regime two earning $0.38 per mile, the target wage in pay regime two. A similar pattern emerges whereby drivers receiving a wage increase in the highest pay categories exit at rates significantly lower than the newly hired drivers. For drivers who received a raise that moved them into the pay level of $0.26 to $0.30, or the pay level of $0.31 to $0.34, the raise was insufficient to retain them. These drivers exit at one and one-half times that of newly hired drivers that are paid $0.38 per mile. Although not statistically significant, the magnitude of the remaining estimates for these drivers suggest that the increase in pay was not substantial enough for the drivers to continue employment with the cooperating firm; the firm did not value these employees highly enough to warrant a larger pay increase, thereby increasing the exit probability of these drivers. In Table 6, the diagonal value estimates the effect of the pay increase for a driver who received an increase in pay and who remained in the same pay category; for example, a driver that earned $0.34 per mile was given a $0.03 per mile increase to $0.37 per mile exits at a rate of 40 percent less than a driver at the same pay level that did not receive an increase in his/her pay level. Presumably the driver believes that the firm values his/her efforts and exits at a lower rate. Further, in addition to the per mile pay that a driver receives, mileage driven per month affects overall income; the number of dispatches per month relates to, in many cases, unpaid labor that firms require of their drivers, affecting income, which, in turn, leads to drivers exiting the firm. There is more unpaid labor when a driver's dispatches are more frequent and the mileage for each load is shorter, as more unpaid time is consumed in the loading/unloading transaction.

Table 6 Here

In the results shown in Table 7, mileage that a driver accrues during a month significantly influences his/her decision to exit. In all cases, when drivers of equivalent pay levels are compared across the various mileage categories, increased monthly mileage reduces driver exit rates. Beyond the pay per mile that a driver earns, their income is dependent on the actual miles driven in the period; controlling for pay per mile, the more time a driver spends moving down the road, the higher their income.

Table 7 Here

Often overlooked, however, is the number of dispatched hauls a driver received to attain the monthly mileage. The results listed in Table 8 indicate in every instance that when drivers with equivalent pay levels are compared across the four dispatch categories, increased dispatches actually reduces driver exit rates. Further, prior research suggests that drivers experiencing a low income event are more likely to quit (Beilock & Capelle 1990). Combining low mileage attained from a large number of dispatched hauls, by conventional wisdom, would create an unfavorable low-income situation for drivers. Comparing the remaining mileage levels in combination with the various dispatch levels supports Beilock's and Capelle's finding, see Table 9.

Table 8 Here

Table 9 Here

7. Conclusion

This research quantifies three things: Utilizing the natural experiment undertaken by the cooperating firm and the nature of the data set, the effects of increased driver's pay, the effects of driver's experience at hiring, and the effects of the change in managerial practices on driver exit rates. The firm's experiment allowed for a rare opportunity, that social scientists are not usually afforded, to investigate the affects of increasing a driver's pay, identifying specific driver groups by experience, and changing managerial practices had on a driver's decision to exit employment. Stated directly, the findings reinforced the importance that pay, controlling for other important operational and demographic characteristics, has on the retention of truckload drivers. Substantially increasing driver pay increased the pool of qualified applicants from which more experienced drivers were hired, as well as facilitating the retention of their current drivers that possessed the desired qualities the firm wanted to emphasize.

The firm effectively reduced turnover from approximately 126 percent in the first pay regime to an average of 40 percent during the second pay regime. For the firm's experiment to be complete there is an expectation that newly hired drivers should be indistinguishable from the drivers who remained in their employment. That was not the case, however, for the cooperating firm. The new hires during pay regime two separated at higher rates that were significantly different from the retained drivers from pay regime one during the second pay regime. The cooperating firm, through detailed surveys or other methods, should determine what characteristics the retained drivers were endowed with that the new hires did not possess. From the standpoint of the firm, the experiment was a success—just not as successful as it could have been.

The current research has several limitations. As is the case with any data set, the collection process is prone to errors and omissions. In the current data set, it is not known if the recorded driver exits are voluntary quits, or if the exits are from the driver being involuntarily released from the firm. Importantly, the change in management and its role in exit rates was unexpectedly a detriment to the firm; management and supervision has been shown to be a significant reason for driver exits in the literature. The data set does not have information concerning the driver's direct supervisor. A thorough collection of the missing covariates would sharpen the current results. Additionally, the data are representative of one large U.S. TL motor carrier; caution is warranted in the application of the current results to the TL sector of the motor carrier industry in general.

This paper is part one of a project to estimate the net present value of an inexperienced TL driver and compare it to the net present value of an experienced TL driver, employing the cooperating firm's data set. The model presented in this paper is utilized to estimate exit probabilities. In another part of the project, the model will be utilized to calculate the probability of a TL driver experiencing a crash incident. Finally, the aforementioned probabilities, with additional estimation of the firm's profits per mile and estimated driver mileage per month, will be combined to calculate the driver net present values in order to explore the firm's pay off, quantifying the cost for the cooperating firm of trading their effective labor. A favorable outcome in this experiment for the firm will enhance future policy decisions concerning pay rate levels and the experience levels of current and future drivers in the TL motor carrier sector.

Table 1. Cooperating Firm Data					
			Number	**Observation Months**	
Drivers			11,509	91,744	
Gender	Male		11,103	89,303	
	Female		406	2,441	
Race	White		8,862	69,324	
	Black		1,986	16,166	
	Other		661	6,254	
Marital Status	Married		6,097	47,409	
	Single		5,995	44,335	
		Minimum	Mean	Standard Deviation	Maximum
Baseline Age		20.0	40.5	9.8	76.0
Baseline Pay		16.0	30.5	6.0	48.0
Miles per Month		2.0	8,966.5	3,331.3	15,996.0
Dispatches per Month		1.0	15.9	6.2	81.0

Table 2. Estimation Results for all Covariates

Number of subjects =		11509			Number of observations =	91744
Number of failures =		5796			LR chi2(33) =	9131.93
Time at risk =		85491.16667			Prob > chi2	0.0000
Log likelihood =		-36861.838				
Analysis Time, _t		Hazard Ratio	z	P>|z|	[95% Confidence Interval]	
Pay Categories						
≤ $0.22		.6281642	-7.76	0.000	.5585515	.7064529
$0.26 - $0.30		.8535771	-3.06	0.002	.7712701	.9446675
$0.31 - $0.33		.6640386	-6.23	0.000	.5837282	.7553982
$0.34 - $0.37		.7247977	-3.03	0.002	.5886742	.892398
$0.38		.3721135	-2.78	0.005	.1855094	.7464226
> $0.38		.3520839	-2.52	0.012	.1563501	.7928555
Period 2		1.635389	3.42	0.001	1.234161	2.167059
Pay Categories	Period					
≤ $0.22	2	.5919686	-1.91	0.057	.3452775	1.014914
$0.26 - $0.30	2	.7152767	-1.84	0.066	.5002186	1.022794
$0.31 - $0.33	2	.9190286	-0.50	0.617	.6602729	1.279189
$0.34 - $0.37	2	.4475519	-4.45	0.000	.3140059	.6378947
$0.38	2	.6585846	-1.09	0.277	.3102715	1.397917
> $0.38	2	.9904281	-0.02	0.983	.4192111	2.339986
Mileage Category						
≤ 6,607 Miles		3.557538	29.93	0.000	3.273836	3.865825
9,316 – 11,019 Miles		.4649971	-12.70	0.000	.4131593	.5233388
> 11,019 Miles		.2758481	-15.45	0.000	.2342619	.3248169
Dispatch Category						
≤ 12 Dispatches		1.82219	13.86	0.000	1.673905	1.983611
17 – 19 Dispatches		.7945029	-3.84	0.000	.706409	.8935827
> 19 Dispatches		.6630896	-5.55	0.000	.5734898	.766688
Age Category						
21 – 25 year olds		1.139647	2.49	0.013	1.028377	1.262956
26 – 30 year olds		1.089005	1.77	0.076	.9910471	1.196645
31 – 35 year olds		1.043797	0.90	0.368	.9508243	1.14586
36 – 40 year olds		.9934101	-0.14	0.891	.9035465	1.092211
46 – 50 year olds		.9291177	-1.35	0.176	.8351844	1.033616
51 – 55 year olds		.9802367	-0.32	0.750	.8670496	1.1082
> 55 year olds		1.188261	2.56	0.010	1.041489	1.355718
Female		1.00586	0.09	0.925	.8908794	1.135679
Single		.9406548	-2.24	0.025	.8916789	.9923207
Crash Incidents		1.606692	12.51	0.000	1.491626	1.730633
Race						
African American		.8170283	-5.97	0.000	.7645429	.8731167
Other		.8375971	-3.04	0.002	.7472108	.9389171
Winter		.7619635	-9.42	0.000	.7200725	.8062915
Pay Raise		.6078683	-7.82	0.000	.536559	.6886546
			Stratified by Experience at Hire			

Table 3. Pay Categories Pay Regime One

	≤ $0.22	$0.23 - $0.25	$0.26 - $0.30	$0.31 - $0.33	$0.34 - $0.37	$0.38	> $0.38
≤ $0.22							
$0.23-$0.25	.6281642*** (.037644)		.8535771*** (.0441591)	.6640386*** (.0436731)	.7247977*** (.076926)	.3721135*** (.1321584)	.3520839*** (.145825)
$0.26 - $0.30	.7359197*** (.0530658)			.777948*** (.0565819)	.8491298 (.0922782)	.435946** (.1555201)	.4124805** (.1707649)
$0.31 - $0.33	.9459755 (.0785545)				1.091499 (.1261913)	.5603793 (.2013412)	.530216 (.2205541)
$0.34 - $0.37	.8666752 (.1015858)					.5134032* (.1892218)	.4857685* (.2058743)
$0.38	1.688099 (.6057442)						.9461734 (.514501)
> $0.38	1.784132 (.7439692)						
Statistical Significance:							
*** .01							
** .05							
* .1							

The table shows the hazard ratio for drivers of the various pay levels in the top row compared to the drivers of the other pay levels indicated in the column. The comparison is for pay rate categories in pay regime one for a 41 to 45 year old, white, married, male that drives between 6,608 and 9,315 miles per month that originated from 13 to 16 dispatched loads.

Table 4. Pay Categories Pay Regime Two							
	≤ \$0.22	\$0.23 - \$0.25	\$0.26 - \$0.30	\$0.31 - \$0.33	\$0.34 - \$0.37	\$0.38	> \$0.38
≤ \$0.22							
\$0.23 - \$0.25	.3718535*** (.0997458)		.6105437*** (.106596)	.6102705*** (.0943134)	.3243846*** (.0470822)	.2450682*** (.0360551)	.3487138*** (.3487138)
\$0.26 - \$0.30	.609053** (.1548411)			.9995524 (.1287206)	.5313044*** (.0626548)	.4013933*** (.0488139)	.57115258*** (.0702249)
\$0.31 - \$0.33	.6093258** (.1462997)				.5315423*** (.0448742)	.4015731*** (.03707)	.5714086*** (.0539851)
\$0.34 - \$0.37	1.146335 (.269181)					.7554866*** (.0547313)	1.075001 (.0806312)
\$0.38	1.517347* (.3614324)						1.422925*** (.1046209)
> \$0.38	1.066357 (.2552547)						
Statistical Significance:							
*** .01							
** .05							
* .1							

The table shows the hazard ratio for drivers of the various pay levels in the top row compared to the drivers of the other pay levels indicated in the column. The comparison is for pay rate categories in pay regime two for a 41 to 45 year old, white, married, male that drives between 6,608 and 9,315 miles per month that originated from 13 to 16 dispatched loads.

Table 5. Pay Category for New Hire Pay Regime Two

	≤ $0.22	$0.23 - $0.25	$0.26 - $0.30	$0.31 - $0.33	$0.34 - $0.37	$0.38	> $0.38
≤ $0.22							
$0.23 - $0.25					.5304951*** (.0315083)	.4007819*** (.0302793)	.5702827*** (.0448246)
$0.26 - $0.30							
$0.31 - $0.33							
$0.34 - $0.37							
$0.38							
> $0.38							
Statistical Significance:							
*** .01							
** .05							
* .1							

The table shows the hazard ratio for drivers of the various pay levels in the top row compared to the drivers of the other pay levels indicated in the column. The comparison is for a new hired driver in pay regime two that is 41 to 45 year old, white, married, male that drives between 6,608 and 9,315 miles per month that originated from 13 to 16 dispatched loads, to that of a similar new hired driver in pay regime one.

Table 6. Pay Categories for a Pay Regime One Driver that Received a Raise

	≤ $0.22	$0.23 - $0.25	$0.26 - $0.30	$0.31 - $0.33	$0.34 - $0.37	$0.38	> $0.38
≤ $0.22							
$0.23 - $0.25		.6078683*** (.0387001)					
$0.26 - $0.30			.6078683*** (.0387001)				
$0.31 - $0.33				.6078683*** (.0387001)			
$0.34 - $0.37			1.144106 (.1553431)	1.143593 (.1248982)	.6078683*** (.0387001)	.4592363*** (.040117)	.653459*** (.0600161)
$0.38			1.514396*** (.2193966)	1.513718*** (.1853479)	.844605** (.0842806)	.6078683*** (.0387001)	.8649512 (.0860003)
> $0.38			1.064283 (.1538247)	1.063807 (.1301617)	.5654583*** (.0590978)	.4271962*** (.0406006)	.6078683*** (.0387001)
Statistical Significance:							
*** .01							
** .05							
* .1							

The table shows the hazard ratio for drivers of the various pay levels in the top row compared to the drivers of the other pay levels indicated in the column. The comparison is for a 41-45 year old, white, married, male driver who drives between 6,608 and 9,315 miles per month and that originated from 13 to 16 dispatched loads who was hired in pay regime one and received a pay increase, compared to that of a similar new hired driver in pay regime two.

Table 7. Mileage Category Hazard Ratios				
	≤ 6,607 Miles	6,608 - 9,315 Miles	9,316 - 11,019 Miles	> 11,019 Miles
≤ 6,607 Miles		.2810933*** (.0119189)	.1307076*** (.0084189)	.0775391*** (.0067488)
6,608 - 9,315 Miles			.4649971*** (.0280422)	.2758481*** (.0229987)
9,316 - 11,019 Miles				.5932255*** (.0524304)
> 11,019 Miles				
Statistical Significance:				
***.01				
**.05				
*.1				
The table shows the hazard ratio for drivers of the various mileage levels in the top row compared to the drivers of the other mileage levels indicated in the column at the base levels of the remaining covariates.				

Table 8. Dispatch Category Hazard Ratios

	≤ 12 Dispatches	13 – 16 Dispatches	17 – 19 Dispatches	> 19 Dispatches
≤ 12 Dispatches		.5487903*** (.0237664)	.4360155*** (.0271926)	.3638971*** (.0278836)
13 – 16 Dispatches			.7945029*** (.0476395)	.6630896*** (.0491135)
17 – 19 Dispatches				.8345968*** (.066048)
> 19 Dispatches				
Statistical Significance				
***.01				
**.05				
*.1				

The table shows the hazard ratio for drivers of the various dispatch levels in the top row compared to the drivers of the other dispatch levels indicated in the column at the base levels of the remaining covariates.

Table 9. Low Pay Event Hazard Ratios

6,608 - 9,315 Miles	≤ 6,607 Miles combined with > 19 Dispatches			
≤ 12 Dispatches		.7724526*** (.0765558)		
13 – 16 Dispatches		.4239145*** (.0369585)		
17 – 19 Dispatches		.3368013*** (.0299297)		
9,316 - 11,019 Miles				
≤ 12 Dispatches		.3591882*** (.0431037)		
13 – 16 Dispatches		.197119*** (.0214235)		
17 – 19 Dispatches		.1566116*** (.0163984)		
> 11,019 Miles				
≤ 12 Dispatches		.2130796*** (.0299138)		
13 – 16 Dispatches		.116936*** (.0153396)		
17 – 19 Dispatches		.092906*** (.0117723)		
Statistical Significance:				
***.01				
**.05				
*.1				

The table shows the hazard ratio for the low pay event driver in the top row compared to the combined mileage and dispatch levels in the column at the base levels of the remaining covariates.

CHAPTER 2 PAY AND SAFETY: A PROPORTIONAL HAZARDS APPROACH TO SAFETY IN THE TRUCKLOAD SECTOR OF THE MOTOR CARRIER INDUSTRY

1. Introduction

Background

The Motor Carrier Act of 1980 ushered in an era of profound changes in the motor carrier industry. The economic regulations that existed were replaced by market forces, whereby the common carrier general freight motor carrier industry in a relatively short period of time fragmented into the truckload (TL) and less than truckload (LTL) industry sectors. The removal of entry controls that resulted from the Interstate Commerce Commission's (ICC) new interpretation of the "public convenience and necessity" doctrine (Moore 1983), in conjunction with the ability of the new firms to now adjust prices and services in accord with market forces, unleashed a wave of new motor carriers into the industry.

A large number of the new entrants in the motor carrier industry were small TL carriers (McMullen 2005; Burks & Guy 2012) that owned one to a few trucks that were previously employed under an existing firm's route certificate (McMullen 2005; Grawe 2008). In 1981, following the enactment of the MCA, there was a surge of just over 4000 new entrants into the industry (Moore 1983, 1986), and by 1986 there was an increase of roughly 19,000 new carriers, in addition to the approximate 18,000 carriers that existed in 1980 (Corsi & Fanara 1989; Grawe 2008). The elimination of the patchwork of former route certificates enabled new entrants to "cream" TL shipments (Belzer 2000) from the existing common carrier sector, leaving primarily LTL shipments to the remaining firms. The LTL sector found fewer and fewer firms competing for carriage (Boyer 1993; Corsi 1993; Belzer 2000; Burks & Guy 2012); the TL sector saw a marked increase in competition for carriage and most nearly replicates a competitive market (Burks & Guy 2012). The new carriers aided by the ability of freight brokers to find carriage (McMullen 2005) enabled small motor carriers to effectively compete with the largest motor carriers for carriage where the marginal carrier's cost of production for the next shipment greatly influenced the price charged for carriage in the market.

The market segmentation into TL and LTL industry sectors (Belzer 1995, 2000; Burks & Guy 2012) that resulted from deregulation, coincident with the 1979 through 1982 recessionary period (Belman & Monaco 2001), lowered motor carrier freight rates (Moore 1983) whereby overall wages were reduced; moreover, the labor force was effectively segmented in the motor carrier industry. In conjunction with the labor market segmentation, the consolidation of the LTL sector and the burgeoning TL sector effectively reduced overall union coverage in the motor carrier industry (Rose 1987; Hirsch 1993; Belzer 1995; Belman & Monaco 2001). The level of unionization in the motor carrier industry has significantly declined after the passage of the Motor Carrier Act of 1980 (Belzer 2000; Belman & Monaco 2001; Henrickson & Wilson 2008; Burks & Guy 2012) and union density is currently 10.2% (Hirsch & Macpherson 2014). The decentralized nature of the TL segment, combined with the difficulty of organizing within the National Labor Relations Act as amended, precluded the union from actively recruiting new membership. As a result of the economic deregulation, the current logistics of TL carriage places a significant level of disutility on TL drivers' work experience. As market forces began to affect the TL sector of the motor carrier industry, prices paid for freight carriage began to fall, eroding margins of TL motor carrier firms. Issues of safety quickly rose to the forefront of discussion among policymakers, researchers, and the general public that continues today.

Some industry pundits, academics, and researchers contend that there has been a decline in overall safety levels in the industry; however, a significant number of others contend just as fervently that safety has appreciably increased since the passage of the Motor Carrier Act of 1980 (Kraas 1993). After the passage of the Motor Carrier Act of 1980, especially in the years of 1985 and 1986, there was a sharp increase in the number of crashes in the motor carrier industry . Recent data published in the Federal Motor Carrier Safety Administration's Large Truck and Bus

Crash Facts 2012 reveals the number of fatal crashes, the number of vehicles involved in a fatal crash per 100 million vehicle miles traveled (VMT), fatal crashes per 100 million VMT, and fatalities per 100 million VMT have all trended down through 2009; while the number of large trucks[4] registered and the number of vehicle miles traveled has increased over the same time period[5]. However, recent releases of crash statistics reveal that there has been a surge in fatal crashes involving large trucks (FMCSA 2014; NHTSA 2014a, 2014b). Since the end of the Great Recession in 2009, the trend in the number of large truck crash fatalities has increased 25% from 1.17 per 100 million VMT to 1.46 per 100 million VMT in 2012[6], while automobile crashes have continued a downward trend and have declined to a historic low level of 1.1 per 100 million VMT (NHTSA 2014b). The high profile nature and coverage of a select few large truck crashes and fatalities by the media has increased public awareness for the need for continued improvements in safety levels in the motor carrier industry. For this reason, crashes are a serious problem for TL motor carriers and have a deleterious effect on the motor carrier firms and on society as a whole.

Crashes, from the motor carrier's perspective, are extremely costly and increase the costs imposed on society (Saltzman & Belzer 2002). Although this list is not exhaustive, the increase in costs due to crashes include vehicle down time, higher insurance rates, reduced customer service for the carrier (LeMay *et al.* 1993; Suzuki *et al.* 2009); and the external cost imposed on society resulting from property damage, productivity loss, and loss of life that exceed the limits of current insurance regulations (Saltzman & Belzer 2002). The average cost of a crash for all large trucks was estimated to be $91,112.00 in 2005 dollars (Zaloshnja & Miller 2007). Importantly, the average cost for a heavy duty truck crash was $171,710 when the injuries to the victim were non-incapacitating (Zaloshnja & Miller 2007). When the injuries were incapacitating for the victim, the

[4] Large trucks are vehicles with a gross vehicle weight rating (GVWR) greater than 10,000 pounds.
[5] Large Truck and Bus Crash Facts accessed at http://www.fmcsa.dot.gov/safety/data-and-statistics/large-truck-and-bus-crash-facts-2012, accessed on April 10, 2015.

[6] Authors calculation based on data contained in Table 4 in Large Truck and Bus Facts 2012, accessed on April 10, 2015.

costs increased to $437,845; moreover, the average cost per crash dramatically increased to $3,833,721 when there was a fatality involved in the crash (Zaloshnja & Miller 2007), far above the Federal Motor Carrier Safety Administration's (FMCSA)regulated minimum liability insurance of $750,000. The FMCSA estimated the cost of all 2012 fatal injury crashes to be $40 billion, and with the inclusion of all truck and bus crashes the estimate increases to $99 billion, in 2012 dollars (FMCSA 2014). Currently, the FMCSA pursues the mission of eliminating fatalities in the motor carrier industry and are intent on eliminating crashes.

Motivation

A typical TL motor carrier driver can expect to work long and irregular hours in the delivery of freight. Although these hours are limited by hours of service (HOS) regulation, drivers frequently report working considerably more hours than allowed by the law (Stephenson & Fox 1996; Belzer 2000; Kemp *et al.* 2013). The demands of driving are exacerbated by the loading and unloading operations carried out by the drivers, often times without adequate compensation similar to what they earn while driving (Belzer 2000). Drivers have reported that the compensation is not adequate for the long hours and extended periods away from home (Rodriguez & Griffin 1990). Some argue that truckload drivers experience "sweatshop" working conditions. However, in this case, the drivers are "sweating" their own labor, whereby they earn a subsistence level of pay, work extremely long and irregular hours, and experience working conditions that are not conducive to their overall good health, or the health of the industry (Belzer 2000). The disutility endured by the drivers in the TL sector, in combination with low pay levels, contributes to higher crash rates in the TL sector of the motor carrier industry.

In the movement of freight, TL motor carrier firms must choose the cost minimizing amount of capital and labor inputs in order to deliver shipments of freight in a manner that is most efficient and cost effective to the firm. This requires the firm to have equipment and drivers strategically located in order to affect these movements. The labor choice for motor carriers considers the overall price of "effective labor" that includes the total cost to the firm for hiring and employing labor (Burks *et al.* 2008). The driver's effective labor consists of the original cost to recruit and train a driver; the operational costs of creating the best working conditions for the driver; the cost of insurance and crashes that the firm incurs from selecting certain types of drivers; and the actual compensation paid to the driver including any compensating differential for the drivers that operate under the worst of conditions. The TL driver's effective labor has emerged in the TL sector as being characterized by high turnover levels, high rates of crash incidents, and low to non-existent compensating differentials being paid to the drivers (Burks *et al.* 2008). The entrenchment of the model in the TL sector of the motor carrier industry has witnessed few firms exploiting the cost tradeoffs that could be afforded in the price of their drivers' effective labor.

The objective of the cooperating firm was to become a world class provider of transportation, supplanting their tarnished image in the TL motor carrier industry. To fulfill this goal, the firm initiated a new managerial culture where managers and supervisors were to take responsibility for being more attentive to safety issues and to recognize the issues of their drivers, turning attention to stabilize their workforce. To accomplish this task, the firm raised the per mile rate of pay for the drivers that remained in their employ on the average of 37%, and substantially increased the per mile rate of pay for their new hires who were safe and experienced drivers. The underlying objective was to pay the drivers a higher wage that was significant enough to attract and retain the most experienced drivers in the TL sector, where the increase in pay eroded the disutility of the TL driving job and thereby reduce the number of crashes sustained by the firm. In other words, the cooperating firm moved from the model of high crash incidence and low wages, to the untried model of low crash incidence and high wages[7].

In addition to increasing wages, to the highest in the industry, the firm completely remade the corporate culture by enhancing the benefit package of the drivers. The firm increased the

[7] The cooperating firm's internal documentation acknowledges the tradeoff of effective labor and discusses appropriate remedies summarized in this paragraph.

amount of home time earned with a 100% guarantee to be at the home terminal by the date requested by the driver with a minimum of fourteen days notice; implemented a new recognition program in order to restore driver dignity and accountability; and reduce tractor age and increase maintenance schedules, among many other remedies[8]. Hiring experienced and safe motor carrier drivers who are paid a higher starting wage, as well as other motor carriers that are dedicated to increasing driver compensation, will retain valued employees longer and will attract a larger pool of qualified applicants from which firms can hire drivers that possess the necessary human capital required to operate a large commercial motor vehicle, thereby improving overall safety levels and reducing crashes sustained by the firm.

To investigate the above statement, the current research will employ a Cox proportional hazards model to build upon the previous work of Belzer et al. (Belzer *et al.* 2002) and Rodriguez et al. (Rodríguez *et al.* 2006). The Cox proportional hazards model is appropriate when the dependent variable in the analysis is a measure of the time to a single event or multiple events; in this research the time until a driver experiences a crash incident is the variable of interest where some of the drivers experience multiple crashes. Further, in research where the data are right censored, a significant number of drivers do not experience the event of interest, and interest only in the effect of the covariates on the time to the event warrant the utilization of the Cox proportional hazards model. To build upon the prior research employing the cooperating firm's data, the current research disentangles the affects of pay, the affects of driver experience, and the new management regime's affects on the driver crash rate of the cooperating firm that was not considered in the prior research, controlling for various demographic and operational covariates. The expectation is that a more experienced driver workforce who is earning a higher rate of per mile pay, in conjunction with an improved management team will reduce the crash rates of the firm.

[8] The cooperating firm's internal documentation.

2. Literature Review

Truck driver compensation methods vary from being paid a piece-rate per mile driven, on a percentage of the value of the load being hauled, or an hourly wage rate. Further, the entire benefit of compensation can include health insurance, safety bonuses, retirement packages, as well as many other financial incentives that a motor carrier may offer to their drivers. With regards to a truck driver's method of compensation, there are relatively few papers that research the link between a driver's compensation to the driver's overall safety performance. One position in the literature attempts to find a relationship between a firm's financial health and its affect on the firm's safety outcome. An indirect result of this research has been to demonstrate the driver's compensation effect on safety outcomes. The more relevant position considers the literature where the research has directly investigated the affect of driver's compensation on safety outcomes. The purpose of this section is to review the identified literature that has demonstrated the relationship between the driver's compensation and driver safety performance germane to the current research.

Indirect Research of Pay and Safety

Exploring the effects of deregulation in the motor carrier industry, Kraas obtained data from a 1989 California Highway Patrol (CHP) fact sheet for truck at fault statistics. In the absence of firm data, Kraas used drivers' real wages to proxy the profitability of motor carriers; carriers that were in better financial health were assumed to pay their drivers more in compensation. Over time, Kraas found that safety, in terms of the crash rate, has declined independently of the other variables in this particular research and that the real wage after deregulation has become a significant predictor of crash rates. As real wages fall from increased competition or decreased firm profitability, overall crash rates will increase (Kraas 1993).

Corsi et al.'s goal, as part of their analysis, was to determine if a relationship existed between a firm's safety performance, measured by driver and vehicle evaluations carried out in roadside inspections, and a firm's financial health with respect to commonly accounted financial measures. Corsi et al. segmented the data by carrier type and performed a correlation analysis on the collected data. Corsi et al. find that there is a statistically significant negative correlation between the driver's safety measure and the driver's wages as a percent of operating expenses (Corsi 2002); moreover, the vehicle safety measure is negatively correlated with driver's wages as a percent of operating expenses. Corsi et al.'s conclusion is that carriers will attain better driving and vehicle safety scores when the carrier expends a larger percentage of their operating expenses on wages (Corsi 2002). Prior research suggests that motor carriers with high violation rates found during roadside inspections have a crash rate that is 30% higher than those carriers that have favorable roadside inspections (Moses & Savage 1996).

Rodriguez et al. 2004 combine three data sources compiled at the firm level to construct the variables for driver compensation, a firm's financial status, and variables for the various occupational demands placed upon the drivers. The researchers amended the data to include the number of power units operated by each of the carriers in the data set. Ultimately, 60 TL motor carrier firms that paid drivers by the mile driven remained in their analysis. Rodriguez et al., due to the limited number of observations in the data set, estimated a series of three separate regressions that include various variables to determine if the operating ratio, the cash flow ratio, or the labor cost ratio, all measures of the financial health of the motor carriers, have an effect on the safety outcomes of the motor carriers. Across all three of the financial data models, the control for unpaid driver working time has a statistically significant effect on safety outcomes. A 10% increase in a workers unpaid working time will increase crashes by 2.3% (Rodriguez *et al.* 2004). Although pay rate is not statistically significant in the models, the compensation variables were included in the modeling process as a block, and the resultant test of significance on the block of variables indicates that the variables are statistically different from zero and should be included in the model. Further, the researchers computed elasticity where a 10% increase in the labor cost ratio, representing a higher pay percentage for drivers compared to the firm's revenue stream, reduces crashes by .6

percent; increased liquidity and appropriately having the ability to pay drivers higher wages as a percent of revenue reduces overall crashes (Rodriguez *et al.* 2004).

Building upon the work of Corsi et al. (Corsi 2002), Britto et al. wants to establish statistical evidence that a motor carrier's financial health is linked to that firm's safety performance. Britto et al.'s data set consists of 657 carriers in all major motor carrier industry segments. Importantly, 86% of the 657 carriers in this study are truckload motor carriers. A key point of Britto et al.'s analysis is the use of average driver wages as a control variable in the three regressions in this study; moreover, in all three regressions, Britto et al. finds a statistically significant relationship between the driver safety performance score, the vehicle safety performance score, and total reported crashes from SafeStat and average driver wages. Improved driver safety and vehicle safety indicate that motor carriers that pay higher wages on average experienced fewer driver and vehicle regulatory violations and have improved safety performance; the implication is higher average wages paid to drivers lowers the firm's overall crash rates (Britto *et al.* 2010).

Direct Research of Pay and Safety

Monaco and Williams utilize a survey conducted by the University of Michigan Trucking Industry Program (UMTIP) that was carried out during the summer and fall of 1997. The depth of the survey allowed for a much richer understanding of the vast number of characteristics that contribute to truck crashes. Monaco and Williams found that the way in which a driver is paid has a statistically significant effect on the probability of that driver having a crash incident. For example, if a driver were to receive a $.10 per mile raise, his/her probability of experiencing a crash incident falls by 1.76%; moreover, if drivers are paid an hourly rate, they are 10.2% less likely to have been involved in a crash incident (Monaco & Williams April 2000). The most notable result in Monaco and Williams' research is the increased significance of occupational variables over demographic variables, particularly the method in which a driver is paid. Those drivers that receive a higher effective per mile rate of pay have a reduced incidence of a crash and are less likely to have logbook or moving violations (Monaco & Williams April 2000). .

Belzer et al.'s research objective is to examine the relationship between the various compensation practices of motor carrier firms and the resulting behavior of the drivers employed by those motor carriers. To understand the relationship between compensation and safety, Belzer et al. employ three distinct data sets and carry out three separate analyses. In Safety Study One, the compiled data was utilized to create the control for unpaid time variable used in the analysis; moreover, unpaid time has a mean value of .004 hours per mile driven, which translate into approximately 3.6 hours of unpaid work on a 906 mile average delivery trip (Belzer *et al.* 2002). The calculated elasticity for the relevant compensation control is -.52. The implication of the mileage pay elasticity is that a 10% increase in the drivers pay rate per mile will result in a 5.2% reduction in crashes (Belzer *et al.* 2002). The calculated elasticity for safety bonus is -.10, whereby a 10% increase in the bonus will lead to a 1% reduction in the number of crashes (Belzer *et al.* 2002).

In Safety Study Two in the same report, Belzer et al. employs a unique driver level data set from J. B. Hunt, a large US truckload carrier. The relevant compensation controls are base pay and percent pay increase. The reported result for a one penny increase in a driver's base pay suggests a reduction in the probability of a crash by approximately 11 percent; further, a 10% increase in the level of the drivers pay reduces crash risk by 6% (Belzer *et al.* 2002).

In Safety Study Three of the same report, an analysis of the University of Michigan Trucking Industry Program (UMTIP) truck driver survey results in a statistically insignificant overall model with significant variables. Belzer et al. concluded that the trend of the model is similar to the trend of the other models in their overall analysis and still provides useful insight into the relationship between compensation and safety; a 10% increase in the driver's mileage rate from 29.5 cents per mile to 32.4 cents per mile reduces the probability of a crash from 13.8% to 10.86%, a significant decrease of 21% in the overall probability of a crash (Belzer *et al.* 2002). Overall, Belzer et al.'s extensive examination of driver's compensation and safety outcomes reveals that truck driver compensation is an extremely strong predictor of a truck driver's safety performance.

Rodriguez et al. 2003 is motivated to understand the underlying structural factors of a driver's behavior that contribute to a truck crash that builds upon the evidence suggested by Belzer et al. 2002. Rodriguez et al. 2003 find that occupational factors, specifically the rate of pay, in addition to tenure on the job, influence safety outcomes, in terms of crashes, significantly more than demographic factors (Rodriguez *et al.* 2003). Additionally, their results suggest that if the driver were to receive a one cent per mile increase in pay that the driver's expected crash count would fall by 8.15 percent; moreover, when the model is estimated at the mean rate of pay, $.30 per mile, the estimation results in elasticity measurement of -2.47, implying that if the driver's pay rate increases by 10% there is a resulting 24.7% decline in overall crash count. When the model is standardized, the model validity is unchanged; however, the estimated coefficients must be interpreted in units of standard deviation. Therefore, when a drivers pay is increased from $.307 per mile to $.37 per mile, a one standard deviation change, there is an associated 43.6% decrease in the expected crash count (Rodriguez *et al.* 2003).

The prior research of Belzer et al. 2002 and Rodriguez et al. 2003 indentifies the importance of compensation as an influencing factor on motor carrier safety in terms of reduced crash incidence and reduced crash risk. What are not clear, however, as Rodriguez et al. 2006 suggest, are the causal pathways on how pay actually influences safety outcomes. Their research objective in this study was to disentangle the direct effect of pay on safety outcomes from the indirect effect. The indirect effect refers to the ability of the motor carrier firms to attract and retain employees that will allow for the employee to accumulate human capital and as a result, the firm will experience improved safety outcomes, as measured by the number of crashes (Rodríguez *et al.* 2006). In the crash model, the control variable for the driver's pay at his/her time of hire, Basepay, was not statistically different from zero. The control variable, Newpay, a driver's pay level after a raise is received, suggests that a 1% increase in a driver's pay rates reduces a driver's crash probability by 1.33%. The result of the modeling was that Rodriguez et al. 2006 were unable to disentangle the aforementioned causal path, specifically the indirect path of human capital accumulation controlled by Basepay in the model.

3. Model

To explore the relationship between the driver's pay rate and the rate at which a driver experiences a crash incident, the current analysis will employ time to an event analysis, or survival analysis to estimate a driver's hazard function following the prior work of Belzer et al. and Rodriguez et al. (Belzer *et al.* 2002; Rodríguez *et al.* 2006). The hazard function is semi-parametric as a direct result of the fact that the baseline hazard function, $h_0(t)$, the error component of the regression model, is not estimated following Cox (Cox 1972). The systematic component of the hazard function is parameterized to be the exponential function. The hazard function, measuring the instantaneous rate of a driver crash, is required to take on only positive values and the choice of the exponential function as the parameterization assures that conditional requirement. With the exponential function chosen for the model's systematic component, the hazard function becomes,

$$h(t, x) = h_0(t) \exp(x(t)'\beta). \tag{1}$$

In the data set supplied by the firm, there are multiple observations on each of the individual drivers that are measured on monthly time intervals. Denote,

$$x_{lk}(t_i) = (x_{l1}(t_i), \ldots, x_{lp}(t_i))', \tag{2}$$

to be the measured value of the K^{th} covariate, $K = (1, 2, \ldots, P)$, for each of the individual l drivers where $l = (1, 2, \ldots, n)$ at each time t_i. The given definition of $\boldsymbol{x}(t)'$ above allows an individual's covariate to vary for each of the successive monthly measurements to accommodate the covariates that vary from month to month. To compare the crash rate of different drivers, or different groups of drivers, the hazard ratio, also known as the relative risk ratio, is formed from individual hazard functions as,

$$HR(t,x) = \frac{h_0(t)exp\beta_0\exp(x_1(t_i)'\beta)}{h_0(t)exp\beta_0\exp(x_2(t_i)'\beta)} \quad (3)$$

$$= \exp(\beta(x_1 - x_2))\,. \quad (4)$$

The coefficient β is estimated by maximizing the partial likelihood function from the cooperating firm's data following Cox's work on equation one (Cox 1972).

To estimate the parameter β by maximizing the partial likelihood function it is assumed that the baseline hazard function, $h_0(t)$, is an arbitrary function of time. On the intervals for which there are no failure times, drivers experiencing a crash, the baseline hazard function may take on values equal to zero that do not contain any information on the parameter β (Cox 1972). Only at the ordered driver crash times r, where $r = t_1 < t_2 < \cdots < t_r$ is the set of crash times, is the probability of an individual driver sustaining a crash on the interval $[\,t_i, t_i + \Delta t_i)$ conditional on the fact that the driver did not crash at the time just before he/she actually crashed. Assuming that driver right censoring is independent, the probability that driver j sustains a crash at time t_i is given by,

$$L_j(\beta) = \frac{h(t_i, x_j)\Delta t_i}{\sum_{l\in R(t_i)} h(t_i, x_l)\Delta t_i}, \quad (5)$$

where $R(t)$ is the set of drivers at the firm that are still under observation (Kalbfleisch & Prentice 2002); the set of drivers at the firm that have not sustained a crash or are uncensored at the time that driver j crashes. In the above equation, $h_0(t)\Delta t_i$ cancels and the simplified expression becomes,

$$L_j(\beta) = \prod_{j=1}^{r} \frac{\exp(x_j(t_i)'\beta)}{\sum_{l\in R(t_i)} \exp(x_l(t_i)'\beta)}\,. \quad (6)$$

The model is further stratified into s strata, where $s = (1, 2, \ldots, q)$, by driver experience at hire, whereby the above expression becomes,

$$L(\beta) = \prod_{s=1}^{q} \prod_{j=1}^{r_{(s)}} \left[\frac{\exp\left(x_{j(s)}\left(t_{j(s)}\right)' \beta\right)}{\sum_{l_{(s)} \in R_{(s)}(t_{j(s)})} \exp\left(x_{l(s)}\left(t_{j(s)}\right)' \beta\right)} \right], \tag{7}$$

the partial likelihood function to be maximized over β, from which the inferences will be made (Kalbfleisch & Prentice 2002). It is the partial likelihood function in the sense that the actual censored and uncensored survival times are not used in the estimation of β (Collett 2003).

4. Empirical Analysis

Data

The cooperating firm is a large TL motor carrier that hauls general freight in the U.S. The proprietary data supplied by the firm for the current research consists of 87,887 driver observation months that includes driver demographic and operational covariates, considering 11,457 drivers in their random over the road irregular route truckload division. In addition to the standard operational covariates of driver mileage and dispatches per month, information on a driver's prior driving experience before hire, crashes each driver sustained per month, and the month that a driver, if appropriate, exits the firm's employment is included in the data set. The drivers are observed during two time periods; referred to henceforth as pay regime one for the first observation time period, and as pay regime two for the second observation time period. Pay regime one, thirteen months of observation, commenced on September 1, 1995 and ended on September 30, 1996, which corresponded with the firm's formal announcement of the aforementioned impending corporate changes. Observation for pay regime two continued from February 1, 1997, the month that the drivers remaining in the firm's employment received a per mile pay increase and newly hired drivers fulfilled the firm's new hiring objective, and completed on February 28, 1998, thirteen months of observation. No data, except the hire dates of the drivers hired in the intervening period for pay regime two employment, are observed during the intervening four month period. Selected statistics for the entire data set are shown in Table 1.

Table 1 Here

Methodology

The modeling approach employed in the current analysis fulfilled two primary objectives. The first objective is to build on the previous work of Belzer et al. 2002 and Rodriguez et al. 2006, improving on their model specification where similar data is utilized for use as a future reference; the second objective is to utilize the data in such a way that corresponded to the firm's intent, as gleaned from the supplied internal documentation on the data. The analysis will model time to a driver's crash, employing what is understood from past research on demographic and operational covariates constrained by the supplied data set. In this data, there is no distinction as to whether each crash incident involved only the freight being carried, only the tractor or trailer, other pedestrian or road user vehicles, property damage, or any combination of these various types of incidents; moreover, it is unknown whether each particular driver crash was preventable or unpreventable. The independent covariates were further categorized to fulfill the aforementioned objectives.

The categorization of the covariates in the current analysis accomplished several important functions. In the prior analysis of Belzer et al., the driver's pay rate entered into the model as a continuous covariate accompanied by a continuous covariate for the percent increase in the base pay level for those drivers that received a pay raise at the beginning of pay regime two; moreover, age and tenure were additionally included as continuous covariates with a specified functional form (Belzer *et al.* 2002). Although significant, no distinction can be drawn between the drivers that the firm targeted for hire in pay regime one and pay regime two. Separating the pay rate into the various categories allows for the comparison of crash rates for new hires in pay regime one to the crash rates of new hires in pay regime two, the primary intent of the firm, and similarly for other covariates. Further, categorization does not force a specified functional form on the covariate of interest, in particular age and tenure, affecting inference of the results if the incorrect functional form is chosen; and categorization aids in the correction of nonlinearities if the covariate appear nonlinear in the data. Importantly, categorization restores proportionality of the covariates of interest required during the modeling process, thereby improving the model specifications. Further, tenure was removed from the analysis simply because the model is specified from the hiring date of the driver to the time of the crash incident, essentially a tenure time model. For the aforementioned reasons, all of the covariates were categorized based on the details outlined in the supporting documentation and descriptive analysis.

The stated goals of the cooperating firm, in conjunction with the internal documents supplied by the firm, were utilized to further categorize the data to aid in correctly disentangling the affect of pay, the affect of the driver's experience at hire, and the affect of the managerial improvements on a driver's crash rate. In pay regime one, the firm primarily paid drivers $.23 per mile to $.25 per mile. These were the rates paid to the predominantly inexperienced commercial motor vehicle drivers hired in pay regime one to be trained by the firm and are the pay rates that comprise the base pay category of pay rates utilized in the regression analysis. In pay regime two, the target pay rate of the firm was identified as $.38 per mile; the pay rate according to the internal documentation that corresponds to the average experience level of drivers hired during pay regime two. In total, the driver's pay rate was separated into seven distinct pay categories based on the above information, the remaining distribution of the pay rate data, and proportionality in the model. The operational covariates of mileage per month and dispatches per month were separated into four distinct categories that approximated 25% of the observations in each of the categories; the mileage category for 6,608 to 9,315 miles per month and the dispatch category for 13 to 16 dispatches per month were chosen as the base category in the regression analysis because the mean of those covariates fall within the categories, respectively. Driver baseline age, the age of the driver when he/she was first observed in the data, is categorized into seven, five year, categories beginning with age 21, the minimum age at which a driver can become a commercial motor vehicle driver. The eighth, and final, age category represents all of the drivers that had a baseline age greater than 55 years old. The category of drivers aged 41 to 45 years of age is the base category in the analysis. Driver race was categorized into the three groups; Caucasian, the predominant race in the data and the base category for analysis, African American, and other, which consists of Indian, Asian, and Latino drivers, among others. The remaining covariates of period, gender, marital status, pay raise, and winter (the months of December through March) are categorized as zero one indictor covariates.

In the resulting model, the period covariate is the control employed in the analysis for the change in the managerial practices in the two observation periods. The pay categories were then interacted with the period covariate to control for the affect that the management change had on a driver's pay rate during each of the observation periods. Further, it was found in preliminary analysis that the inexperienced drivers at hire have different baseline hazard functions when compared to the experienced driver at hire and the model was therefore stratified on the driver's prior experience at the time of their hiring.

5. Results

As hypothesized, the findings of this research, shown in Table 2, reveal that higher rates of pay for a driver lead to lower crash rates, a result similar to the prior results of Belzer et al. and Rodriguez et al. (Belzer *et al.* 2002; Rodríguez *et al.* 2006). Further, these results coincide with the findings of Monaco and Williams, whereas the operational covariates are more significant at predicting driver crash rates than demographic covariates (Monaco & Williams April 2000). Controlling for all available covariates in the analysis, the control for the managerial change indicates that drivers in pay regime one experience a crash rate that is similar to a drivers' crash rate in pay regime two; management changes were found to have a statistically insignificant affect on driver crash rates, support against the hypothesis that the management's changes would reduce crash rates. A driver that experienced higher driving mileage per month crashed at lower rates than a driver with lower mileage per month. Although Belzer et al. measured mileage differently than in the current analysis where monthly miles driven per month entered their analysis continuously and a term is included for the average miles driven to date , Belzer et al. found that higher mileage driven per month leads to lower crash rates (Belzer *et al.* 2002), similar to the current results; and similarly Rodriguez et al. find that drivers with higher miles per month have lower crash rates (Rodríguez *et al.* 2006). Contrary to intuition, when a higher number of dispatches are received by a driver each month, there is no statistically significant affect on driver crash rates, confirming Belzer et al.(Belzer *et al.* 2002) and Rodriguez et al. (Rodríguez *et al.* 2006) results. Further, a driver that received a pay increase crashed at a rate that is not statistically different from a driver that did not receive a pay increase; Belzer et al. employ a covariate for the percentage change in a driver's pay from an increase in pay that estimates a statistically significant decrease in driver crash risk (Belzer *et al.* 2002); Rodriguez et al. employ a linear and a squared term and report that increases in pay above a driver's base pay reduce crash probability at a decreasing rate (Rodríguez *et al.* 2006). The seasonal covariate for the winter months suggests that drivers' crash at approximately 14% more during the winter contradicting the result reported in Belzer et al. (Belzer *et al.* 2002); whereas Rodriguez et al. do not find a statistically significant winter effect in the subset of data (Rodríguez *et al.* 2006).

Table 2 Here

The primary demographic covariate controlled for in the analysis was driver age. Young drivers, age 21 to 25 years old, drivers aged 26 to 30, drivers aged 31 to 35, and the two driver age groups above 50 years old crash at a statistically significant, different rate than the base age group of drivers. Unexpectedly, the younger age groups crash at a modestly lower rate than the base group drivers aged 41 to 45 years old, 12% less on average; whereas the 51 to 55-year-old drivers and the drivers older than 55 crash at a rate higher than the base group drivers, 13% and 30% respectively. The remaining driver age groups crash at rates that suggest they are not statistically different from the base age group of 41 to 45-year-old drivers. This result contradicts prior research. Belzer et al.'s prior finding is that a driver's crash rate decreases until age 41 where crash risk begins to increase (Belzer *et al.* 2002) and Rodriguez et al. find that crash risk decreases at an increasing rate (Rodríguez *et al.* 2006); moreover, the results of Cantor et al. and Green and Blower are contradicted where younger drivers experience higher crash rates than older drivers (Cantor *et al.* 2010; Green & Blower August 2011). The effect of race on crash rates is mixed; African American drivers in this analysis crash at rates 17% higher than Caucasian drivers and other races are not statistically different from Caucasian drivers. Belzer et al. find that Caucasian drivers crash at less than half the rate of other races (Belzer *et al.* 2002); Rodriguez et al. find that Caucasian drivers crash at a 30% lower rate than other races (Rodríguez *et al.* 2006). Single drivers crash at rates that are 14% higher than their married counterparts; whereas Belzer et al. finds that single drivers are safer (Belzer *et al.* 2002). Monaco and Williams find that drivers who are separated, widowed, and divorced are 8.9% safer than their single counterparts (Monaco & Williams April 2000). There is no statistical difference between the male and female crash rates, coinciding with Belzer et al.'s, Rodriguez et al.'s, and Monaco and Williams' prior findings (Belzer *et al.* 2002; Rodríguez *et al.* 2006; Monaco & Williams April 2000); however, Cantor et al. find that males are more likely to be involved in future crash incidents than female drivers (Cantor *et al.* 2010).

6. Discussion

The primary objective of this research, given the current design of the pay categories, controlling for the demographic and the operational covariates contained in the data, was to allow the researcher to examine and compare the crash rate of the firm for the various driver groups targeted by the cooperating firm. The current methodology departs from Belzer et al.'s and Rodriguez et al.'s in significant ways. Importantly, the current analysis created categories based on internal documentation to explore the relative risk of driver groups targeted by the firm. The categories chosen aided in smoothing any nonlinearities that may have existed in the data maintaining the integrity of the firm's objectives without forcing a specific functional form onto the data. As in the case of age in the analysis, the above methods have led to contradictions in the results. Further, categorizing the data restored proportionality to the key covariates of interest, pay and age, which was a key aspect of the current modeling process. Pay and age were not proportional in the prior research conducted by Belzer et al. (Belzer *et al.* 2002).

During pay regime two, higher paid drivers crash at rates less than their lower paid counterparts, see Table 3; the same result is shown for pay regime one in Table 2. Table 3 shows the hazard ratios for drivers in the various pay levels in the top row relative to the drivers of other pay levels indicated in the column of the table during pay regime two. For example, a driver who earns \$0.38 per mile crashes at a rate that is 59% less than the base group driver who earns \$0.23 to \$0.25 per mile; moreover, in all cases except two where drivers are paid a higher per mile rate relative to their lower paid counterparts, there is a statistically significant decrease in crash rates. In the two remaining cases, the crash rates in those pay groups are not statistically different. Intuitively this is reasonable for small differences in pay per mile. A driver who is paid \$0.39 per mile might not be different from the driver who is paid \$0.38 per mile; similarly drivers who are paid \$0.31 relative to drivers paid \$0.30 per mile are not significantly different. Further, the lowest paid drivers are an anomaly during pay regime two, where the analysis indicates that the lowest paid drivers crash at rates that are not statistically different from the other driver groups; however, the magnitude of the hazard ratio estimate increases, implying higher relative crash rates for the lower paid drivers when compared to drivers with higher levels of per mile pay. Overall, the comparison of drivers in the same pay regime reveals what was expected, is intuitively known, and has been presented in the prior literature; the higher the level of pay, the lower the crash risk. This research further demonstrates that crash rates across pay regimes were reduced by the cooperating firm's experiment.

Table 3 Here

To attract an experienced workforce, the cooperating firm paid newly hired drivers in pay regime two either $0.37 or $0.38 per mile, with an observed final target of $0.38 per mile. Comparison of the pay levels of new hires in pay regime two to the pay level of new hires in pay regime one indicates that, on average, pay regime two new hires have a crash rate that is 40% less than their pay regime one counterparts, see Table 4. Further, an interesting part of the firm's experiment is to compare the drivers in pay regime one who received a pay increase in pay regime two to their new counterparts in pay regime two[9]. For complete details see Table 5. In Table 5, the pay levels in the row represent the drivers that received a pay increase and moved into the listed pay level as a result of the increase in pay. They are compared to the newly hired pay regime two drivers in the column that would have been hired into the firm at the corresponding pay level. As an example, a retained driver now earning $0.38 per mile crashes at a rate that is 13% less than a new hire in pay regime two earning $0.34 to $0.37 per mile. Interestingly, a pattern emerges whereby drivers receiving a wage increase into the highest pay categories are not statistically different from their newly hired counterparts in the same pay category; moreover, drivers who received a raise that moved them into the pay level of $0.26 to $0.30, or the pay level of $0.31 to $0.34, had a statistically significant higher crash rate, on average 44% higher, relative to the higher paid newly hired drivers. The raise was insufficient to motivate safer driving habits; the firm did not value these employees highly enough to warrant a larger pay increase, thereby increasing the crash risk for these drivers. The diagonal values in Table 5 are the estimates for the effect of the pay increase for a driver that received an increase in pay and who remained in the same pay category; for example, a driver that earned $0.34 per mile was given a $0.03 per mile increase to $0.37 per mile. The drivers are not statistically different from the driver in the same pay level that did not receive an increase in their pay level.

Table 4 Here

[9] For complete details see Table.5.

Table 5 Here

7. Conclusion

The contribution of this research is, utilizing the natural experiment undertaken by the cooperating firm and the rare nature of the data set, to quantify the effects of increased driver's pay, to quantify the effects of driver's experience at hiring, and to quantify the change in managerial practices on driver crash risk. The examination reinforced the importance of pay, controlling for other important operational and demographic characteristics, on the relative crash rates of truckload motor carrier drivers. Substantially increasing driver pay increased the pool of qualified applicants from which more experienced drivers were hired, as well as facilitating the retention of their current drivers that possessed the desired qualities the firm wanted to exemplify. The firm effectively reduced their average crash rate from approximately 8.8 crashes per million vehicle miles travelled with an average cost per crash of $41,628 in the first pay regime to an average of 5.2 crashes per million vehicle miles travelled with an average per crash cost of $22,506 during the second pay regime. Although the crash rate in the second pay regime was reduced by approximately 41% and crash costs reduced by approximately 46%, further improvements in the crash rate could still have been attained. For the firm's experiment to be complete there is an expectation that new hired drivers should be indistinguishable from the drivers that remained in their employment. That was not the complete case for the cooperating firm. Drivers who received significant raises into the highest pay group were not statistically different from the new hires in the highest pay groups; however, drivers that the firm identified as possessing the necessary skills that remained with the firm, and who received smaller raises in pay, had higher relative crash risk than the higher paid drivers who could have been improved upon. From the standpoint of the firm, the experiment was a success; however, it was not as successful as it necessarily could have been.

The current research is subject to several limitations. As is the case with any data set, the collection process is prone to errors and omissions. In the current data set, it is not known if the recorded driver crash incidents were preventable or unpreventable; and the magnitude and type of damage of each of the incidents is not known. Importantly, the change in management and its role in the firm’s crash rates was unexpectedly a detriment to the firm. The data set is absent information concerning the driver’s direct supervisor. A thorough collection of the missing covariates would sharpen the current results and reveal a more detailed perspective into management’s role in the crash rate of the firm. Additionally, the data are representative of one large U.S. TL motor carrier; caution is warranted in the application of the current results to the TL sector of the motor carrier industry in general. Other errors and omissions are strictly those of the researcher.

This paper is part two of a three part project to estimate the net present value of an inexperienced TL driver and compare it to that of the experienced TL driver, employing the cooperating firm's data set. The model presented in this paper will be utilized to estimate crash probabilities for the aforementioned project. In the next paper of the series, the model introduced in paper one, as well as this paper, will be utilized to calculate the probability of a driver being in the firm’s employment, and the probability of a TL driver experiencing a crash incident, respectively. Finally, in the third examination of the data, the probabilities, with additional estimation of the firm's profits per mile and estimated driver mileage per month, will be combined to calculate the aforementioned driver net present values in order to explore the firm's pay off; quantifying the cost for the cooperating firm of trading their effective labor. The results of this research will enhance future policy decisions concerning pay rate levels and the experience levels of current and future motor carrier drivers in the truckload sector of the motor carrier industry.

Table 1. Cooperating Firm Data					
			Number	**Observation Months**	
Drivers			11,457	87,887	
Gender	Male		11,052	85,525	
	Female		405	2,362	
Race	White		8,810	66,116	
	Black		1,986	15,726	
	Other		661	6,045	
Marital Status	Married		6,055	44,977	
	Single		5,976	42,910	
		Minimum	Mean	Standard Deviation	Maximum
Baseline Age		20.0	40.4	9.8	76.0
Baseline Pay		16.0	30.5	6.0	48.0
Miles per Month		2.0	8,966.4	3,348.2	15,996.0
Dispatches per Month		1.0	15.8	6.2	81.0

Table 2. Crash Model Results for all Covariates

Number of subjects =		11457			Number of observations =	87877
Number of failures =		5549			Wald chi2(33) =	639.27
Time at risk =		81681.66667			Prob > chi2	0.0000
Log likelihood =		-37577.154	(Standard Error adjusted for 11457 clusters in observation)			
Analysis Time, _t		Hazard Ratio	z	P>|z|	[95% Confidence Interval]	
Pay Categories						
≤ $0.22		.8518223	-2.27	0.023	.741813	.9781458
$0.26 - $0.30		.7110217	-5.97	0.000	.6357071	.7952591
$0.31 - $0.33		.6148486	-6.73	0.000	.5336279	.7084315
$0.34 - $0.37		.7496602	-2.34	0.019	.5890008	.9541422
$0.38		.9211931	-0.30	0.763	.5397695	1.572147
> $0.38		.8537471	-0.68	0.497	.5410143	1.347255
	Period 2	1.424388	1.52	0.130	.90132	2.251012
Pay Categories	Period					
≤ $0.22	2	.7166294	-0.97	0.333	.3647787	1.407861
$0.26 - $0.30	2	.8700269	-0.49	0.623	.4993405	1.515893
$0.31 - $0.33	2	1.000761	0.00	0.998	.6052285	1.654784
$0.34 - $0.37	2	.6201745	-1.80	0.071	.3689018	1.042598
$0.38	2	.4482276	-2.24	0.025	.2222408	.9040102
> $0.38	2	.446365	-2.45	0.014	.2343835	.850067
Mileage Category						
≤ 6,607 Miles		1.38235	7.34	0.000	1.267824	1.507221
9,316 – 11,019 Miles		.840016	-4.87	0.000	.7830754	.901097
> 11,019 Miles		.6730704	-9.26	0.000	.6189605	.7319106
Dispatch Category						
≤ 12 Dispatches		1.018888	0.43	0.667	.9357298	1.109437
17 – 19 Dispatches		1.004316	0.11	0.911	.9315199	1.082801
> 19 Dispatches		1.071879	1.73	0.084	.9907428	1.159659
Age Category						
21 – 25 year olds		.8755488	-2.30	0.021	.7819059	.9804066
26 – 30 year olds		.8388909	-3.40	0.001	.7581979	.9281719
31 – 35 year olds		.8834512	-2.63	0.008	.8055875	.9688407
36 – 40 year olds		.9303885	-1.57	0.116	.8504151	1.017883
46 – 50 year olds		1.0792	1.54	0.123	.9796143	1.18891
51 – 55 year olds		1.130912	2.14	0.033	1.010272	1.265958
> 55 year olds		1.298967	4.22	0.000	1.150513	1.466578
Female		.9268817	-1.04	0.297	.8036036	1.069071
Single		1.135335	4.51	0.000	1.074463	1.199655
Race						
African American		1.170762	4.73	0.000	1.096784	1.249729
Other		1.033878	0.56	0.576	.9199453	1.161921
Winter		1.14551	5.08	0.000	1.087039	1.207127
Pay Raise		.9755929	-0.48	0.633	.8813721	1.079886
			Stratified by Experience at Hire			

Table 3. Pay Categories Pay Regime Two-Crash

	≤ $0.22	$0.23 - $0.25	$0.26 - $0.30	$0.31 - $0.33	$0.34 - $0.37	$0.38	> $0.38
≤ $0.22							
$0.23-$0.25	.610441 (.2068997)		.618608* (.1716594)	.6153164** (.1518217)	.4649201*** (.1086323)	.4129042*** (.0958784)	.3810828*** (.0894304)
$0.26 - $0.30	.9867978 (.2989384)			.9946791 (.1789473)	.7515586* (.1216168)	.6674731*** (.1072682)	.6160328*** (.1001127)
$0.31 - $0.33	.9920766 (.2715698)				.755579*** (.0750291)	.6710436*** (.066549)	.6193283*** (.0629915)
$0.34 - $0.37	1.313002 (.3445596)					.8881184* (.0549621)	.8196737*** (.0541585)
$0.38	1.478408 (.3918027)						.9229329 (.0531764)
> $0.38	1.601859* (.4263663)						
Statistical Significance:							
*** .01							
** .05							
* .1							

Compares the relative crash rate across pay rate categories in pay regime two for a 41 to 45 year old, white, married, male that drives between 6,608 and 9,315 miles per month that originated from 13 to 16 dispatched loads.

Table 4. Pay Category for New Hire Pay Regime Two

	≤ $0.22	$0.23 - $0.25	$0.26 - $0.30	$0.31 - $0.33	$0.34 - $0.37	$0.38	> $0.38
≤ $0.22							
$0.23 - $0.25					.6622268*** (.0367959)	.5881359*** (.0393208)	.5428099*** (.0395238)
$0.26 - $0.30							
$0.31 - $0.33							
$0.34 - $0.37							
$0.38							
> $0.38							
Statistical Significance:							
*** .01							
** .05							
* .1							

The table shows the hazard ratio for drivers of the various pay levels in the top row compared to the drivers of the other pay levels indicated in the column. The comparison is for a new hired driver in pay regime two that is 41 to 45 year old, white, married, male that drives between 6,608 and 9,315 miles per month that originated from 13 to 16 dispatched loads, to that of a similar new hired driver in pay regime one.

Table 5. Pay Categories Pay Regime One-Crash

	≤ $0.22	$0.23 - $0.25	$0.26 - $0.30	$0.31 - $0.33	$0.34 - $0.37	$0.38	> $0.38
≤ $0.22							
$0.23-$0.25		.9755929 (.0505553)					
$0.26 - $0.30			.9755929 (.0505553)				
$0.31 - $0.33				.9755929 (.0505553)			
$0.34 - $0.37			1.298093 (.220651)	1.291186** (.1452232)	.9755929 (.0505553)	.866442** (.0625561)	.7996679*** (.0611041)
$0.38			1.461621** (.2524738)	1.453844*** (.1715737)	1.098494 (.0971263)	.9755929 (.0505553)	.9004068 (.0702971)
> $0.38			1.58367*** (.2758057)	1.575244*** (.1886784)	1.190221* (.1081936)	1.057057 (.0812952)	.9755929 (0505553)
Statistical Significance:							
*** .01							
** .05							
* .1							

Compares the hazard ratio for drivers of the various pay levels in the top row relative to the drivers of the pay levels indicated in the column. The comparison is for a 41 to 45 year old, white, married, male that drives between 6,608 and 9,315 miles per month that originated from 13 to 16 dispatched loads who was hired in pay regime one and received a pay increase relative to that of a driver with the above characteristics hired at the indicated pay level in pay regime two.

CHAPTER 3 INVESTING IN EXPERINCED VS. INEXPERIENCED DRIVERS AT A LARGE U.S. TRUCKLOAD MOTOR CARRIER: AN EXPECTED NET PRESENT VALUE ANALYSIS

1. Introduction

Background

The Motor Carrier Act of 1980 (MCA) ushered in an era of profound changes in the motor carrier industry. The economic regulations that existed were replaced by market forces, whereby the common carrier general freight motor carrier industry in a relatively short period of time fragmented into the truckload (TL) and less than truckload (LTL) industry sectors. The removal of entry controls that resulted from the Interstate Commerce Commission's (ICC) new interpretation of the "public convenience and necessity" doctrine (Moore 1983), in conjunction with the ability of the new firms to now adjust prices and services in accord with market forces, unleashed a wave of new motor carriers into the industry.

A large number of the new entrants in the motor carrier industry were small TL carriers (McMullen 2005; Burks & Guy 2012) that owned one to a few trucks that may have been previously employed under an existing firm's route certificate (McMullen 2005; Grawe 2008). In 1981, following the enactment of the MCA, there was a surge of just over 4000 new entrants into the industry (Moore 1983, 1986), and by 1986 there was an increase of roughly 19,000 new carriers, in addition to the approximate 18,000 carriers that existed in 1980 (Corsi & Fanara 1989; Grawe 2008). The elimination of the patchwork of former route certificates enabled new entrants to "cream" TL shipments (Belzer 2000) from the existing common carrier sector, leaving primarily LTL shipments to the remaining firms. The LTL sector found fewer and fewer firms competing for carriage (Boyer 1993; Corsi 1993; Belzer 2000; Burks & Guy 2012); the TL sector saw a marked increase in competition for carriage and most nearly replicates a competitive market (Burks & Guy 2012). The new carriers aided by the ability of freight brokers to find carriage (McMullen 2005) enabled small motor carriers to effectively compete with the largest motor carriers for carriage where the marginal carrier's cost of production for the next shipment greatly influenced the price charged for carriage in the market.

The market segmentation into TL and LTL industry sectors (Belzer 1995, 2000; Burks & Guy 2012) that resulted from deregulation, coincident with the 1979 through 1982 recessionary period (Belman & Monaco 2001), lowered motor carrier freight rates (Moore 1983) whereby overall wages were reduced; moreover, the labor force was effectively segmented in the motor carrier industry. In conjunction with the labor market segmentation, the consolidation of the LTL sector and the burgeoning TL sector effectively reduced overall union coverage in the motor carrier industry (Rose 1987; Hirsch 1993; Belzer 1995; Belman & Monaco 2001). The level of unionization in the motor carrier industry has significantly declined after the passage of the Motor Carrier Act of 1980 (Belzer 2000; Belman & Monaco 2001; Henrickson & Wilson 2008; Burks & Guy 2012) and union density is currently 10.2% (Hirsch & Macpherson 2014), excluding United Parcel Service (UPS), which has been classified as a courier (Belzer 2000). The decentralized nature of the TL segment, combined with the difficulty of organizing within the National Labor Relations Act as amended, precluded the union from actively recruiting new membership. As a result of economic deregulation, the current logistics of TL carriage places a significant level of disutility on TL drivers' work experience. As market forces began to affect the TL sector of the motor carrier industry, prices paid for freight carriage began to fall, eroding margins of TL motor carrier firms. Issues of safety quickly rose to the forefront of discussion among policymakers, researchers, and the general public that continues today.

Some industry pundits, academics, and researchers contend that there has been a decline in overall safety levels in the industry; however, a significant number of others contend just as fervently that safety has appreciably increased since the passage of the MCA (Kraas 1993). After the passage of the MCA, especially in the years of 1985 and 1986, there was a sharp increase in the number of crashes in the motor carrier industry (Glaskowsky 1986). Recent data published in the

Federal Motor Carrier Safety Administration's Large Truck and Bus Crash Facts 2012 reveals the number of fatal crashes, the number of vehicles involved in a fatal crash per 100 million vehicle miles traveled (VMT), fatal crashes per 100 million VMT, and fatalities per 100 million VMT have all trended down through 2009; while the number of large trucks[10] registered and the number of vehicle miles traveled has increased over the same time period[11]. However, recent releases of crash statistics reveal that there has been a surge in fatal crashes involving large trucks (FMCSA 2014; NHTSA 2014a, 2014b). Since the end of the Great Recession in 2009, the trend in the number of large truck crash fatalities has increased 25% from 1.17 per 100 million VMT to 1.46 per 100 million VMT in 2012[12], while automobile crashes have continued a downward trend and have declined to a historic low level of 1.1 per 100 million VMT (NHTSA 2014b). The high profile nature and coverage of a select few large truck crashes and fatalities by the media has increased public awareness for the need for continued improvements in safety levels in the motor carrier industry. For this reason, crashes are a serious problem for TL motor carriers and have a deleterious effect on the motor carrier firms and on society as a whole.

Crashes, from the motor carrier's perspective, are extremely costly and increase the costs imposed on society (Saltzman & Belzer 2002). Although this list is not exhaustive, the increase in costs due to crashes include vehicle down time, higher insurance rates, reduced customer service for the carrier (LeMay *et al.* 1993; Suzuki *et al.* 2009); and the external cost imposed on society resulting from property damage, productivity loss, and loss of life that exceed the limits of current insurance regulations (Saltzman & Belzer 2002). The average cost of a crash for all large trucks was estimated to be $91,112.00 in 2005 dollars (Zaloshnja & Miller 2007). Importantly, the average cost for a heavy duty truck crash was $171,710 when the injuries to the victim were non-

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[10] Large trucks are vehicles with a gross vehicle weight rating (GVWR) greater than 10,000 pounds.
[11] Large Truck and Bus Crash Facts accessed at http://www.fmcsa.dot.gov/safety/data-and-statistics/large-truck-and-bus-crash-facts-2012, accessed on April 10, 2015.

[12] Authors calculation based on data contained in Table 4 in Large Truck and Bus Facts 2012, accessed on April 10, 2015.

incapacitating (Zaloshnja & Miller 2007). When the injuries were incapacitating for the victim, the costs increased to $437,845; moreover, the average cost per crash dramatically increased to $3,833,721 when there was a fatality involved in the crash (Zaloshnja & Miller 2007), far above the Federal Motor Carrier Safety Administration's (FMCSA) regulated minimum liability insurance of $750,000. The FMCSA estimated the cost of all 2012 fatal injury crashes to be $40 billion, and with the inclusion of all truck and bus crashes the estimate increases to $99 billion, in 2012 dollars (FMCSA 2014). Currently, the FMCSA pursues the mission of eliminating fatalities in the motor carrier industry and are intent on eliminating crashes.

Motivation

A typical TL motor carrier driver can expect to work long and irregular hours in the delivery of freight. Although these hours are limited by hours of service (HOS) regulation, drivers frequently report working considerably more hours than allowed by the law (Stephenson & Fox 1996; Belzer 2000; Kemp *et al.* 2013). The demands of driving are exacerbated by the loading and unloading operations carried out by the drivers, often times without adequate compensation similar to what they earn while driving (Belzer 2000). Drivers have reported that the compensation is not adequate for the long hours and extended periods away from home (Rodriguez & Griffin 1990). Some argue that truckload drivers experience "sweatshop" working conditions. However, in this case, the drivers are "sweating" their own labor, whereby they earn a subsistence level of pay, work extremely long and irregular hours, and experience working conditions that are not conducive to their overall good health, or the health of the industry (Belzer 2000). The disutility endured by the drivers in the TL sector, in combination with low pay levels, contributes to higher crash rates in the TL sector of the motor carrier industry.

In the movement of freight, TL motor carrier firms must choose the cost minimizing amount of capital and labor inputs in order to deliver shipments of freight in a manner that is most efficient and cost effective to the firm. This requires the firm to have equipment and drivers strategically located in order to effect these movements. The labor choice for motor carriers considers the overall price of "effective labor" that includes the total cost to the firm for hiring and employing labor (Burks *et al.* 2008). The driver's effective labor cost consists of the original cost to recruit and train a driver; the operational costs of creating the best working conditions for the driver; the cost of insurance and crashes that the firm incurs from selecting certain types of drivers; and the actual compensation paid to the driver including any compensating differential for the drivers that operate under the worst of conditions. The TL drivers' effective labor has emerged in the TL sector as being characterized by high turnover levels, high rates of crash incidents, and low to non-existent compensating differentials being paid to the drivers (Burks *et al.* 2008). The entrenchment of the model in the TL sector of the motor carrier industry has witnessed few firms exploiting the cost tradeoffs that could be afforded in the price of their drivers' effective labor.

The objective of the cooperating firm was to become a world class provider of transportation, supplanting their tarnished image in the TL motor carrier industry. To fulfill this goal, the firm initiated a new managerial culture where managers and supervisors were to take responsibility for being more attentive to safety issues and to recognize the issues of their drivers, turning attention to stabilize their workforce. To accomplish this task, the firm raised the per mile rate of pay for the drivers that remained in their employ, by an average of 37%, and substantially increased the per mile rate of pay for their new hires who were safe and experienced drivers. The underlying objective was to pay the drivers a higher wage that was significant enough to attract and retain the most experienced drivers in the TL sector, where the increase in pay eroded the disutility of the TL driving job and thereby reduce the number of crashes sustained by the firm. In other words, the cooperating firm moved from the model of high crash incidence and low wages, to the untried model of low crash incidence and high wages[13].

[13] The cooperating firm's internal documentation acknowledges the tradeoff of effective labor and discusses appropriate remedies summarized in this paragraph.

In addition to increasing wages, to the highest in the TL industry, the firm completely remade the corporate culture by enhancing the benefit package for the drivers to attract the highest quality drivers to the firm. The firm increased the amount of home time earned with a 100% guarantee to be at the home terminal by the date requested by the driver with a minimum of fourteen days notice; implemented a new recognition program in order to restore driver dignity and accountability; and reduced tractor age and increased maintenance schedules, among many other remedies[14]. Hiring experienced and safe motor carrier drivers who are paid a higher starting wage will have an expected net present value (NPV) of returns to the firm that is greater than the expected NPV of returns to the firm for the drivers that were previously hired with no prior experience and received general training from the firm.

To investigate the above statement, the expected NPV of the two driver types under investigation will be estimated. To date, what has not been able to be shown, due to limitations of the current data that is available to researchers, is whether the returns that accrue to a firm for increasing compensation levels for drivers are greater than the savings in the associated costs for improved safety levels? The prior research of Faulkiner, utilizing the cooperating firm's data, estimated a Cox proportional hazards model that disentangled the affects of pay, the affects of driver experience, and the new management regime's affects on the driver exit rate (Faulkiner 2015a) and driver crash rate (Faulkiner 2015b) controlling for various demographic and operational covariates that were not considered in the prior research of Belzer et al. (Belzer *et al.* 2002) and Rodriguez et al. (Rodríguez *et al.* 2006). The estimates for the driver survival rate and the driver crash rate from the Cox proportional hazards models will be instrumental in the calculation of the expected costs and expected revenues in the current NPV analysis. The expectation is that drivers who are paid a higher starting wage will stay in the firm's employ longer; moreover, drivers who are paid a higher starting wage will experience a lower probability of a

[14] The cooperating firm's internal documentation.

crash incident affecting the overall expected NPV. Finally, experienced-at-hire drivers will be more productive in terms of miles driven per month.

2. Literature Review

Truck driver compensation methods vary from being paid a piece-rate per mile driven, on a percentage of the value of the load being hauled, or an hourly wage rate. Further, the entire benefit of compensation can include health insurance, safety bonuses, retirement packages, as well as many other financial incentives that a motor carrier may offer to their drivers. With regards to a truck driver's method of compensation, there are relatively few papers that research the link between a driver's compensation to the driver's overall safety performance. One position in the literature attempts to find a relationship between a firm's financial health and its effect on the firm's safety outcome. An indirect result of this research has been to demonstrate the driver's compensation effect on safety outcomes. The more relevant position considers the literature where the research has directly investigated the affect of driver's compensation on safety outcomes. The purpose of this section is to review the identified literature that has demonstrated the relationship between the driver's compensation and driver safety performance germane to the current research.

Indirect Research of Pay and Safety

Exploring the effects of deregulation in the motor carrier industry, Kraas obtained data from a 1989 California Highway Patrol (CHP) fact sheet for truck at fault statistics. In the absence of firm data, Kraas used drivers' real wages to proxy the profitability of motor carriers; carriers that were in better financial health were assumed to pay their drivers more in compensation. Over time, Kraas found that safety, in terms of the crash rate, has declined independently of the other variables in this particular research and that the real wage after deregulation has become a significant predictor of crash rates. As real wages fall from increased competition or decreased firm profitability, overall crash rates will increase (Kraas 1993).

Corsi et al.'s goal, as part of their analysis, was to determine if a relationship existed between a firm's safety performance, measured by driver and vehicle evaluations carried out in roadside inspections, and a firm's financial health with respect to commonly accounted financial measures. Corsi et al. segmented the data by carrier type and performed a correlation analysis on the collected data. Corsi et al. find that there is a statistically significant negative correlation between the driver's safety measure and the driver's wages as a percent of operating expenses (Corsi 2002); moreover, the vehicle safety measure is negatively correlated with driver's wages as a percent of operating expenses. Corsi et al.'s conclusion is that carriers will attain better driving and vehicle safety scores when the carrier expends a larger percentage of their operating expenses on wages (Corsi 2002). Prior research suggests that motor carriers with high violation rates found during roadside inspections have a crash rate that is 30% higher than those carriers that have favorable roadside inspections (Moses & Savage 1996).

Rodriguez et al. 2004 combine three data sources compiled at the firm level to construct the variables for driver compensation, a firm's financial status, and variables for the various occupational demands placed upon the drivers. The researchers amended the data to include the number of power units operated by each of the carriers in the data set. Ultimately, 60 TL motor carrier firms that paid drivers by the mile driven remained in their analysis. Rodriguez et al., due to the limited number of observations in the data set, estimated a series of three separate regressions that include various variables to determine if the operating ratio, the cash flow ratio, or the labor cost ratio, all measures of the financial health of the motor carriers, have an effect on the safety outcomes of the motor carriers. Across all three of the financial data models, the control for unpaid driver working time has a statistically significant effect on safety outcomes. A 10% increase in a workers unpaid working time will increase crashes by 2.3% (Rodriguez *et al.* 2004). Although pay rate is not statistically significant in the models, the compensation variables were included in the modeling process as a block, and the resultant test of significance on the block of variables indicates that the variables are statistically different from zero and should be included in the model. Further, the researchers computed elasticity where a 10% increase in the labor cost ratio, representing a higher pay percentage for drivers compared to the firm's revenue stream, reduces crashes by .6 percent; increased liquidity and appropriately having the ability to pay drivers higher wages as a percent of revenue reduces overall crashes (Rodriguez *et al.* 2004).

Building upon the work of Corsi et al. (Corsi 2002), Britto et al. determined that a motor carrier's financial health is linked to that firm's safety performance. Britto et al.'s data set consists of 657 carriers in all major motor carrier industry segments. Importantly, 86% of the 657 carriers in this study are truckload motor carriers. A key point of Britto et al.'s analysis is the use of average driver wages as a control variable in the three regressions in this study; moreover, in all three regressions, Britto et al. finds a statistically significant relationship between the driver safety performance score, the vehicle safety performance score, and total reported crashes from SafeStat and average driver wages. Improved driver safety and vehicle safety indicate that motor carriers that pay higher wages on average experienced fewer driver and vehicle regulatory violations and have improved safety performance; the implication is higher average wages paid to drivers lowers the firm's overall crash rates (Britto *et al.* 2010).

Direct Research of Pay and Safety

Monaco and Williams utilized a survey conducted by the University of Michigan Trucking Industry Program (UMTIP) that was carried out during the summer and fall of 1997. The depth of the survey allowed for a much richer understanding of the vast number of characteristics that contribute to truck crashes. Monaco and Williams found that the way in which a driver is paid has a statistically significant effect on the probability of that driver having a crash incident. For example, if a driver were to receive a $.10 per mile raise, his/her probability of experiencing a crash incident falls by 1.76%; moreover, if drivers are paid an hourly rate, they are 10.2% less likely to have been involved in a crash incident (Monaco & Williams April 2000). The most notable result in Monaco and Williams' research is the increased significance of occupational variables over demographic variables, particularly the method in which a driver is paid. Those drivers that receive a higher effective per mile rate of pay have a reduced incidence of a crash and are less likely to have logbook or moving violations (Monaco & Williams April 2000).

Belzer et al.'s research objective is to examine the relationship between the various compensation practices of motor carrier firms and the resulting behavior of the drivers employed by those motor carriers. To understand the relationship between compensation and safety, Belzer et al. employ three distinct data sets and carry out three separate analyses. In a cross sectional analysis of 102 non-union TL carriers, the compiled data was utilized to create the control for unpaid time variable used in the analysis. Unpaid time has a mean value of .004 hours per mile driven, which translate into approximately 3.6 hours of unpaid work on a 906 mile average delivery trip (Belzer *et al.* 2002). The calculated elasticity for the relevant compensation control is -.52. The implication of the mileage pay elasticity is that a 10% increase in the drivers pay rate per mile will result in a 5.2% reduction in crashes (Belzer *et al.* 2002). The calculated elasticity for safety bonus is -.10; a 10% increase in the bonus will lead to a 1% reduction in the number of crashes (Belzer *et al.* 2002).

In the same report, Belzer et al. employ a unique driver level data set from J.B. Hunt, a large US truckload carrier. The relevant compensation controls are base pay and percent pay increase. The reported result for a one penny increase in a driver's base pay suggests a reduction in the probability of a crash by approximately 11 percent; further, a 10% increase in the level of the drivers pay reduces crash risk by 6% (Belzer *et al.* 2002).

In the same report, an analysis of the University of Michigan Trucking Industry Program (UMTIP) truck driver survey results in a statistically insignificant overall model with significant variables. Belzer et al. concluded that the trend of the model is similar to the trend of the other models in their overall analysis and still provides useful insight into the relationship between compensation and safety; a 10% increase in the driver's mileage rate from 29.5 cents per mile to 32.4 cents per mile reduces the probability of a crash from 13.8% to 10.86%, a significant decrease of 21% in the overall probability of a crash (Belzer *et al.* 2002). Overall, Belzer et al.'s extensive examination of driver's compensation and safety outcomes reveals that truck driver compensation is an extremely strong predictor of a truck driver's safety performance.

Rodriguez et al. 2003 is motivated to understand the underlying structural factors of a driver's behavior that contribute to a truck crash that builds upon the evidence suggested by Belzer et al. 2002. Rodriguez et al. 2003 find that occupational factors, specifically the rate of pay, in addition to tenure on the job, influence safety outcomes, in terms of crashes, significantly more than demographic factors (Rodriguez *et al.* 2003). Additionally, their results suggest that if the driver were to receive a one cent per mile increase in pay that the driver's expected crash count would fall by 8.15 percent; moreover, when the model is estimated at the mean rate of pay, $.30 per mile, the estimation results in elasticity measurement of -2.47, implying that if the driver's pay rate increases by 10% there is a resulting 24.7% decline in overall crash count. When the model is standardized, the model validity is unchanged; however, the estimated coefficients must be interpreted in units of standard deviation. Therefore, when a drivers pay is increased from $.307 per mile to $.37 per mile, a one standard deviation change, there is an associated 43.6% decrease in the expected crash count (Rodriguez *et al.* 2003).

The prior research of Belzer et al. 2002 and Rodriguez et al. 2003 indentifies the importance of compensation as an influencing factor on motor carrier safety in terms of reduced crash incidence and reduced crash risk. What are not clear, however, as Rodriguez et al. 2006 suggest, are the causal pathways on how pay actually influences safety outcomes. Their research objective in this study was to disentangle the direct effect of pay on safety outcomes from the indirect effect. The indirect effect refers to the ability of the motor carrier firms to attract and retain employees that will allow for the employee to accumulate human capital and as a result, the firm will experience improved safety outcomes, as measured by the number of crashes (Rodríguez *et al.* 2006). In the crash model, the control variable for the driver's pay at his/her time of hire, Basepay, was not statistically different from zero. The control variable, Newpay, a driver's pay level after a raise is received, suggests that a 1% increase in a driver's pay rates reduces a driver's crash probability by 1.33%. The result of the modeling was that Rodriguez et al. 2006 were unable to disentangle the aforementioned causal path, specifically the indirect path of human capital accumulation controlled by Basepay in the model.

3. Model

Following Becker 1962, labor shares many of the characteristics of capital that is employed in the production process. In particular, the firm hires labor with the reasonable expectation that the employee will be employed in the production process past the initial hiring period. Training, if provided by the firm, and on-the-job experience gained by the employee during the production of a good or service contributes to the expected future revenue stream for the firm. Similar to capital, the long lived nature of labor allows for a multi-period analysis (Becker 1962) that compares the discounted stream of expected future revenues to the associated discounted stream of expected future costs. After the subtraction of the initial hiring cost, firms will hire the employee if the expected future revenues exceed the expected future cost. The model utilized to make the NPV comparison for the cooperating firm is,

$$E(NPV) = -C_{l0} + \sum_{t=1}^{T} \frac{E(Revenues_{lt})}{(1+\frac{r}{12})^t} - \sum_{t=1}^{T} \frac{E(Cost_{lt})}{(1+\frac{r}{12})^t}. \quad (1)$$

In the above equation, $C$is the initial cost of hiring a driver at time zero, and $l = (1, 2)$ denotes the driver types hired by the cooperating firm. Drivers denoted as type one are pay regime one drivers who were inexperienced at their hiring; and type two drivers were drivers who were experienced at their hiring during pay regime two. Time is measured in driver tenure months where $t = (1, 2, \dots, T)$; and the expected revenue and cost is discretely discounted by the driver tenure month.

4. Empirical Analysis

Data

The cooperating firm is a large TL motor carrier that hauls general freight in the U.S. The proprietary data supplied by the firm for the current research consists of 87,887 driver observation months that includes driver demographic and operational covariates, considering 11,457 drivers in their random over the road irregular route truckload division. In addition to the standard operational covariates of driver mileage and dispatches per month, information on a driver's prior driving experience before hire, crashes each driver sustained per month, and the month that a driver exits the firm's employment is included in the data set.

The drivers are observed during two time periods; the periods are referred to as pay regime one for the first observation time period, and as pay regime two for the second observation time period. Pay regime one, thirteen months of observation, commenced on September 1, 1995 and ended on September 30, 1996, which corresponded with the firm's formal announcement of the aforementioned impending corporate changes. Observation for pay regime two continued from February 1, 1997, the month that the drivers remaining in the firm's employment received a per mile pay increase and newly hired drivers fulfilled the firm's new hiring objective, and completed on February 28, 1998, thirteen months of observation. No data, except the hire dates of the drivers hired in the intervening four month period for pay regime two employment, are observed during that period. Selected statistics for the entire data set are shown in Table 1.

Table 1 Here

Methodology

The modeling approach employed in the current analysis fulfilled two primary objectives. The first objective is to build on the previous work of Faulkiner 2015a and Faulkiner 2015b; the second objective is to utilize the data in such a way that corresponds to the firm's intent, as gleaned from the supplied internal documentation on the data. The analysis will model and estimate the expected NPV, constrained by the supplied data set, for drivers inexperienced-at-hire and for drivers experienced-at-hire, two large driver subsets in the data. This analysis employs a probability estimate for a driver exit in each tenure month and a probability estimate for a driver crash incident in each tenure month from the models in Faulkiner 2015a and Faulkiner 2015b. In this data, there is no distinction as to whether each crash incident involved only the freight being carried, only the tractor or trailer, other pedestrian or road user vehicles, property damage, or any combination of these various types of incidents; moreover, it is unknown whether each particular driver crash was preventable or unpreventable. It is also unknown if the driver exits from the cooperating firm were driver voluntary quits or involuntary firings carried out by the firm. Other estimates used in this analysis were calculated from the current data or obtained from publicly available sources.

The initial cost estimate for hiring each driver type *l*, C_{l0}, is obtained from the internal documents that were supplied by the firm for which no specific breakdown is given. As explained in the firm's supplied documentation, the cost reflects advertising, recruitment, training, and may include other incidentals not mentioned in the documentation related to the hiring of the driver that was undertaken by the firm at time $t = 0$, the time period before each driver appears in the data and drives for the firm. For drivers who were inexperienced-at-hire, their cost reflects a per driver estimate for the firm's driver training facilities that were operated by the firm and any wages and benefits paid to the driver while attending the firm's intensive driver's training course; all inexperienced drivers would have been required to undertake the firm's training course; it is not known if any payments for the training were recovered in the event that a driver's employment terminated. At the end of the first observation period, the firm closed its training facilities. For drivers who were experienced-at-hire, their initial cost reflects training at the firm intended only to familiarize new employees to company policies and procedures. The costs utilized in this analysis are estimated by the firm to be $3,973 for a pay regime one driver and $886 for a pay regime two driver, in December 2014 dollars.

The data are recorded in driver tenure months and therefore the discounting in the model is estimated discretely on a monthly basis. The discount factor, *r*, is the average of the Two Year U.S. Treasury Note rate from the beginning of 1995 through the end of 1998, and other discount rates will be used for comparison. The U.S. Treasury Note rates were obtained from the U.S. Department of Treasury website, www.treasury.gov. It should, however, be noted that the Two Year Treasury Note rate is a conservative estimate of the opportunity cost for the firm during this time period; and during this time period, the firm's commercial paper rate, the short term rate the firm paid to obtain funding, closely approximated the Two Year U.S. Treasury Note rate.

In model (1) above, the expected revenue is,

$$E(Revenues_{lt}) = (PredictedMiles_{lt} * OperatingRevenuePerMile) * P(Survival_{lt}). \quad (2)$$

A fixed effects (FE) regression was run on the two subsets of drivers of interest in the data to obtain the predicted miles for each driver type *l* during each tenure month *t*, where the FE model is,

$$\ddot{y}_{lt} = \ddot{x}'_{lt}\beta + \ddot{u}_{lt} . \quad (3)$$

A dummy variable is included for each tenure month in the FE regression to control for potential time trends and effects. The operating revenue per mile was calculated from the cooperating firm's publicly available annual reports and averaged over the years that the drivers were under observation. The firm's reported insurance and claims' cost were added to the operating income reported in the annual reports and divided by the firm's reported miles driven where,

$$OperatingRevenuePerMile = \frac{(OperatingIncome + InsuranceCostandClaims)}{MilesDriven}. \quad (4)$$

The probability of survival for each driver type *l* at each tenure month *t* is,

$$L(\beta) = \prod_{s=1}^{q} \prod_{j=1}^{r_{(s)}} [\frac{\exp\,(x_{j(s)}(t_{j(s)})'\beta)}{\sum_{l_{(s)} \in R_{(s)}(t_{j(s)})} \exp\,(x_{l(s)}(t_{j(s)})'\beta)}, \quad (5)$$

Where each driver *j* of type *l* has survived to the time just before his/her employment at the firm was terminated.

The expected cost in model (1) from above is,

$$E(Cost_{lt}) = AverageCrashCost_l * P(Crash_{lt}) + PredictedLostMiles_{lt} * OperatingRevenuePerMile. \quad (6)$$

The average crash cost for each driver type *l* is calculated from the firm's supplied data and was chosen to smooth the monthly expected NPV estimates; and the probability of a crash is estimated from equation (5) above. The predicted lost miles are estimated from equation (3) above; and operating revenue per mile is calculated from equation (4) above.

Finally, in model (1), no residual value is estimated. In the analysis of capital, a scrap value or residual value is employed to estimate the dollar amount for the material used in the capital that is typically sold by a firm at the end of the capital's useful life. Labor exhibits instantaneous depreciation and therefore has no residual value.

5. Results

As hypothesized, drivers who are paid a higher starting wage in pay regime two remain in the firm's employment longer. The results are similar for the estimated driver crash probabilities. In the early tenure months, experienced drivers in pay regime two have a significantly lower crash probability. The estimate from the FE productivity analysis shows by way of a difference in means test that there is a statistically significant difference between the two driver groups tested. As hypothesized, the experienced-at-hire drivers are more productive and their average monthly miles are estimated to be 1268 miles more than the inexperienced-at-hire drivers' average monthly miles.

The results of the expected NPV analysis show, at the preferred discount rate of 5.78%, the average rate of the two year U.S. Treasury Note during the observation period, and the preferred average operating revenue of $.12 per mile estimated from the firm's publicly available financial reports, that inexperienced-at-hire drivers during pay regime one have an expected NPV of -$2,315 for the firm; moreover, experienced-at-hire drivers have an expected NPV of $7,474. Once adjusted to account for the large pay increase, there is a significant difference between the two groups of $2,601, where all of the above values are in December, 2014 dollars.

6. Discussion

The principal objective of this research was to examine and compare the expected NPV of the inexperienced-at-hire drivers to the same for the experienced-at-hire drivers, the primary target groups of the cooperating firm. Building on Faulkiner 2015a, survival probabilities are estimated to calculate the expected revenues that each driver type accrued for the firm; moreover, crash probabilities are estimated from Faulkiner 2015b to calculate the expected costs to the firm for each of the above driver types. A FE regression was employed to predict driver productivity, miles driven, during each tenure month of employment with the firm. This research has shown that experienced-at-hire drivers are more productive and have a large positive expected NPV; whereas, inexperienced-at-hire drivers have a negative expected NPV for the firm.

During pay regime one, the firm required all inexperienced drivers to attend one of their facilities for training. Although the firm did not break down the cost of this training, it is reflected in the substantial initial cost of hiring a pay regime one driver when compared to the initial cost of hiring an experienced pay regime two driver. The closing of the training facilities, and the consequent reduction in hiring costs offset the higher wage the firm paid to pay regime two drivers contributing to the larger NPV of pay regime two drivers.

During pay regime one, inexperienced drivers at hire were hired at the pay rate of $.23 to $.25 per mile; experienced drivers at hire in pay regime two were hired at either $.37 or $.38 per mile, based on their prior driving experience. In the first two months of employment, drivers of both types survive at about the same rate. However, beginning at the third month of employment the data show a marked difference in the driver survival rates. By the eighth month of employment, only 40% of the inexperienced drivers at hire remain employed at the firm while, approximately 70% of the experienced drivers at hire who are paid $.37 per mile remain with the firm. At eight months of employment, 75% of the drivers paid $.38 per mile remained with the firm. By the twelfth month of employment, the period where inexperienced drivers at hire would be reclassified as an experienced driver, only 28% of the inexperienced-at-hire drivers remain employed with the firm; whereas 62% and 70% of the higher paid drivers, ($.37 and $.38 respectively), still remain employed at the firm, Figure 1. The fact that the higher starting wage influenced experienced drivers to remain in the firm's employ longer is one of the primary reasons that the expected revenues in the current analysis and the expected NPV is larger for the experienced-at-hire drivers in pay regime two.

Figure 1 Here

Throughout the experienced-at-hire drivers' tenure, drivers who were paid $.37 and $.38 per mile have close to the same crash probability; whereas during the tenure months two through eight, inexperienced drivers at hire have a significantly higher crash probability that peaks in tenure month three at approximately a 15% probability of a crash during the month. Importantly, however, at approximately tenure month ten when the inexperienced-at-hire driver will soon become classified as experienced, the drivers' crash probabilities are indistinguishable from the experienced-at-hire drivers' (Figure 2).

Figure 2 Here

In pay regime one, inexperienced-at-hire drivers' average crash cost was $8087, in December, 2014 dollars, while the experienced-at-hire drivers' average crash cost was $4281 in December, 2014 dollars. The large probability of a crash early in the tenure of the inexperienced-at-hire drivers, in conjunction with their much larger average crash cost during pay regime one, significantly contributed to the large expected costs for those drivers that were also a principal contributor to their much lower expected NPV.

The estimates from the FE productivity regression, in the first tenure month of employment, indicate that both driver groups experience similar levels of estimated miles driven per month.

However, experienced-at-hire drivers have significantly greater estimated miles driven per month in tenure month two; and from tenure month three forward, experienced-at-hire drivers consistently drive approximately 1,000 miles per month more than the inexperienced-at-hire drivers (Figure 3). This productivity increase arises as a result of the firm utilizing their more experienced and safe drivers more intensively, awarding more dispatches per period allowing for more miles to be logged by these drivers.

Figure 3 Here

Further, consider that if the mileage prediction from FE productivity analysis was the same for both driver types, experienced-at-hire drivers would still have a larger expected NPV because of the significance of the aforementioned estimates.

Due to the constraints placed on the analysis from the supplied data, the expected NPV is estimated to nine tenure months, the 75th percentile in the data. The preferred discount rate employed in the analysis is the two year U.S. Treasury Note average of 5.78% during the observation periods; and the preferred operating revenue is $.12 per mile as calculated from the firm's publicly available annual reports. Various discount rates from 3% to 8%, as well as various operating revenues from $.07 to $.16 per mile for experienced-at-hire drivers that are paid $.37 per mile and from $.07 to $.30 for inexperienced-at-hire drivers that are paid $.23 to $.25 per mile were applied to find a range of expected NPV's. In the preferred range of operating revenue per mile from $.07 to $.16, the NPV for the inexperienced-at-hire drivers is negative, including estimates past nine tenure months that are not shown. At operating revenue estimates greater than $.16 per mile for inexperienced-at-hire drivers, the expected NPV is positive, (Table 2).

Table 2 Here

The expected NPV of inexperienced drivers ranged from the low of negative $5,289 to a high of $7,596. For the experienced-at-hire drivers, their estimated NPV is always positive and ranged in value from $3,132 to $10,680, (Table 3). All estimated values are stated in December, 2014 dollars.

Table 3 Here

To adjust for the large difference in pay levels between the two drivers groups under investigation not accounted for in the annual report data, the mean difference of $.13 per mile is added to the inexperienced-at-hire driver's operating revenue per mile in order to make an equivalent comparison between the two driver groups. The results in Table 4 indicate the difference in the expected NPV's between the two driver groups under investigation for the various discount rates and the adjusted operating revenue per mile.

Table 4 Here

Overall, three important facts stand out in the analysis. First, the large wage difference increased the probability of survival for the experienced-at-hire drivers; the probability of survival greatly influenced the estimated expected revenues of both driver types. Second, the severity of a crash represented by the average crash cost, in conjunction with the probability of incurring a crash, significantly influenced the estimated expected costs, especially for the inexperienced-at-hire drivers during pay regime one who experienced more frequent and more costly crashes. Finally, as inexperienced at hire drivers gain experience, their crash probabilities begin to mirror the lower crash probabilities of experienced-at-hire drivers. As a result of the decreased probability of a crash, potentially the expected driver costs would also decrease. As the number of crashes is reduced, the expected costs fall; the E (NPV) would increase, therefore, creating value for the firms and eliminating the potential for the externality to be imposed on society, as well as a potential reduction in liability insurance costs for TL motor carrier firms.

7. Conclusion

This research utilizes the natural experiment undertaken by the cooperating firm and the rare nature of the data set to quantify the effects of increased driver pay on driver retention rates and to quantify the effects of driver experience at hire on driver crash probabilities. Further, the researcher employs those estimates in order to calculate the expected NPV for the target driver groups of the cooperating firm. These findings, in addition to being a new contribution to the existing literature, can be used as a valuable tool in future policy decisions regarding driver pay with regards to safety in the motor carrier industry.

The findings indicate that the large increase in the wage paid by the firm effectively improved driver retention rates, reduced turnover at the firm; reduced driver crash probability; and reduced the average cost of a crash sustained by the firm's drivers during pay regime two. The lower cost of driver turnover (search and training costs) as well as reduced crash casualty cost (and better freight transport performance for the firm) appears to have led to significantly increased expected NPV of the experienced drivers that were hired during pay regime two at the firm when compared to the previously hired inexperienced drivers during pay regime one.

From this firm's position, increasing the wage for newly hired drivers allowed for the hiring of safe and experienced drivers, which significantly improved the firm's return on investment[15] (ROI). The ROI, calculated from the NPV estimate, for pay regime one is -25 percent; whereas, for pay regime two drivers, the ROI to the firm is 285%. A large contributor to these estimates is the aforementioned improvement in retention rates and crash rates; moreover, the firm's ROI is additionally enhanced from the estimated productivity gains of the experienced drivers in pay regime two. Although the two driver groups are statistically different in this data, the productivity gain in this analysis arises from the firm's awareness of the drivers' abilities in terms of experience and safe driving skills. This skill of the new workforce enabled the firm to utilize their drivers more intensively, leading drivers to produce more miles per month per driver. The mileage gains reflected are manifested from the increased number of dispatches the firm allowed for each driver per month, not as a direct result of increased driver wages. In essence, the drivers are driving more

[15] Return on investment is a metric the firm can utilize to measure the efficiency of one investment to other investments. In this analysis, ROI is calculated by dividing a driver's E (NPV), model (1), by a driver's total E (Cost), for each driver type.

and driving more safely, therefore, resulting in increased driver retention rates and greater productivity.

Overall, the firm effectively traded the costs of their drivers' effective labor and created value for this firm. During pay regime one, as a result of excessive turnover rates, the firm incurred the high cost of recruitment of drivers and the consequent training for the inexperienced driver; the high cost from frequent and more severe crashes; and paid the OTR drivers a low wage. In pay regime two, there was a significant reduction in recruitment and training costs. There were fewer and less severe crash incidents based on the average crash cost, and the OTR drivers' wage was increased dramatically. For the firm, trading the costs of the drivers' effective labor was successful.

The current research is subject to limitations. As is the case with any data set, the collection process is prone to errors and omissions. It is unknown if the crashes sustained by the drivers were preventable or unpreventable events. A significant limitation of the current data set is the duration of the observation periods. This limitation of time restricted the estimation of the drivers' expected NPV. Further, due to the nature of the data collected by the firm, the number of controls utilized in the FE productivity regression analysis was restricted. Additionally, the data are representative of one large U.S. TL motor carrier that self insures; caution is warranted in the application of the current results to the TL sector of the motor carrier industry in general.

Future research will further develop an understanding as to why the current MC industry matured with a high tolerance for excessive crashes and underpaid drivers. This research has shown that tradeoffs could be afforded in the cost of the drivers' effective labor creating value for the cooperating firm that is a self insured TL motor carrier; however, most TL motor carriers purchase insurance in the market and do not self insure for future crash incidents. As stated previously, the average cost of crashes in the United States is quite high; in the case of a fatality it has been estimated to be in excess of $3,000,000. The actual costs of crashes can be much higher than the average costs and can exceed the regulated minimum liability of $750,000. The current firm is no exception; there are several incidents in the data that exceed the current regulated minimum liability. If the marginal carrier is pricing their freight rates based on an insurance level that does not adequately price the potential risk of the carrier, freight rates will be underpriced, distorting the competitive market; much of the cost of the future crash is borne externally by society, in many cases this can be significantly greater than the minimum liability; and keep driver wage levels lower than they would be if the price accurately reflected all of the freight costs including driver wages. When the FMCSA rules on and increases the minimum required liability level for an insurance policy to more accurately reflect the cost of future crash incidents and the imposed external cost, insurance costs will certainly increase, not decrease, as in the case at hand. Employing what was demonstrated in this research, firms will be under increased pressure to hire quality drivers and therefore adequately increase driver compensation. This research suggests that hiring quality drivers will reduce the quantity and severity of future crash incidents, increase driver retention, lowering the firm's overall costs; and allow for freight rates to reflect the true cost of carrying freight, and thereby create value for the firm and society.

There are a myriad of questions that this research provokes. For example, how do drivers obtain the necessary training to become the experienced and safe drivers that this research demonstrates are needed? How do drivers effectively signal insurers that they are safe drivers in order to obtain appropriately priced insurance premiums? How does the insurer accurately price the potential externality that drivers impose on society? This research raises significant questions for future research regarding pay and safety, as well as impacting current and future policy decisions in the motor carrier industry.

Table 1. Cooperating Firm Data					
			Number	**Observation Months**	
Drivers			11,457	87,887	
Gender	Male		11,052	85,525	
	Female		405	2,362	
Race	White		8,810	66,116	
	Black		1,986	15,726	
	Other		661	6,045	
Marital Status	Married		6,055	44,977	
	Single		5,976	42,910	
		Minimum	Mean	Standard Deviation	Maximum
Baseline Age		20.0	40.4	9.8	76.0
Baseline Pay		16.0	30.5	6.0	48.0
Miles per Month		2.0	8,966.4	3,348.2	15,996.0
Dispatches per Month		1.0	15.8	6.2	81.0

Table 2.	Inexperienced at Hire Driver's Expected NPV					
Operating Revenue Per Mile	Discount Rate					
	3.00%	4.50%	5.78%	6.50%	7.00%	8.00%
$0.07	-$5,289	-$5,282	-$5,275	-$5,272	-$5,269	-$5,264
$0.09	-$4,150	-$4,149	-$4,148	-$4,147	-$4,147	-$4,146
$0.11	-$3,010	-$3,016	-$3,020	-$3,023	-$3,024	-$3,028
$0.12	-$2,298	-$2,308	**-$2,315**	-$2,319	-$2,323	-$2,329
$0.14	-$1,301	-$1,316	-$1,329	-$1,336	-$1,341	-$1,350
$0.16	-$162	-$183	-$201	-$211	-$218	-$232
$0.18	$977	$950	$926	$913	$904	$886
$0.20	$2,116	$2,083	$2,054	$2,038	$2,027	$2,005
$0.21	$2,686	$2,649	$2,618	$2,600	$2,588	$2,564
$0.22	$3,256	$3,216	$3,181	$3,162	$3,149	$3,123
$0.23	$3,825	$3,782	$3,745	$3,725	$3,710	$3,682
$0.24	$4,395	$4,348	$4,309	$4,287	$4,272	$4,241
$0.25	$4,965	$4,915	$4,873	$4,849	$4,833	$4,800
$0.26	$5,534	$5,451	$5,436	$5,412	$5,394	$5,360
$0.27	$6,104	$6,048	$6,000	$5,974	$5,955	$5,919
$0.28	$6,674	$6,614	$6,564	$6,536	$6,517	$6,478
$0.29	$7,243	$7,181	$7,128	$7,098	$7,078	$7,037
$0.30	$7,813	$7,747	$7,692	$7,661	$7,639	$7,596

Table 3. Experienced-at-hire Driver's Expected NPV						
Operating Revenue Per Mile	Discount Rate					
	3.00%	4.50%	5.78%	6.50%	7.00%	8.00%
$0.07	$3,216	$3,190	$3,169	$3,156	$3,148	$3,132
$0.09	$4,875	$4,839	$4,809	$4,792	$4,780	$4,757
$0.11	$6,534	$6,488	$6,449	$6,427	$6,412	$6,383
$0.12	$7,570	$7,518	**$7,474**	$7,449	$7,432	$7,398
$0.14	$9,022	$8,961	$8,909	$8,880	$8,860	$8,821
$0.16	$10,680	$10,609	$10,549	$10,516	$10,492	$10,446

Table 4. Difference Between Experienced and Inexperienced Driver's Expected NPV							
Operating Revenue Per Mile		Discount Rate					
Experienced Driver	Inexperienced Driver	3.00%	4.50%	5.78%	6.50%	7.00%	8.00%
$0.07	$0.20	$1,100	$1,107	$1,115	$1,118	$1,121	$1,127
$0.09	$0.22	$1,619	$1,623	$1,628	$1,630	$1,631	$1,634
$0.11	$0.24	$2,139	$2,140	$2,140	$2,140	$2,140	$2,142
$0.12	$0.25	$2,605	$2,603	**$2,601**	$2,600	$2,599	$2,598
$0.14	$0.27	$2,918	$2,913	$2,909	$2,906	$2,905	$2,902
$0.16	$0.29	$3,437	$3,428	$3,421	$3,418	$3,414	$3,409

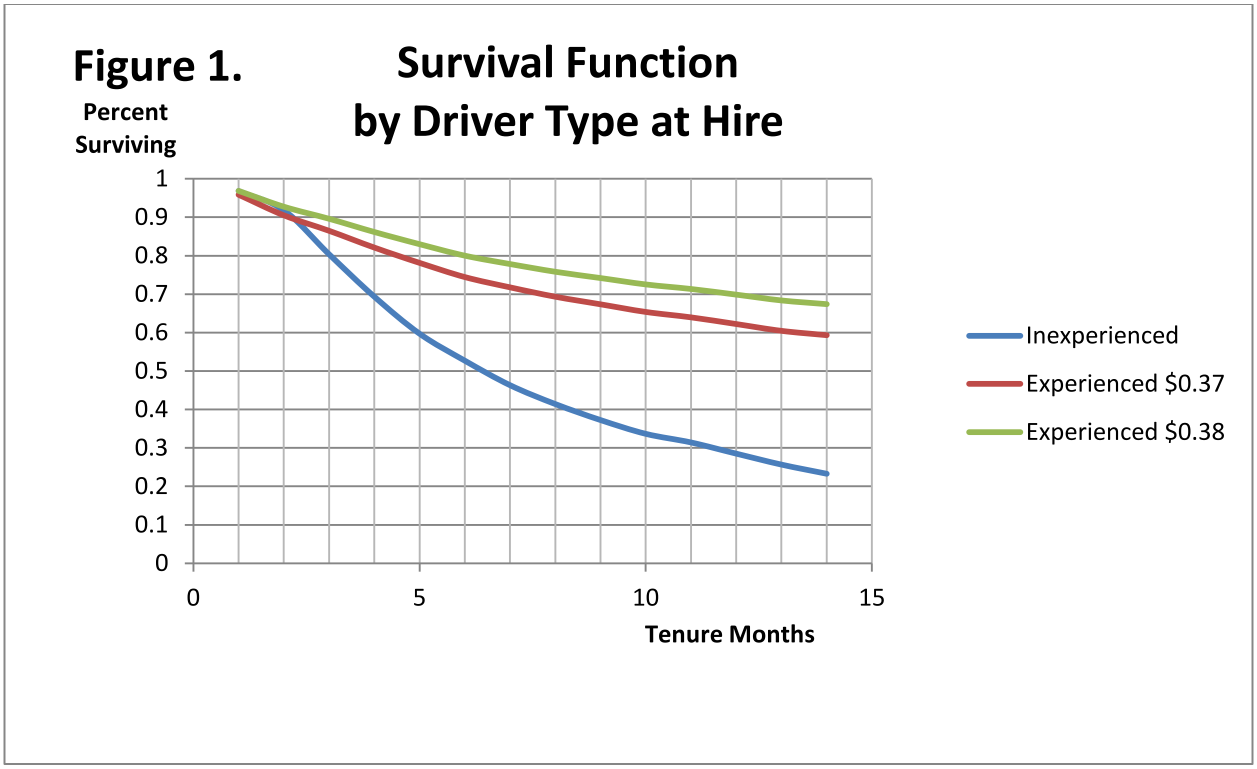
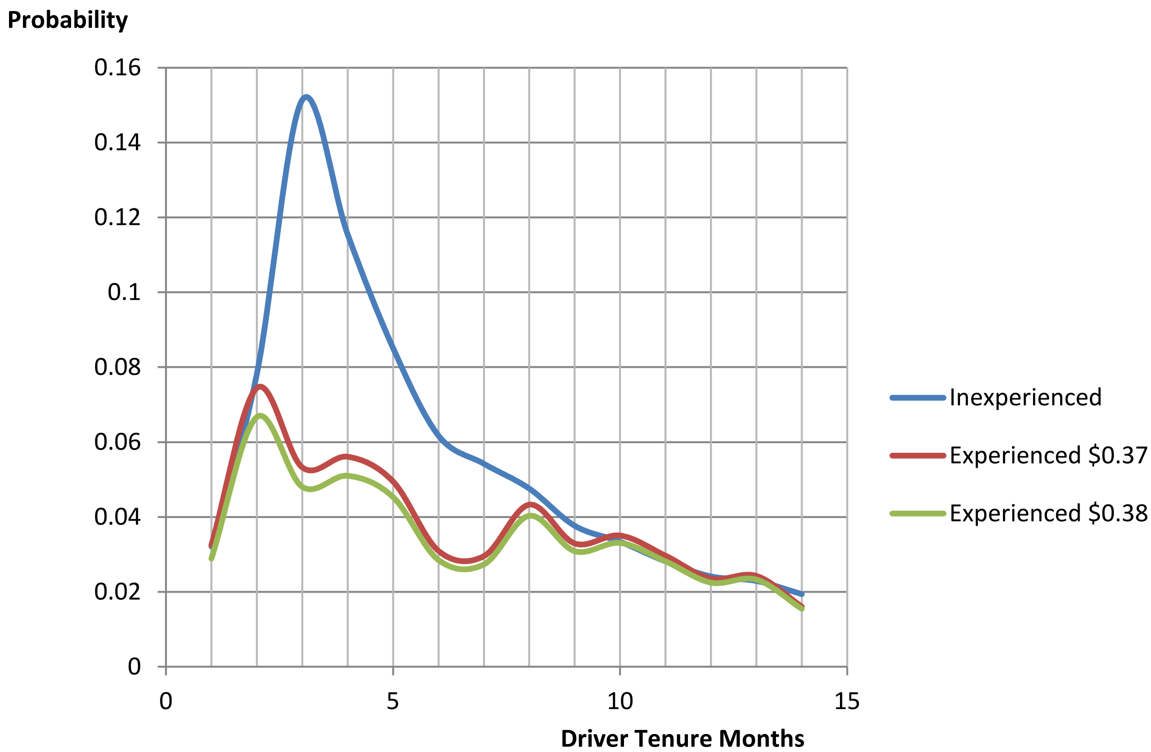


Figure 1.
Survival Function
by Driver Type at Hire
Percent Surviving
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
Tenure Months
Inexperienced
Experienced $0.37
Experienced $0.38

Figure 2. **Hazard Rate for Crashes by Driver Type at Hire**



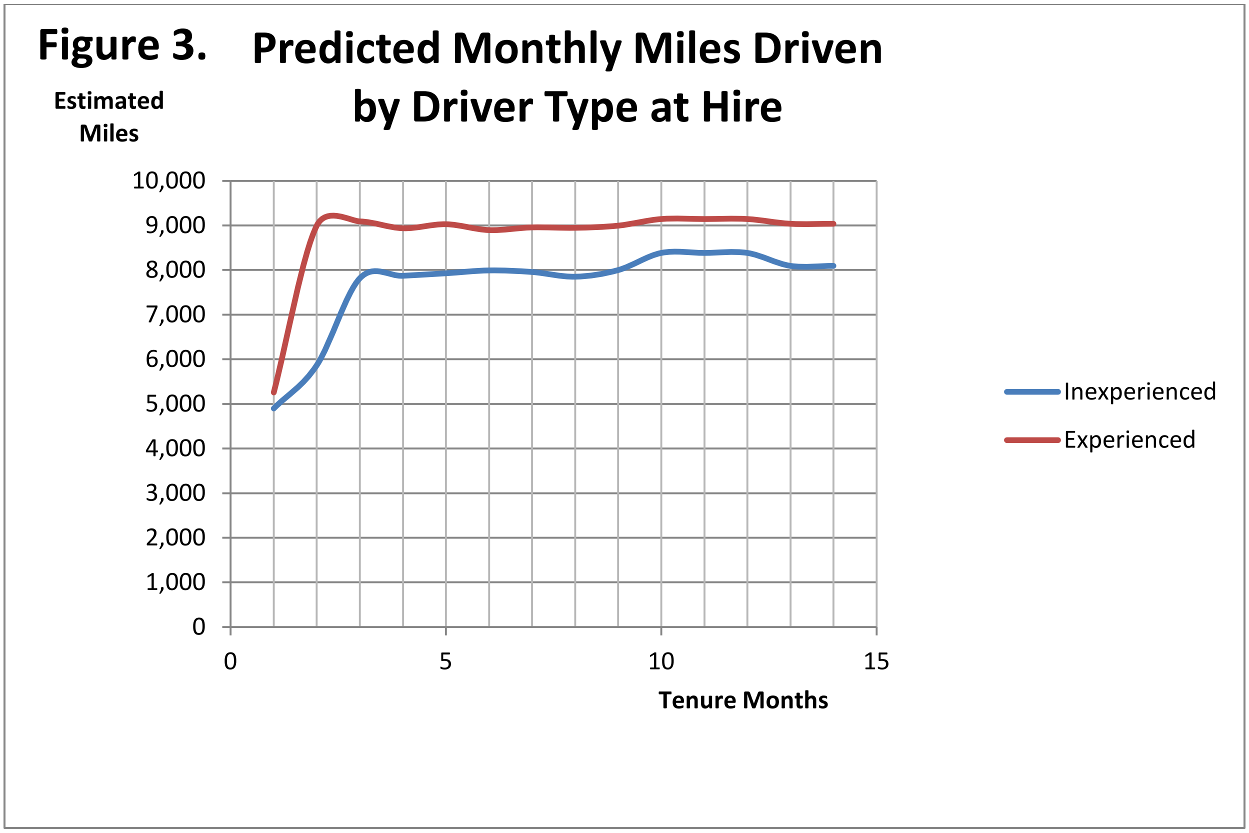


Figure 3.
Predicted Monthly Miles Driven by Driver Type at Hire
Estimated Miles
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0
5
10
15
Tenure Months
Inexperienced
Experienced

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ABSTRACT

A THREE ESSAY EXAMINATION OF CURRENT PAY AND SAFETY ISSUES IN THE TRUCKLOAD SECTOR OF THE MOTOR CARRIER INDUSTRY

by

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December 2015

Advisor: Dr. Michael H. Belzer

Major: Economics

Degree: Doctor of Philosophy

Driver turnover remains a significant problem in the truckload sector of the motor carrier industry and has been linked to large truck crashes. Large truck crashes remain a significant problem in the truckload sector of the motor carrier industry. Employing a unique firm level data set from a large U.S. truckload motor carrier, this research showed that higher driver pay reduced driver exit rates, significantly reduced a driver's relative crash rate, reduced driver probability of sustaining a crash, and lowered the average cost of a crash for the cooperating firm.

This research identified two driver groups who were hired during two distinct pay regimes, where higher paid, experienced drivers in pay regime two experienced significantly improved driver retention rates at the firm. Experienced drivers also had lower average crash costs and were more productive during each tenure month. As a result, experienced drivers had a considerably larger expected discounted net present value when compared to inexperienced drivers. As the inexperienced drivers gained experience, their crash probabilities began to mirror those of the experienced drivers.

This research suggests that hiring quality drivers will reduce the quantity and severity of future crash incidents, increase driver retention, lowering the firm's overall costs; and allow for freight rates to reflect the true cost of carrying freight, reducing the externality imposed on society, and thereby creating value for the firm and for society.

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