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NOTHING GOOD HAPPENS AFTER DARK: THE INFLUENCE OF TEMPORAL FACTORS ON MOTOR CARRIER CRASH SEVERITY

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ABSTRACT

Motor carrier safety is a topic of great importance for both industry and makers of public policy. Regulatory agencies, such as the Federal Motor Carrier Safety Administration (FMCSA), regularly publish data detailing the circumstances surrounding roadway accidents. FMCSA's Large Truck and Bus Crash Facts (LTBCF) data demonstrate an increase in accidents during daylight hours and on weekdays. Roadway risks are ever-present but differ by time of day and day of the week. These differences may potentially engender crashes of different severities at different times. This study analyzes FMCSA LTBCF data to determine when crashes of different severities are more likely to occur. Findings indicate that crashes resulting in property damage are more likely to occur during the day and on weekdays. However, fatal and injury crashes are significantly more likely during nights and weekends. Recommendations to improve safety outcomes are provided along with suggestions for future research.

INTRODUCTION

The trucking industry is crucial to US economic success. Over 70% of the nation's freight moves by truck (Trucking.org, 2017) and trucking expenditures exceed that of the other four transport modes combined (CSCMP, 2017). Given trucking's size and importance, it comes as no surprise that a great deal of past research has been devoted to the industry. This research can be summarized into three overarching areas: operations and technology, people, and regulatory compliance.

A review of the literature based on the operations and technology perspective indicates that the majority of the research in this area has focused on topics such as carrier management (Hada and Kleiner, 2000; Overstreet, Hanna, Byrde, Cegielski and Hazen, 2013); cost control (Grimm, Corsi and Jarrell, 1989; Thomas and Callan, 1992); carrier productivity (Weber and Weber, 2004; Han, Corsi, and Grimm, 2008; Boyer and Burks, 2009; Villarreal, Garza-Reyes and Kumar, 2016); survival techniques (Grimm, Corsi and Smith, 1993; Voss, Cangelosi, Rubach and Nadler, 2011); and the adoption of technology (Cantor, Corsi and Grimm, 2006; Keller, 2006; Cantor, Corsi and Grimm, 2009). People oriented motor carrier research has generally focused on truck driver management and retention (Mejza, Barnard, Corsi and Keane, 2003; Mello and Hunt, 2009; Nadler and Kros, 2014), driver ethics (Douglas and Swartz, 2017), workplace violence (Anderson, 2004), the use of medical marijuana (Stringham, Allard, Knapp and Minor, 2017); and driver health (Lemke and Apostolopoulos, 2015; Hilliard, 2016; Olson, Wipfli, Thompson, Elliot, Anger, Bodner, Hammer and Perrin, 2016).

Interestingly, regulatory aspects of the motor carrier industry have received little recent research attention. Research in this area can be further divided into two time frames: pre-2000 and the impact of deregulation (Daicoff, 1988; Corsi, Grimm, Smith and Smith, 1992; Jerman and

Anderson, 1994) and post 2000 (motor carrier safety/security). Safety/security studies of interest include hours of service (Saltzman and Belzer, 2002), regulatory compliance (Flatow, 2000), the adoption of safety processes (Huang, Jeffries, Tolbert and Dainoff, 2017); and motor carrier security (Chang and Wu, 2015; Boone, Skipper, Murfield and Murfield, 2016).

Given the breadth and depth of the motor carrier literature, most investigations of temporal factors associated with safety have been limited to Federal and state-level studies. No recent business logistics articles of which we are aware examine accident probabilities and the temporal factors associated with safety incidents. Studies exist related to the temporal dimensions of motor carrier safety but few academic articles in the business logistics space analyze available data or offer useful conclusions to motor carrier managers. For instance, the subject of motor carrier safety, as it relates to nights and weekends, was hotly debated during recent discussions related to federal hours of service (HOS) regulations (FMCSA, 2017). This debate centered around a 2013 update to HOS regulations that limited drivers' ability to restart their 60/70 hour clock. This was accomplished by limiting drivers to one "34-hour restart" every 168 hours and dictating that this restart must include two nighttime periods including the hours of 1AM to 5AM. These provisions were eventually stricken in part due to trucking industry arguments that they forced drivers to operate in rush-hour traffic, which increases congestion and safety risk. Second order impacts with unintended consequences often occur when new regulations are implemented and the cost/benefits of these now repealed regulations are hotly debated.

Of course, risks occur more frequently when a subject is exposed to risk factors. In a roadway safety context, crash frequency is positively correlated with miles driven and traffic congestion (Knipling, 2009). Mileage and traffic congestion are greater during weekday, daylight hours (Hendrix 2002; ATRI 2014). However, other factors increase risk while driving on weekends and nights, when roadways are populated with a larger number of impaired automobile drivers (Knipling, 2009). The National Highway Traffic and Safety Administration (NHTSA, 2017) reported automobile drivers were impaired by alcohol in 27% of fatal light vehicle crashes.

Thankfully, most crashes are not fatal. Crashes are usually less severe and result in injury and/or property damage. However, no business logistics work of which we are aware assesses crash severity risk (e.g. fatal, injury, or property damage only) by time of day (e.g. day v. night) or day of the week (e.g. weekday v. weekend). This study draws from Federal Motor Carrier Safety Administration (FMCSA) data to explore the frequency and probability of fatal, injury, or property damage crashes by day of the week and time of day.

This study begins with a review of relevant literature related to motor carrier safety. The authors then discuss the methodology used to explore differences in crash severity by examining temporal factors. Results are subsequently presented. The authors then suggest implications for managers and how they may use study findings to improve safety performance. Limitations and implications for future research are presented followed by concluding remarks.

LITERATURE REVIEW

Motor vehicle crashes are an unfortunate reality in modern society. NHTSA (2017) reported that U.S. roadway accidents killed 37,461 people in 2016, an increase of 5.6% over 2015. Of those killed, only 4,317 (11.5%) resulted from an accident involving a large truck, and vehicles other than the truck are predominantly at fault in these fatal incidents (FMCSA, 2007). These statistics highlight the importance of government and private investments in roadway safety.

Investments in roadway safety are made in order to mitigate the severe economic, physical, and psychological harm caused by these incidents. NHTSA (2014) calculated that motor vehicle crashes cost the United States $871 billion a year. This includes $277 billion in economic costs and

$594 billion from death, pain, and suffering. The Federal Motor Carrier Safety Administration (FMCSA, 2008) found that the cost of an accident involving a large truck ranged between $334,892 and $7,633,600. Given the high cost of safety incidents, it is incumbent upon the motor carrier industry to understand the conditions under which most crashes occur. Most truck crashes occur on weekdays during daylight hours in clear conditions on dry roads (Knipling, 2009). There are three primary risk factors contributing to motor vehicle crashes: enduring driver characteristics (e.g. age, medical conditions, and susceptibility to fatigue), temporary driver characteristics (amount of sleep, illness, or moodiness that may lead to aggressive actions), and situational factors (e.g. traffic congestion, weather, and maintenance problems) (Knipling, 2009). These factors are important whether or not a truck is involved in the incident but, given the skill required to operate a commercial motor vehicle, their impact may be more pronounced when incidents involve a truck.

Time of day and day of the week are related to each of these factors. Driver fatigue more commonly manifests itself at night (Massie, Blower and Campbell, 1997) and may result from enduring or temporary driver characteristics. Some people are naturally more susceptible to fatigue and may have medical conditions, such as sleep apnea, that contribute to fatigued driving. Fatal fatigue related truck crashes generally involve only the offending truck, which frequently leaves the road (Massie, Blower and Campbell, 1997). Traffic congestion is more common during the day, particularly during weekday rush hours, and is positively related to the occurrence of safety incidents (Hendrix, 2002) as 85% of truck crashes involve other vehicles; overwhelmingly cars (Knipling, 2009). While night and weekend roads are less congested, they are more likely to be populated by impaired drivers. The Large Truck Crash Causation Study (LTCCS), undertaken as a collaboration between FMCSA and NHTSA, examined 1,000 large truck crashes between 2001 and 2003 and found that alcohol was used by 9.0% of car drivers but only 0.3% of truck drivers (FMCSA, 2007). Hendrix (2002) found the incidence of fatal light vehicle accidents begin rising at 10PM and peaked around 3AM.

Knipling's (2009) motor carrier safety textbook posits that government and academic research have neglected the importance of exposure data (e.g. number and timing of miles driven) when assessing roadway travel risk. The aforementioned literature demonstrates that different risks occur at different times and on different days. Drivers choose the hours of day in which to drive and must decide when to expose themselves and their equipment to roadway risks. Knowing the likelihood that an accident of a given severity will occur might help them make more informed decisions. This work draws from FMCSA data to explore whether fatal, injury, or property only crashes are more likely to happen during the daylight or night and weekday or weekend. Conclusions are supported using the odds ratio, a technique advocated by Knipling (2009), to assess the likelihood a given risk will result in certain outcomes.

METHODOLOGY AND RESULTS

FMCSA was established within the Department of Transportation (DOT) on January 1, 2000 (FMCSA, 2014). At that time, the FMCSA was tasked with commercial driver licensing, data and analysis, regulatory compliance and enforcement, research, technology, and safety assistance activities. Ultimately, the FMCSA's stated mission is to prevent commercial motor vehicle related fatalities and injuries (FMCSA, 2014). In an effort to educate the public, the FMCSA has published the Large Truck and Bus Crash Facts (LTBCF) analysis annually since 2010. LTBCF compiles descriptive statistics pertaining to truck crashes of different severities and draws from four major sources of information: NHTSA's Fatality Analysis Reporting System (FARS), NHTSA's General Estimates System (GES), FMCSA's Motor Carrier Management Information System (MCMIS), and Federal Highway Administration's (FHWA) highway statistics (FMCSA, 2017). This study utilizes LTBCF data from 2011 – 2015, which is the most recent year available. FMCSA requires accidents to be reported that involve a truck, bus, or any vehicle displaying a hazardous materials placard, if one of these vehicles was involved in a crash while operating on a roadway customarily open to the public, or if the accident resulted in fatality, injury or tow-away (FMCSA, 2015). When attempting to understand why these accidents occur and how to prevent them one must first understand when they occur. LTBCF data from 2015 are provided in Tables 1 and 2 below as an example. The information contained in Table 1 provides a comparison of the time of day in which accidents occurred and the severity of those accidents.

Table 1 demonstrates that fatal, injury, and property damage only accident rates are not uniformly distributed throughout the day. Rather, the occurrence of each type of accident is more or less normally distributed with the majority occurring between peak driving hours of 6AM and 6PM. Each year from 2011-2015 exhibited similar characteristics. Table 2 compares days of the week in which accidents occurred and the severity of those accidents.

Table 2 demonstrates that accident rates are not uniformly distributed throughout the week. Accidents of all severities occur more frequently during the work week and less frequently on the weekends. Each year from 2011-2015 exhibited similar

LTBCF data demonstrate a directional difference, with more of each accident severity category occurring during daylight hours and during the week. This would lead one to believe that accidents of any severity are more likely to occur on weekdays during daylight hours. However, this may be deceiving as it does not control for exposure. More people are driving during the day and during weekdays. More accidents occur as more people are driving. This is true for two basic reasons. First, as roads become more crowded, more vehicles are compressed into a given space. As compression increases, proximity between vehicles decreases, and the chance of contact between vehicles increases. Second, each driver has a given risk of being involved in an accident based on skill, mechanical factors, and other issues. For example, driver skill and accident risk would be inversely proportional. Even the most skilled drivers with the most mechanically sound vehicles bear some accident risk. As more people drive, more accidents will occur due to exposure to the accident risks of all drivers with whom the road is shared. Therefore, more people on the road leads to more accidents due to 1) greater compression and 2) more driving participants, which leads to more accidents due to exposure.

TABLE 1
2015 LTBCF DATA BY TIME OF DAY

Time of Day	Fatal Crashes	Injury Crashes	Property Damage Only Crashes
12am - 3am	279	3,000	7,000
3am - 6am	352	4,000	10,000
6am - 9am	578	16,000	55,000
9am - 12pm	569	15,000	71,000
12pm - 3pm	643	19,000	75,000
3pm - 6pm	552	16,000	66,000
6pm - 9pm	324	7,000	29,000
9pm - 12am	295	4,000	16,000
Daytime (6am - 6pm)	*2,342*	*65,000*	*267,000*
Nighttime (6pm - 6am)	*1,256*	*18,000*	*61,000*
Total	**3,598**	**83,000**	**328,000**

TABLE 2
2015 LTBCF DATA BY DAY OF THE WEEK

Day of Week	Fatal Crashes	Injury Crashes	Property Damage Only Crashes
Sunday	245	4,000	14,000
Monday	560	15,000	61,000
Tuesday	605	15,000	64,000
Wednesday	606	13,000	53,000
Thursday	631	16,000	58,000
Friday	598	13,000	56,000
Saturday	353	7,000	22,000
Total	**3,598**	**83,000**	**328,000**

Focusing on fatal accidents in 2015, Table 1 indicates that 2,342 fatal accidents occurred in the daytime compared to 1,256 at night. However, more daytime traffic engenders more accidents. The question remains, if you are involved in an accident, is this accident more likely to be fatal (injury, or property damage only) during the day or night? To answer this question, we must control for exposure.

Optimally, we would control for exposure by comparing the number of accidents per million miles driven (for example) on each day of the week/at each time of day. LTBCF does not provide this data. Given this, we chose to control for exposure by comparing a) the percentage of daytime fatal (injury, property damage only) accidents as a percentage of total daytime accidents to b) the percentage of nighttime fatal (injury, property damage only) accidents as a percentage of total nighttime accidents. Given that more of all accident types occur in daytime, comparing percentages affords a standardized measure to determine whether the likelihood of a fatal (injury, property damage only) accident is greater in day or night.

Summing all accident severity types in Table 1 across all daytime hours reveals 334,342 total daytime accidents; 2,342 of which were fatal (7%). Following the same procedure for nighttime crashes reveals 80,256 nighttime crashes; 1,250 of which were fatal (16%). Percentages were derived in a similar fashion for daytime and nighttime injury and property damage only crashes as well as weekday v. weekend fatal, injury, and property only accidents.

Percentages from 2011 – 2015 were combined, coded, and analyzed using ANOVA to determine if significant differences exist in the number of fatal, injury, and property only accidents that occur in the day v. night. Observations were coded as DAY if the accident occurred from 6AM – 6PM. Observations were coded as NIGHT if the accident occurred from 6PM – 6AM. This yielded a total of 20 DAY and 20 NIGHT observations (n = 40) for each accident severity type. Results for time of day x accident severity type are presented in Table 3.

Results indicate significant differences for all three types of crash severity. The mean column represents the percentage of all crashes during that time period that resulted in a given crash severity outcome. Of all the nighttime crashes, 2.16% resulted in a fatality. Fatal crashes make up a significantly larger percentage of all nighttime crashes than they do daytime crashes. (F = 42.317; p £ 0.01). Of all the nighttime crashes, 24.20% resulted in injury. Injury crashes comprise a significantly larger percentage of all nighttime crashes than they do daytime crashes (F = 11.135; p £ 0.01). Of all daytime crashes, 78.48% result in

TABLE 3
ANOVA COMPARNING CRASH SEVERITY PERCENTAGES BY TIME OF DAY

	Day or Night	Mean	Std. Deviation	N	F	p-value
Fatal	Day	0.83%	0.14%	20	42.317	0.000[a]
	Night	2.16%	0.90%	20		
Injury	Day	20.68%	1.77%	20	11.135	0.002[a]
	Night	24.20%	4.37%	20		
Property	Day	78.49%	1.84%	20	16.520	0.000[a]
	Night	73.64%	5.01%	20		

[a] Significant difference at $p \le 0.01$

property damage only. Property damage only crashes make up a significantly larger percentage of all daytime crashes than they do nighttime crashes (F = 16.520; p £ 0.01).

Following the same procedure utilized in the day v. night comparison, percentages for 2011 – 2015 were combined, coded, and analyzed using ANOVA to determine if significant differences exist in the number of fatal, injury, and property only accidents that occur on weekdays v. weekends. Observations were coded as WEEKDAY if the accident occurred from Monday to Friday. Observations were coded as WEEKEND if the accident occurred from Saturday – Sunday. This yielded a total of 25 WEEKDAY and 10 WEEKEND observations (n = 35) for each accident severity type. Results for day of the week x accident severity type are presented in Table 4.

Results indicate significant differences across all three types of crash severity. Of all the weekend accidents, 1.49% resulted in fatality. Fatal accidents make up a significantly larger percentage of all weekend accidents than they do weekday accidents (F = 47.528; p £ 0.01). Of all the weekend accidents, 23.94% result in injury. Injury crashes comprise a significantly larger percentage of all weekend accidents than they do weekday accidents (F = 8.112; p £ 0.01). Of all the weekday crashes, 78.15% result in property damage only. Property damage only crashes comprise a larger percentage of all weekday crashes than they do weekend crashes (F = 10.082; p £ 0.01).

Given the small sample size utilized in the analyses presented heretofore, we utilized the odds ratio technique to further support our findings. Knipling (2009, p. 50) advocates the use of odds ratios and

TABLE 4
ANOVA COMPARING CRASH SEVERITY PERCENTAGES BY DAY OF THE WEEK

	Weekday or Weekend	Mean	Std. Deviation	N	F	p-value
Fatal	Weekday	0.97%	0.16%	25	47.528	0.000[a]
	Weekend	1.49%	0.30%	10		
Injury	Weekday	20.88%	1.73%	25	8.112	0.008[a]
	Weekend	23.94%	4.72%	10		
Propert	Weekday	78.15%	1.82%	25	10.082	0.003[a]
	Weekend	74.56%	4.96%	10		

[a] Significant difference at $p \le 0.01$

describes them as, "…a derived statistic that estimates the relative risks of a crash [severity type] based on some other factor of interest [day v. night or weekday v. weekend]."

Knipling (2009, p. 50) provides an example of an odds ratio in use. Suppose a motor carrier with 100 drivers wishes to determine the impact of sleep apnea on accident frequency. Over a period of time, 11 company drivers were involved in accidents. Out of these 11 drivers it was determined that 6 had sleep apnea and 5 did not. Computing the odds ratio of crash involvement in this scenario requires comparing the odds of being in a crash for those who have sleep apnea to those who do not. The company is said to have 26 drivers with sleep apnea, 6 of whom were involved in an accident. This leaves 74 drivers without sleep apnea, 5 of whom were involved in an accident. Knipling (2009) structures the aforementioned scenario as follows:

$$\textbf{Sleep apnea odds ratio} = \frac{6/20}{5/69} = \frac{0.30}{0.07} = 4.1$$

In this example, the odds of an accident given that a driver has sleep apnea is 4.1. Values greater than 1.0 indicate greater risk is associated with the factor. Values less than 1.0 indicate less risk associated with the factor. Greater deviations from 1.0 indicate more/less risk.

Tables 3 and 4 indicate that accidents are more likely to be fatal or injurious on nights and weekends. Therefore, we placed night and weekend data in the numerator indicating it is the risk factor for which the odds ratio is quantifying. The odds ratio calculation for 2015 weekend v. weekday fatal crashes is provided below as an example.

Results for 2011 – 2015 are presented in Table 5.

Results presented in Table 5 indicate that fatal accidents are more likely to occur on nights and weekends for each year from 2011 – 2015. Injury accidents were more likely to occur on nights and weekends in 2015, 2013, and 2012 as well as weekends in 2011. Injury accidents were less likely to occur on nights and weekends in 2014 and less likely to occur on nights in 2011. Property damage was less likely to occur on nights and weekends in 2015, 2013, 2012, and 2011. Property damage was more likely to occur on nights and weekends in 2014.

IMPLICATIONS

Results presented in this study indicate statistically significant differences between the likelihood of different accident severities across nights v. days and weekends v. weekdays as a function of the total accidents that occur in each time period. As a percentage of total accidents during a respective time period, accidents involving a fatality or injury are more likely to occur on nights and weekends. Accidents involving property damage only are more likely to occur on days and weekdays. These results may have important managerial implications.

Roadway traffic congestion is greatest during weekday daylight hours and especially in peak, rush hour drive time (ATRI, 2014). Over the road commercial motor vehicles are often compensated on a per mile basis. Congestion reduces the number of miles a truck can travel in a given period of time.

2015 Weekend v. Weekday Fatal Accident

$$= \frac{\text{Total Fatal Weekend Accidents/(Total Weekend Accidents – Total Fatal Weekend Accidents)}}{\text{Total Fatal Weekday Accidents/(Total Weekday Accidents – Total Fatal Weekday Accidents)}}$$

$$= \frac{598/(47{,}598 - 598)}{3{,}000/(367{,}000 - 3{,}000)} = 1.54$$

TABLE 5
ODDS RATIO BY TIME AND ACCIDENT SEVERITY

		Fatal	Injury	Property
2015	**Night/Day**	2.24	1.18	0.86
	Weekend/Weekday	1.54	1.23	0.80
2014	**Night/Day**	2.29	0.93	1.02
	Weekend/Weekday	1.43	0.76	1.27
2013	**Night/Day**	2.12	1.20	0.81
	Weekend/Weekday	1.56	1.47	0.67
2012	**Night/Day**	2.33	1.27	0.71
	Weekend/Weekday	1.65	1.21	0.80
2011	**Night/Day**	2.39	0.74	0.71
	Weekend/Weekday	1.45	1.30	0.76

Sharing the road with fewer drivers is also perceived to improve safety. Therefore, drivers' common sense often dictates a preference to operate on nights and weekends in the interest of maximizing compensation and perceived safety performance.

Raw FMCSA data demonstrate that a larger number of accidents, regardless of severity, occur on weekday days. A disproportionate number of these accidents result in property damage without injury or fatality. However, outcomes differ when controlling for exposure (e.g. the total number of accidents). In this context, our results indicate that accidents occurring at night or on weekends are significantly more likely to result in death or injury compared to accidents that occur during the day. Accidents occurring during the day or on weekdays are significantly more likely to result in property damage only.

Counterintuitively, traffic congestion may actually reduce accident severity. Newton's second law states that force is a function of mass and acceleration. Force increases as the speed of an object with a given mass increases. Greater force increases accident severity. Congestion slows traffic (ATRI, 2014) and, therefore, reduces the force involved in accidents that occur. Therefore, congestion may also reduce accident severity during day and weekdays as demonstrated in our study.

Decreased congestion allows trucks to travel at higher average speeds. Higher speeds allow trucks to increase daily revenue. However, should an accident occur, higher speeds increase accident severity. Increased speed may contribute to the increased severity of night and weekend accidents.

The population of inebriated drivers also increases on nights and weekends. Commercial truck drivers are not often found to be under the influence of alcohol when a fatal accident occurs. NHTSA reported that 2.7% of commercial truck fatal crashes involved alcohol use by the truck driver. Car drivers were impaired by alcohol in 27% of fatal light vehicle crashes (NHTSA, 2017). Blower (1998) studied driver error in accidents involving cars and large trucks. Results indicate that the car driver was at fault in 71% of accidents. The increased presence of impaired car drivers during night and weekend hours likely increases truck accident severity.

Drivers should consider these results when planning their trips. Drivers should not take advantage of decreased congestion and travel at unsafe speeds. Caution should be taken to maintain speeds that are safe for conditions. Drivers should also more carefully weigh the tradeoffs of exposure as it relates to day v night and weekday v. weekend driving. Reduced congestion inherent to night and weekend driving increases profitability, but there is also a significantly increased risk of fatal or injurious accident during these times when compared to days and weekdays.

Safety managers should also consider exposure when setting company policy. Any safety incident is detrimental. However, insurance carriers often dictate safety managers reduce certain types of incidents (e.g. property damage, injury only, or catastrophic fatality losses). Safety managers may use the principals of exposure explained heretofore as a lever to influence safety outcomes. Given an overabundance of past property damage or injury only incidents, safety managers may wish to control for excess exposure to other vehicles and encourage drivers to operate at night or on weekends. However, if faced with the need to reduce catastrophic losses, safety managers may encourage drivers to operate during the day or on weekdays.

LIMITATIONS AND FUTURE RESEARCH

This study is faced with several limitations. First, real-time information cannot be gleaned from the FMCSA LTBCF data due to the two-year delay in its release. However, given the relative stability of accident severity odds ratios presented in Table 5, it is likely that our findings remain applicable today.

Next, secondary data was used in this study. The validity of our results is subject to the practices of those who collect and code the LTBCF data. Finally, small sample sizes employed in our analysis inhibit generalizability. Future investigations should seek to collect more data or obtain larger datasets.

Future investigations should also uncover reasons behind increased night and weekend accident severity. We posit that increased speed and impaired light vehicle drivers play a significant role. However, LTBCF data do not contain information that would allow us to substantiate this theory.

Data limitations also prevented the examination of covariates. Our results would imply that accidents are most severe on weekend nights. Future research should examine this possibility.

Motor carrier safety research is relatively lacking in the business logistics literature. The large volume of available, secondary data makes this a potentially fruitful area for further inquiry. Researchers wishing to collect primary data may wish to define a new "driver deviance" construct and assess its impact on safety performance. Deviant behavior (e.g. such as speeding, poor maintenance practices, and log book violations) have been shown to influence safety outcomes. This research should seek to uncover characteristics of drivers that are more likely to result in bad behavior, and how these drivers can be avoided in the hiring process.

CONCLUSIONS

Safety is of paramount importance to motor carrier operations. However, safety is multi-faceted and not easily achieved. Drivers must operate in a safe manner. Management must put drivers in a position to operate safely by, for instance, scheduling delivery appointments that can be legally achieved in accordance with posted speed limits and Federal HOS regulations. Drivers must also be aware and wary of those with whom they share the road.

Our results demonstrate that safety outcomes differ by time of day and day of the week. However, the clock and calendar do not determine roadway safety. Safety outcomes are primarily determined by human choices. These choices differ by the temporal factors examined herein. These temporal factors are but a small subset of those contributing to the thousands of deaths that occur annually on American roads. Safety is a shared responsibility and one that is equally important at every hour on every day.

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