MEASURING THE IMPACTS OF COVID-19 ON THE TRUCKING INDUSTRY: A SPATIAL AND ECONOMETRIC FRAMEWORK TO CAPTURE THE IMPACTS OF THE HOURS-OF-SERVICE EMERGENCY DECLARATION AND CONGESTION EFFECTS ON TRUCK DRIVER SAFETY

FINAL PROJECT REPORT

by

Salvador Hernandez
Brianna Velasquez
Oregon State University

Sponsorship
PacTrans, Oregon State University

for

Pacific Northwest Transportation Consortium (PacTrans)
USDOT University Transportation Center for Federal Region 10
University of Washington
More Hall 112, Box 352700
Seattle, WA 98195-2700

In cooperation with U.S. Department of Transportation,
Office of the Assistant Secretary for Research and Technology (OST-R)

Disclaimer

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated under the sponsorship of the U.S. Department of Transportation's University Transportation Centers Program, in the interest of information exchange. The Pacific Northwest Transportation Consortium, the U.S. Government and matching sponsor assume no liability for the contents or use thereof.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle

Measuring the Impacts of COVID-19 on the Trucking Industry:
A Spatial and Econometric Framework to Capture the Impacts of the Hours-of-Service Emergency Declaration and Congestion Effects on Truck Driver Safety

5. Report Date

May 2021

6. Performing Organization Code

7. Author(s) and Affiliations

Salvador Hernandez 0000-0001-8160-5949; Brianna Velasquez
Oregon State University

8. Performing Organization Report No.

2020-COV-OSU-4

9. Performing Organization Name and Address

PacTrans
Pacific Northwest Transportation Consortium
University Transportation Center for Federal Region 10
University of Washington More Hall 112 Seattle, WA 98195-2700

10. Work Unit No. (TRAIS)

11. Contract or Grant No.

69A3551747110

12. Sponsoring Organization Name and Address

United States Department of Transportation
Research and Innovative Technology Administration
1200 New Jersey Avenue, SE
Washington, DC 20590

13. Type of Report and Period Covered

Research

14. Sponsoring Agency Code

15. Supplementary Notes

Report uploaded to: www.pactrans.org

16. Abstract

This project quantitatively studied the significant effects of the Coronavirus 2019 pandemic on truck drivers and the trucking industry. A stated-preference survey distributed to truck drivers collected data regarding changes in the demographic, socioeconomic, business, temporal, management, and truck configuration characteristics of the trucking industry. A total of 47 paired variables were generated from the driver survey responses. Their medians were tested for a statistically significant difference through a rank-sum procedure, through which 13 of the comparisons showed significant change during the pandemic. Of the 520 respondents, 243 (34 percent) indicated that roads were more safe during the pandemic. This study also revealed changes in trucking operations and driver behavior as a result of the relaxation of trucking hours-of-service limitations.

17. Key Words	18. Distribution Statement		
COVID-19; Hours-of-service regulations; Truck drivers; Road safety; Freight Transportation			
19. Security Classification (of this report)	**20. Security Classification (of this page)**	**21. No. of Pages**	**22. Price**
Unclassified.	Unclassified.		N/A

SI* (Modern Metric) Conversion Factors

APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: volumes greater than 1000 L shall be shown in m^3			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

Table of Contents

List of Figures

List of Tables

List of Abbreviations

ATRI: American Transportation Research Institute

CDL: Commercial driver license

CMV: Commercial motor vehicle

COVID-19: Coronavirus Disease 2019

DOT: Department of transportation

FHWA: Federal Highway Administration

FMCSA: Federal Motor Carrier Safety Administration

HOS: Hours of service

NATSO: National Association of Truck Stop Operators

OOIDA: Owner-Operator Independent Driver Association

PacTrans: Pacific Northwest Transportation Consortium

RIA: Regulatory impact analysis

SAFETEA-LU: Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users

Acknowledgments

This work has been funded by the US Department of Transportation's University Transportation Center program, Grant #69A3551747110, through the Pacific Northwest Regional University Transportation Center (PacTrans). The authors would like to thank PacTrans for its support. The authors also want to thank the University of Arkansas for its collaboration on the survey.

CHAPTER 1. Introduction

1.1. Background

On March 13, 2020, the United States was declared in a national emergency because of the outbreak of the Coronavirus Disease 2019 (COVID-19). The country began to shut down, and stay-at-home orders were activated in most states. Massive runs on essential goods such as non-perishable food, cleaning products, and medical supplies significantly affected the operations of the freight industry, trucking in particular. The sudden surge in consumer demand for essential goods strained supply systems that relied on regional distribution centers and daily deliveries (Haake, 2020; Del Gatto and Cons, 2020; Desai, 2020). To support motor carriers and truck drivers involved in emergency relief efforts, federal and state government agencies instituted regulatory rule changes in trucking operations. The Federal Motor Carrier Safety Administration (FMCSA) enacted the National Emergency Declaration for commercial motor vehicles (CMVs) delivering essential goods (Federal Motor Carrier Safety Administration, 2020). This is the first time the Agency has issued nationwide relief for truck drivers. As a result of this change, truck drivers were no longer required to take a 30-minute break, have a regular 34-hour restart, or need to fulfill recordkeeping requirements. FMCSA continued to extend and modify the exception throughout the duration of the pandemic, mostly to revise the eligible items or industries as part of the emergency list (Ahart, 2021). In addition, multiple state departments of transportation (DOTs) lifted truck size restrictions and weight limits to accommodate larger shipments of goods (Lamb, 2020). As the pandemic continues, the impacts of the relaxation of hours of service (HOS) remain uncertain for trucking operations and road safety.

At the same time, the spread of COVID-19 and the restrictions implemented in response to it (e.g., stay-at-home orders, social distancing mandates, business closures) also had unprecedented effects on the trucking industry. For example, many restaurants and rest areas

critical to truck drivers closed, leaving many drivers without the opportunity to rest or buy food (Roberts, 2020). For this reason, the Federal Highway Administration (FHWA) encouraged state DOTs to temporarily waive federal regulations prohibiting commercial activities on the Interstate system to allow food trucks to operate at rest areas (Federal Highway Administration, 2020). And while panic buying and the demand for essential goods initially caused truck volumes to surge in some portions of the freight market, other segments of the industry suffered from a drastic drop in demand as many retailers, manufacturers, restaurants, and other businesses across the country temporarily slowed or shut down production. As of December 2020, 140,000 truck drivers had lost their jobs (U.S. Bureau of Labor Statistics, 2020). Also, fewer cars and commuters on the roads meant the elimination, at least temporarily, of truck bottlenecks across the nation (Haake, 2020). Combined with the pressure to deliver shipments quickly, speeding and unsafe driving practices were a growing concern. The American Transportation Research Institute analyzed the nation's top truck bottlenecks in March 2020 and found that average truck travel speeds increased by as much as 25 miles per hour (American Transportation Research Institute, 2020).

1.2. Need for Study

This study sought to uncover the effects of the COVID-19 pandemic and associated restrictions to better understand the impacts of the Hours-of-Service Emergency Declaration on truck drivers. The results from a stated-preference survey distributed to truck drivers during the pandemic were utilized to capture truck drivers' perceptions of the trucking industry before and during the COVID-19 pandemic. The findings of this study will provide insight into changes in the trucking industry due to regulatory rule changes during events like the pandemic or similar system disruptions. Identifying these changes in the industry can shed light on certain driver

behaviors, and the demographic, work, temporal, and management characteristics most affected by the pandemic. Even more, understanding these changes can help ensure that essential goods and supplies are delivered in a timely and safe manner during a pandemic without causing undue harm to the drivers who transport those goods.

CHAPTER 2. Literature Review

2.1. Trucking Industry Disruptions

To study the impacts of the COVID-19 pandemic on the trucking industry, the American Transportation Research Institute (ATRI) and the Owner-Operator Independent Driver Association (OOIDA) Foundation have collaborated to lead the research. Together they investigated the immediate operational impacts that the pandemic has had on trucking operations in the U.S.

In a preliminary analysis, ATRI analyzed trucking activity in California, Florida, Illinois, New York, Pennsylvania, and Washington state that took place from February 9, 2020, through April 18, 2020 (American Transportation Research Institute, 2020). It utilized real-time truck GPS data and converted those into a trucking activity index to determine trucking activity. The data showed that in the early stages of the pandemic, from early February into March, there was a spike in trucking activity in all the states analyzed. This was expected because of the sudden surge in demand for essential goods across the country. The analysis also reflected the impacts of the enacted COVID-19 restrictions that shut down major segments of the economy. By April, trucking operations in all states began to decline. Among the six states, California was the first to implement a statewide stay-at-home order, and it was the first to experience an initial increase in trucking activity in early March. However, the spike in activity lasted only three weeks. California's trucking activity dropped 8.3 percent from February. Florida, Illinois, and New York also saw spikes in trucking activity the week of March 8, but by April that activity had decreased over 10 percent from the starting point of the analysis. Similarly, trucking activity in Pennsylvania and Washington suddenly increased during the week of March 15, but then it decreased 9 percent, on average, by April. These results clearly capture the initial impact on trucking activity.

Following this preliminary analysis, ATRI and OOIDA jointly developed a trucking industry-targeted survey to gain a better understanding of changes in specific areas of trucking operations, including deliveries, travel times, detention, and truck parking (The American Transportation Research Institute and The OOIDA Foundation, 2020). The survey was able to capture the assessments and perspectives of multiple labor categories in trucking, from truck drivers to dispatchers to senior executives. In total, nearly 5,100 survey responses were collected and deemed usable to be analyzed. Nearly 50 percent of respondents described freight levels as "somewhat lower" to "much lower" than pre-pandemic levels, while 28 percent reported no change. Approximately 22 percent of respondents described freight levels as being "somewhat higher" to "much higher" than normal. These were likely drivers transporting essential goods.

Further analysis of the responses provided evidence of changes in the trucking industry as a result of the pandemic. Long-haul demand significantly decreased because of a massive reduction of container imports, and this caused a shift toward local trucking. Local trips under 100 miles more than doubled by April. Detention times were also affected; 34 percent of respondents indicated that their loading/unloading times had increased, and only 12 percent indicated their loading/unloading times had decreased. The respondents also confirmed that average traffic congestion delays decreased significantly; nearly 87 percent indicated that congestion was either "much shorter" or "somewhat shorter." In addition, it was noted that the discrepancies among responses for truck parking were small. Approximately 44 percent of respondents indicated that parking was "somewhat harder" or "much harder" to find, while slightly more than 40 percent of respondents said that locating truck parking was not any worse during the pandemic. Overall, the survey revealed some of the critical impacts on trucking operations from the onset of the COVID-19 pandemic. Still, the data revealed that almost 80

percent of owner-operators and small fleets reported not having any plan in place for managing operations during natural disasters. That is, there was a clear lack of information and resources for the trucking industry for times of unpredictable events. This research will provide insight into how truck drivers behaved during the COVID-19 pandemic to help in developing targeted policies and regulations that will support the trucking industry without compromising safety.

2.2. Regulatory Rule Changes

The pandemic prompted the first significant overhaul of federal HOS regulations in over 15 years. Before the pandemic, the rules were largely unchanged until April 2003, when the FMCSA implemented new rules to amend several notable deficiencies in the old rules. The new HOS rules included several changes primarily designed to promote greater daily sleep and to encourage more regular daily work–rest cycles, including increased daily and weekly maximum driving limits and daily off-duty requirements (Federal Register, 2005).

McCartt et al. (2008) used survey-based data to assess changes in long-distance truck drivers' reported work schedules and reported driving while fatigued after the new rule went into effect. A sample of long-distance truck drivers from Oregon and Pennsylvania were interviewed in three phases: immediately before the rule change (November - December 2003), about one year later (November - December 2004), and then two years after the change (November - December 2005). According to the survey, drivers reported substantially more hours of driving after the rule change because of more drivers regularly using the new restart provision, which allows a substantial increase in weekly driving. The survey also revealed that the frequencies of reported driving while fatigued under the old and new rules were similar. Between 2003 and 2004, before the rule change, reported incidents of falling asleep at the wheel of the truck increased. The same trend was noticed after the rule change, between 2004 and 2005, suggesting

that the rule change may not have been successful at reducing fatigued driving. In 2005, 20 percent of drivers reported falling asleep at the wheel within the past month. It is important to note the survey was conducted during one of the busiest months of the year for truck drivers. When drivers were asked about delivery schedules, less than one out two truck drivers reported that they were always realistic. Truck drivers who reported that they were sometimes or often given unrealistic delivery schedules were approximately three times as likely to violate the work rules than drivers who rarely or never have to deal with unrealistic delivery schedules.

In 2005, the FMCSA conducted an overarching regulatory impact analysis (RIA) of the recently revised regulations (Federal Register, 2005). The RIA evaluated and compared four different regulatory options. The first option was to retain the regulations that were implemented in the 2003 rule change. These regulations served as the baseline for comparison to estimate how often a driver would not be able to perform the same driving tasks if stricter rules were in place. The other options included the updated regulations that were implemented in July 2013, and two variants of the new regulations in which the daily driving time limit was reduced to 10 hours or 9 hours. Truck drivers' typical operating patterns were analyzed, and drivers were categorized according to their average weekly work time. On the basis of this classification of drivers and their share in the industry, estimates were made regarding how a change in HOS regulations would affect the schedules of truck drivers with respect to productivity, accident risk, and occupational health.

2.3. Dependent Likert Scale Data Analysis

The questions regarding the changes from before and during the pandemic were posed using a Likert scale to capture a holistic view of the drivers' opinions. Because of the limited range and dependency of variables in these data, the assumptions of most parametric tests were

violated. Derrick and White (2017) described the possible data analyses for Likert scale data and compared their statistical power. For paired data, they concluded that when sample sizes are large, there is little practical difference in the conclusions drawn from the paired samples t-test, the Wilcoxon test, or Pratt's test. Therefore, given the current goal to assess changes in the trucking industry before and during COVID-19, the most appropriate statistical analysis model for this study was the Related-Samples Wilcoxon Signed Rank test.

The application of this test is rather rare in the field of transportation; nevertheless, critical developments in transportation research have been made because of it. Mokhtarian et al. (2002) used the Wilcoxon signed-rank test to compare paired-matched data on improved and unimproved highway segments in California to investigate the notion of "induced demand" in connection with highway expansion projects. Their implementation of the Wilcoxon test controlled for any background influencing factors that could cause increases in traffic (e.g., population growth, economic activity, and behavioral or life-style changes), and any differences in traffic growth between improved and unimproved segments were attributed to induced demand. Ohlms and Kweon (2018) evaluated the effects of two bike boxes and two turn boxes at an intersection by assessing volume counts and the number of traffic infractions and conflict events before and after their installation. The results identified the types of infractions and intersection approaches that changed the rates of traffic infractions.

CHAPTER 3. Data Collection

This study utilized a stated preference survey of truck drivers collected nationally to capture operational and behavioral patterns before and during the COVID-19 pandemic. The survey was administered through the University of Arkansas by utilizing the online electronic survey instrument Qualtrics. Survey data were collected near the height of social distancing and stay-at-home orders in the U.S., between May 25, and June 1, 2020. Completing the survey was voluntary, but to participate respondents must have been at least 18 years of age, held a commercial driver's license (CDL), and been operating their commercial motor vehicle for more than a year and also during the COVID-19 pandemic.

The survey included 61 questions divided into eight topics. The breakdown of questions within each topic area are presented in table 3.1.

Table 3-1 Survey questions by topic

Topic Area	Type of Questions	Number of Questions
Socioeconomic Characteristics	Driver age, gender, income, years of experience, pay type, education, company type	10
Business Characteristics	Company size, trips per week, distance per trip, origins and destinations of trips	11
Driver Characteristics	Type of shipment, team driving, decisions for parking	7
Driving Characteristics	Risk tolerance, concentration	3
Safety Perceptions	Road Safety, Citation	4
Time of Day Operations	Trip start time, parking difficulties, HOS challenges, service disruptions at private and public rest stops, real time parking	14
Driving Management	Driving hour restrictions, fatigue management, electronic logging device	8
Truck Configuration	Truck configuration, commodity carried	4

Participants were provided an incentive for completing the survey. A total of 521 responses were gathered through a non-probability internet opt-in panel of commercial truck drivers (18 years and older) who had used a public or private truck stop and who were driving during the pandemic. To determine the sample size needed for a desired 95 percent confidence level, the following equation was used (Smith, 2013):

$$n = \frac{z^2 \times p \times (1-p)}{MoE^2} \quad (1)$$

where z is the critical value corresponding to the level of confidence, or 1.96 in this case; p is an estimated value of proportion; and MoE is the desired margin of sampling error. The most conservative estimate of p is 0.5. It assumes half of the population will answer positively and negatively to a posed question (Dillman et.al., 2014). And the acceptable margin of error is the difference between 1 and the desired level of confidence, or 0.95. Therefore, applying these values to Eq. (1), the required sample size for a 95 percent confidence level was 475. As mentioned previously, the survey resulted in 521 valid responses, which exceeded this minimum requirement. Therefore, inferences could be made from this survey with over 95 percent confidence. To ensure we got a random population sample, the origins of the surveyed drivers were included in the survey, and they are presented in figure 3.1.

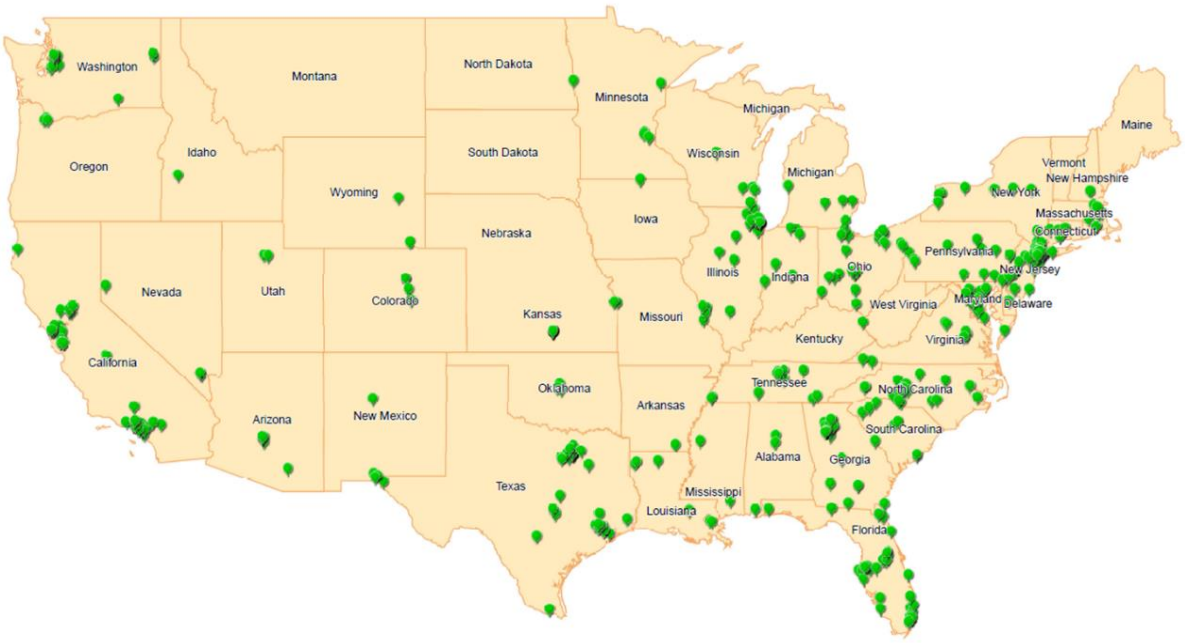

Figure 3.1 Spatial distribution of survey responses

3.1. Survey Results

This section contains an overview of responses to some critical questions in the survey that help explain the impacts of the pandemic on truck drivers and the trucking industry.

3.1.1. Socioeconomic Characteristics

Socioeconomic characteristics were analyzed to depict common traits among the surveyed drivers. Figure 3.2 displays the distribution of driver gender among the respondents. Approximately two-thirds of the respondents were male.

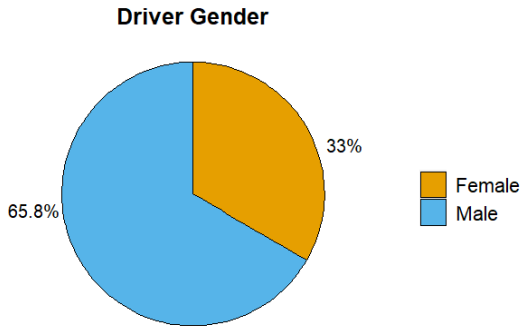

Figure 3.2 Respondents by driver gender

Figure 3.3 reveals that nearly 70 percent of the respondents were under the age of 40; 33.7 percent were from 18 to 29 years old, and 35.4 percent were from 30 to 39 years old.

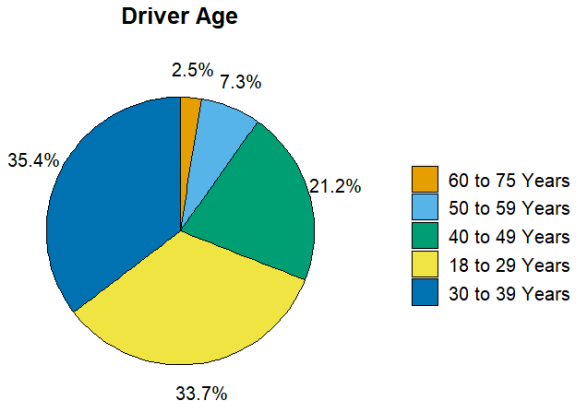

Figure 3.3 Respondents by driver age

Figure 3.4 shows that approximately 39 percent of surveyed drivers had between two and three years of experience driving a truck, while 36 percent had six to ten years.

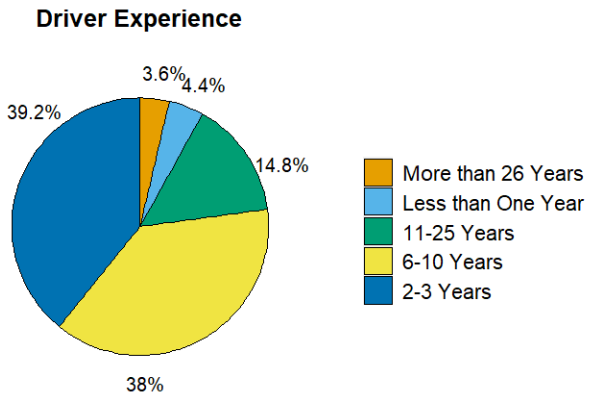

Figure 3.4 Respondents by driver experience

Figure 3.5 illustrates the highest completed level of education that drivers had. The majority of respondents had completed a secondary dipolma/degree (38.8 percent), high school/technical school (22.8 percent), and a trade or technical certificate (19.8 percent).

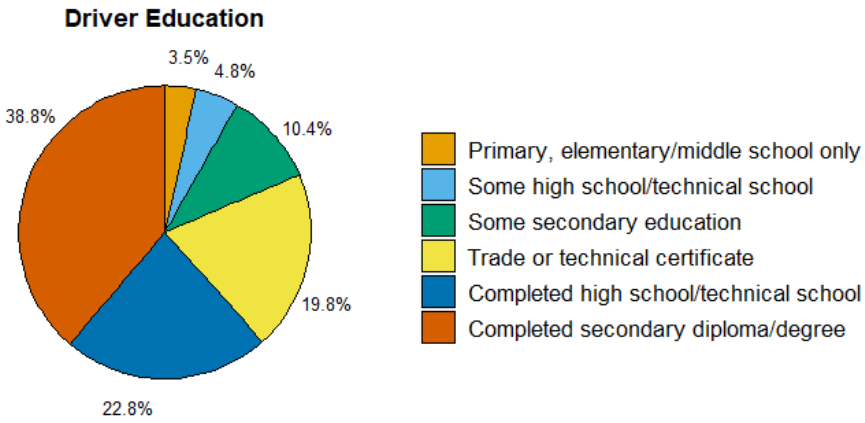

Figure 3.5 Respondents by driver education

Next, socioeconomic characteristics related to operations were analyzed to gain a better understanding of the surveyed drivers and the industry. As shown in figure 3.6, 40 percent of the respondents worked both for-hire and for private carriage, 34.4 percent worked for private

carriage, and 23.7 percent worked for-hire. Also, the majority of drivers, nearly 79 percent, reported receiving hazard pay during the current pandemic (figure 3.7). Figure 3.8 shows the breakdown of company types that offered hazard pay. Among the drivers that did not receive hazard pay, the majority drove for-hire and private, but 28 percent of private carrier drivers received hazard pay versus only 18 percent of for-hire drivers.

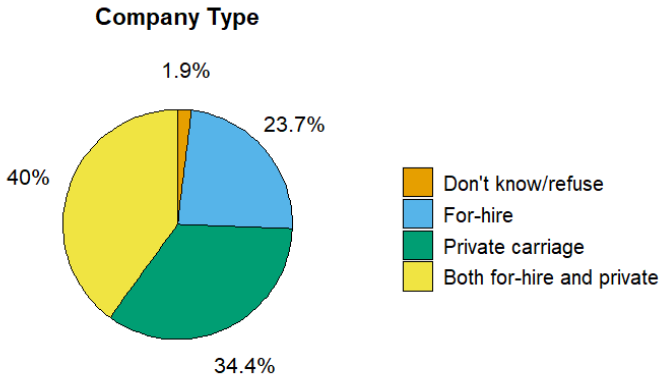

Figure 3.6 Respondents by company type

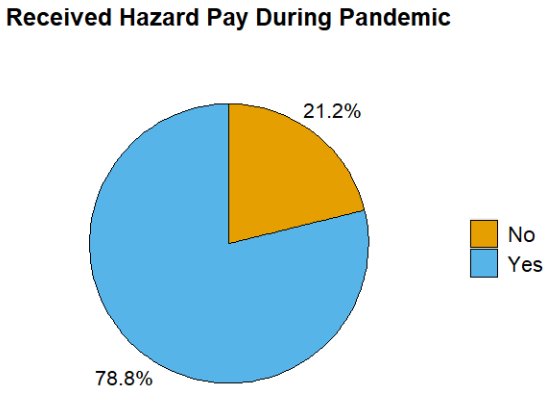

Figure 3.7 Respondents by hazard pay

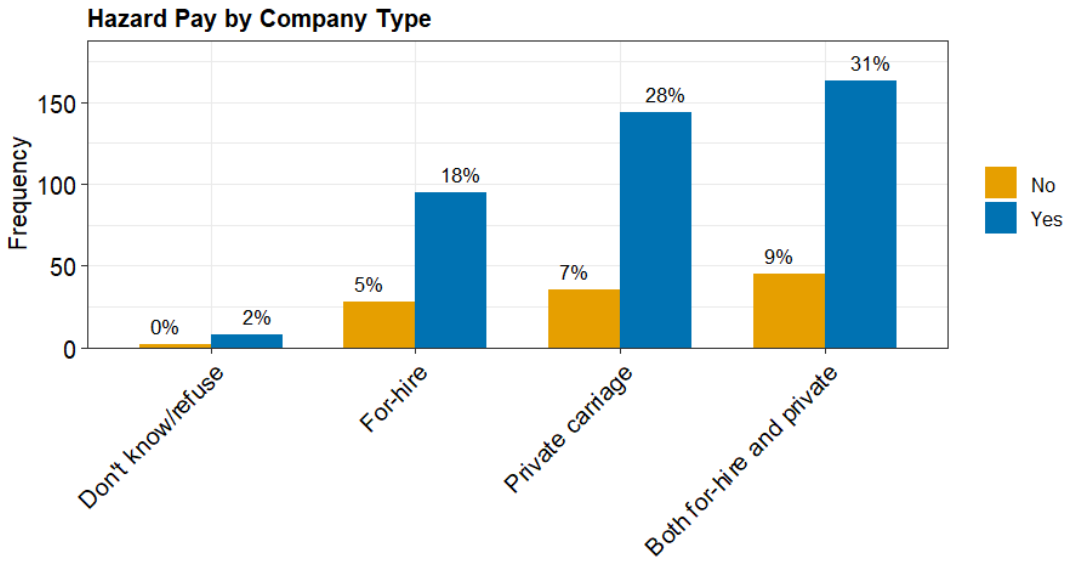

Figure 3.8 Hazard pay by company type

3.1.2. Business Characteristics

Approximately 57 percent of respondents reported making between four and ten freight-related trips per week before the pandemic, with 29 percent reporting making four to five trips and 27 percent reporting making six to ten trips per week (figure 3.9). As a result of the pandemic, 31 percent of drivers reported making fewer weekly trips, whereas 47 percent of drivers reported making more trips, as shown in figure 3.10.

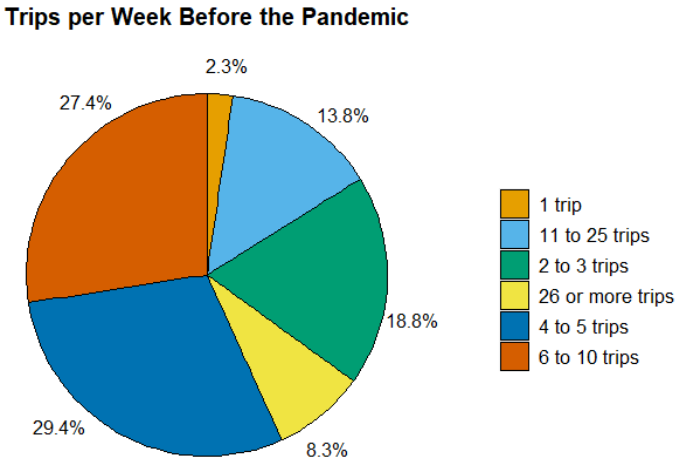

Figure 3.9 Trips per week before the pandemic

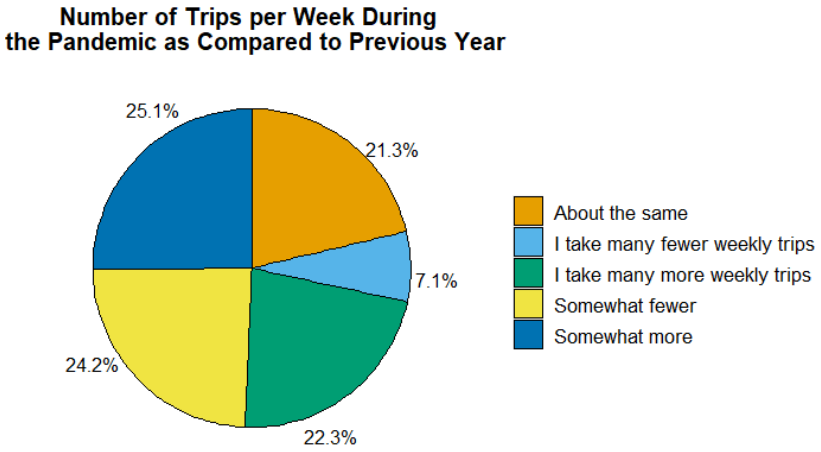

Figure 3.10 Changes in weekly trip rate as a result of the pandemic

Respondents were also asked about the origins and destinations of the majority of their trips before and during the pandemic. Figures 3.11 and 3.12 show that the highest numbers of reported trip origins and destinations were in the Ohio Valley region: 13 percent of trip origins before the pandemic and 14 percent during the pandemic; 15 percent of trip destinations before the pandemic and 14 percent during the pandemic. Ranking the change in the number of responses of origins before and during the pandemic revealed that the largest shift was observed in the Upper Midwest region, a difference of 2 percentage points. And by ranking the change in the number of responses for destinations before and during the pandemic, the largest shift, also a 2 percentage points difference, was observed in the the California, South Texas, and Upper Midwest regions, as seen in figures 3.13 and 3.14.

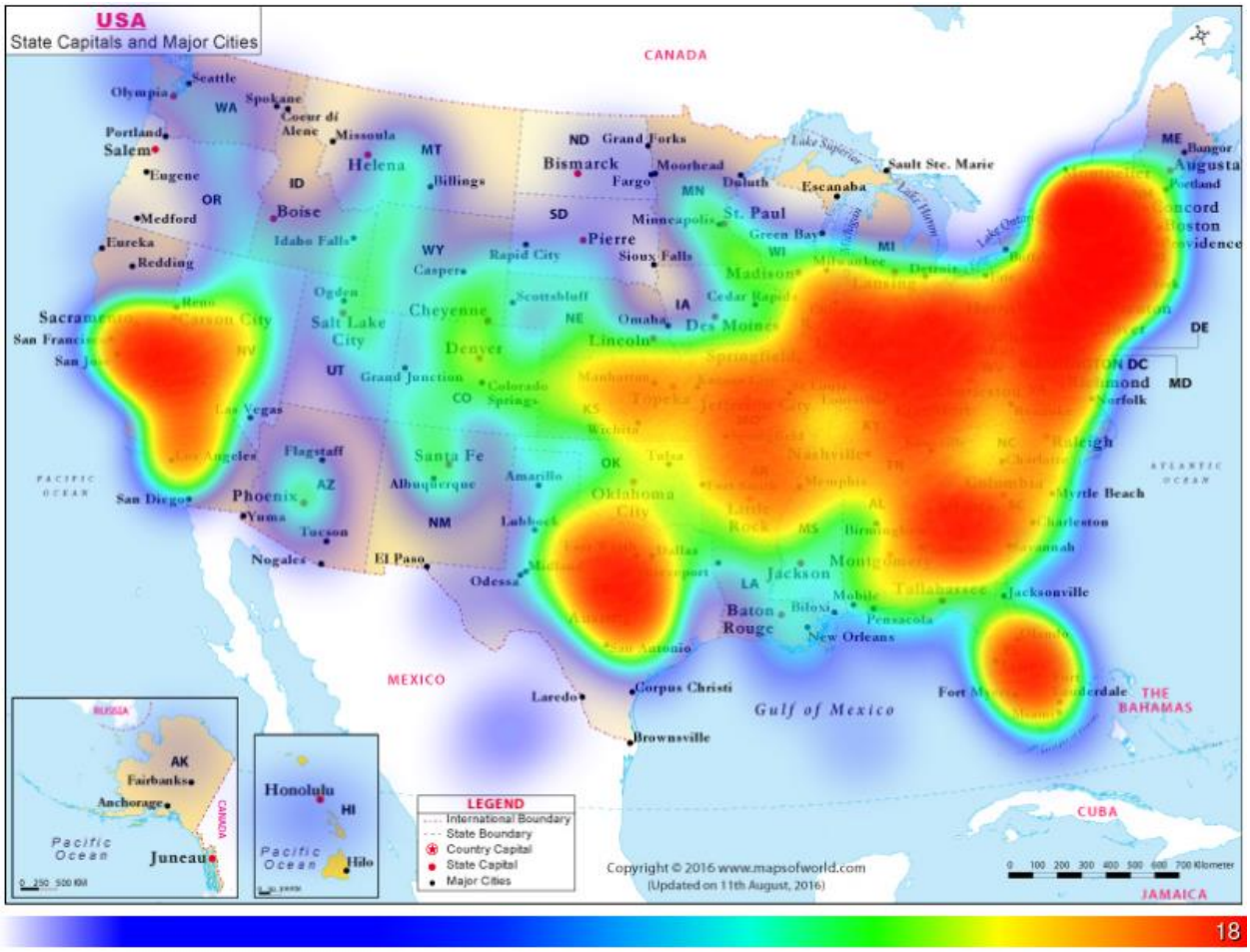

Figure 3.11 Origins of trips before the pandemic

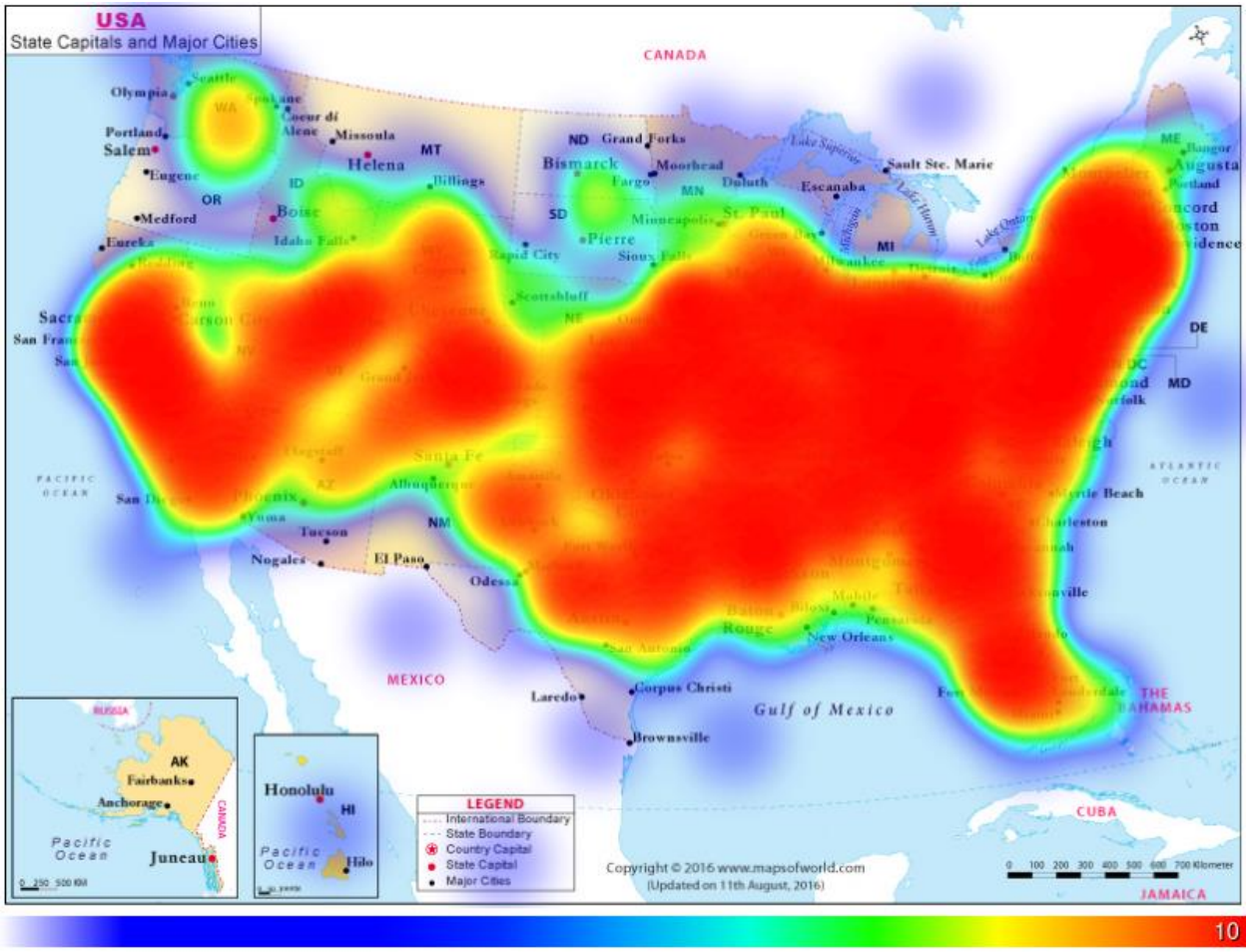

Figure 3.12 Origins of trips during the pandemic

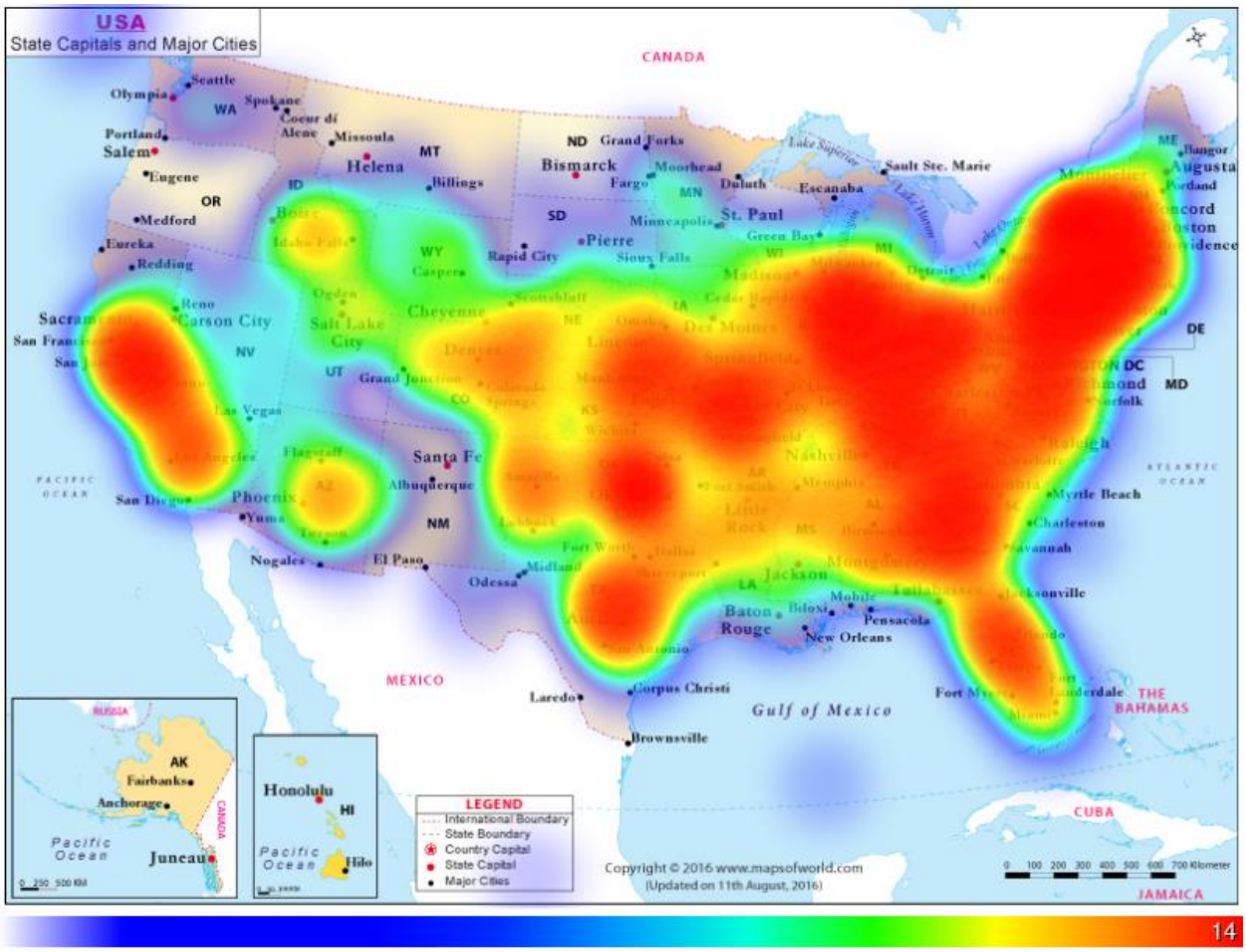

Figure 3.13 Destinations of trips before the pandemic

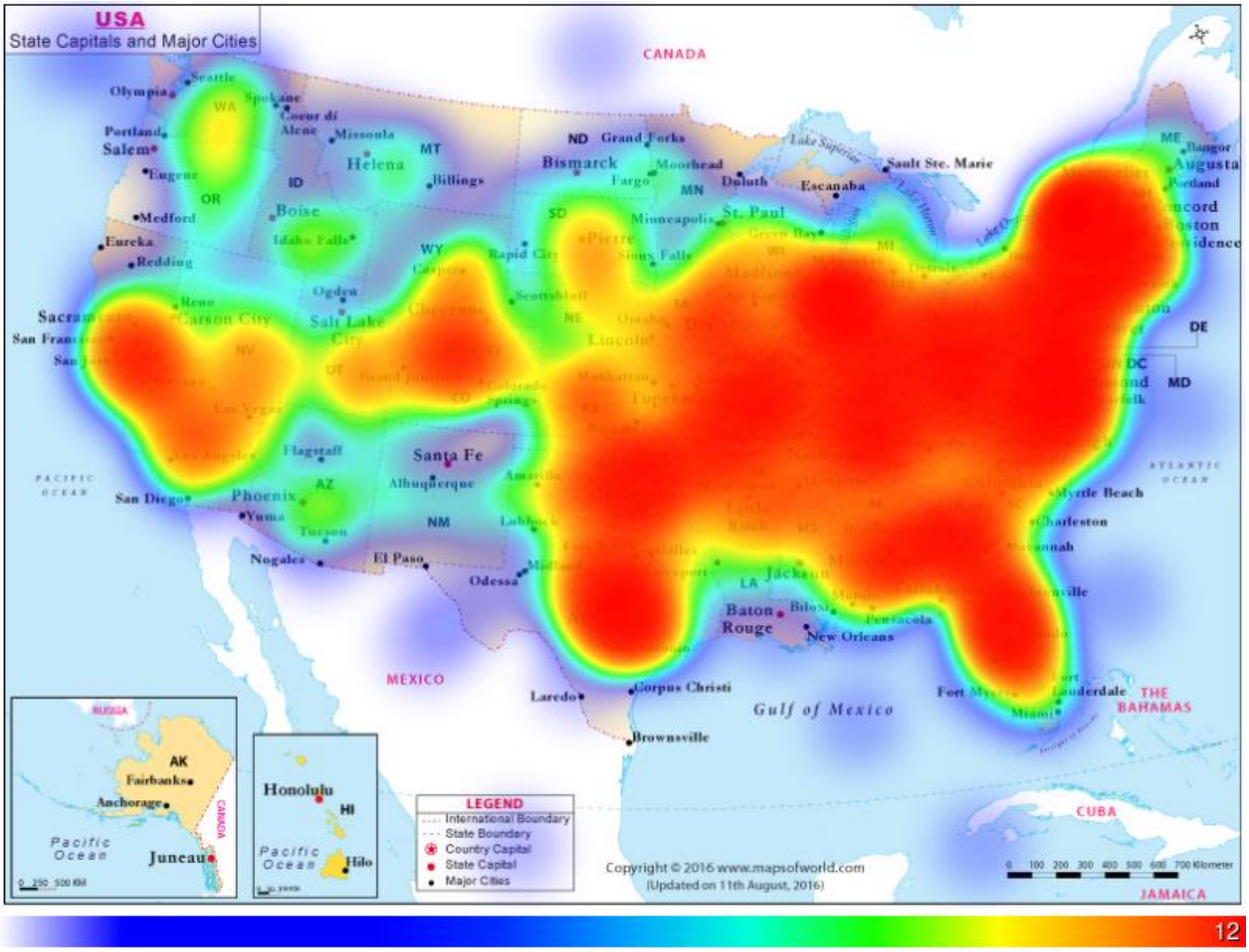

Figure 3.14 Destinations of trips during the pandemic

3.1.3. Safety Perceptions

The impacts on trucking operations as a result of the regulatory rule changes and the COVID-19 restrictions were also investigated. Respondents were asked about their perceptions of how road safety changed during the pandemic, shown in figure 3.15. Most of the truck drivers agreed that road safety improved at least somewhat during the pandemic. This was likely due to the significant decrease in passenger vehicle traffic.

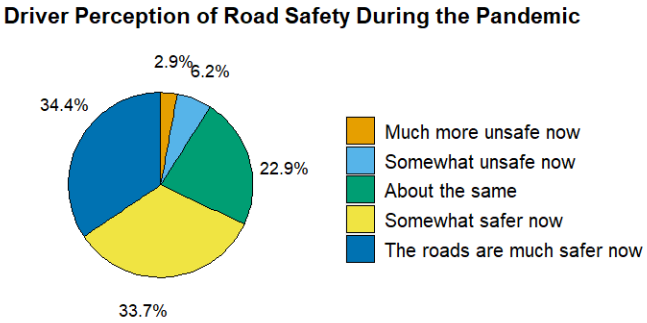

Figure 3.15: Driver perception of change in road safety

3.1.4. Summary

Figure 3.16 displays the surveyed drivers' perceptions of changes in various aspects of the trucking industry. For 12 out of the 13 characteristics, most drivers reported a change in operations as a result of the pandemic. Restrictions on the hours worked per day was the only category for which most drivers saw no change during the pandemic. This was a reflection of the relaxation of HOS rules for truck drivers.

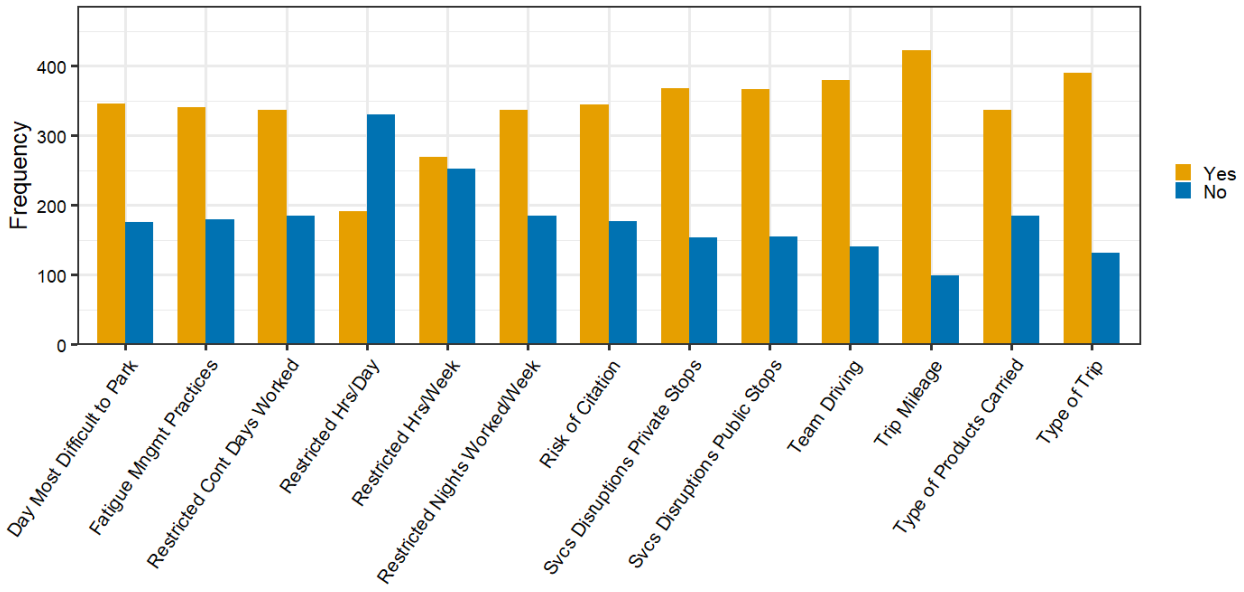

Figure 3.16 Changes in operations as a result of COVID-19

To assess the elements in the trucking industry significantly affected by COVID-19, a total of 47 paired variables were generated from the driver survey responses. Their medians were tested for a statistically significant difference through a rank-sum procedure. Thirteen of the comparisons were found to be statistically significant. In the following sections, the statistical analysis is detailed, performed, and summarized to uncover the differences in before and during pandemic truck driver behavior.

CHAPTER 4. Methods/Analytical Framework

The Related-Samples Wilcoxon Signed Rank test was used to identify changes in trucking operations that took place as a result of COVID-19. Although it has limitations, this test offers a flexible and practical methodology for identifying differences in responses.

This test is the nonparametric alternative to the repeated-measures t-test. It does not require an assumption of normality, but it does require that the differences be symmetric (Geyer, 2003). Eq. (2) measures this symmetry: the differences among the samples are symmetric if the skew is less than 0.5; they are moderately skewed if the skew is between 0.5 and 1.0; and highly skewed if the skew exceeds 1.0 (Date, 2021).

$$skew = \left| \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i - x)^3}{\left(\frac{1}{n}\sum_{i=1}^{n}(x_i - x)^2\right)^{\frac{3}{2}}} \right| \quad (2)$$

where x = the sample median difference

The table in Appendix A shows the variables to which the Wilcoxon Signed-Rank test was applied. The dependent variables had two levels: before and during COVID-19. The independent variables included levels on a five-point Likert scale. The null hypothesis simply stated that there was no systematic or consistent difference between the medians of the two treatments being compared. The differences between the two treatment conditions were first ranked in order without regard to sign (increases were positive and decreases were negative). The Wilcoxon W-statistic was the minimum of either the sum of the positive ranks or the sum of the negative ranks (NCSS Statistical Software, n.d.). The calculation of the test statistic is represented by Eq. (3) below.

$$W = \sum_{i=1}^{N_r}[sgn(x_{2,i} - x_{1,i}) \cdot R_i \quad (3)$$

The sample size for this study was large enough to use the normal approximation; therefore, the test statistic could be converted to a z-score. Using Eq. (4) below (NCSS Statistical Software, n.d.), the critical value could be determined by using the standard normal distribution to perform the two-sided test.

$$z = \frac{W}{\sigma_W}, \text{where } \sigma_W = \sqrt{\frac{N_r(N_r+1)(2N_r+1)}{6}} \tag{4}$$

CHAPTER 5. Findings

The Related-Samples Wilcoxon Signed Rank test was utilized to compare characteristics of trucking operations from before and during the COVID-19 pandemic. Table 5-1 presents the variables found to be statistically significant at the 5 percent level. The following subsections interpret the significance of these variables according to the perceived changes in the trucking industry and the areas most affected by the implementation of COVID-19 restrictions and the relaxation of the HOS limitations.

Table 5-1 Summary of statistically significant variables

Variable	Description	P-value
Driver Characteristics		
LSTMDRV	Participation in team driving before COVID (1 if never – 5 if always)	0.000
CVTMDRV	Participation in team driving during COVID (1 if never – 5 if always)	
Driving Characteristics		
LSCNLAPS	Frequency of lapses of concentration before COVID (1 if very often – 5 if never)	0.024
CVCNLAPS	Frequency of lapses of concentration during COVID (1 if very often – 5 if never)	
Time of Day Operations		
LSSTRDRV	Start driving time before COVID (4 if early morning between 12AM and 6AM – 8 if evening between 9PM and 11:59PM)	0.000
CVSTRDRV	Start driving time during COVID (4 if early morning between 12AM and 6AM – 8 if evening between 9PM and 11:59PM)	
LSADHOS	Lack of parking caused problems adhering to HOS limitations before COVID (1 if always – 5 if never)	0.000
CVADHOS	Lack of parking caused problems adhering to HOS limitations during COVID (1 if always – 5 if never)	
LSDYSUN	Most difficult day of the week to locate safe truck parking before COVID (1 if Sunday, 0 otherwise)	0.016
CVDYSUN	Most difficult day of the week to locate safe truck parking during COVID (1 if Sunday, 0 otherwise)	
LSSVDSFC	Service disruptions encountered at private truck stops before COVID (1 if facility closed, 0 otherwise)	0.010
CVSVDSFC	Service disruptions encountered at private truck stops during COVID (1 if facility closed, 0 otherwise)	
LSSVDPDS	Service disruptions encountered at public truck stops before COVID (1 if dine-in food services, 0 otherwise)	0.008
CVSVDPDS	Service disruptions encountered at public truck stops during COVID (1 if dine-in food services, 0 otherwise)	
LSSVDPVM	Service disruptions encountered at public truck stops before COVID (1 if vending machine access and supply, 0 otherwise)	0.028
CVSVDPVM	Service disruptions encountered at public truck stops during COVID (1 if vending machine access and supply, 0 otherwise)	

Variable	Description	P-value
LSSVDPFC	Service disruptions encountered at public truck stops before COVID (1 if facility closed, 0 otherwise)	0.047
CVSVDPFC	Service disruptions encountered at public truck stops during COVID (1 if facility closed, 0 otherwise)	
Driving Management		
LSDRVTR	Driving while tired before COVID (6 if very often – 10 if never)	0.000
CVDRVTR	Driving while tired before COVID (6 if very often – 10 if never)	
LSOFSTP	Driving Breaks on a longer trip before COVID (1 if only when tired, 2 if a stop is made every 2-3 hours, 4 if a stop is made every 3-4 hours on a longer trip, 5-7, 8 if driver tries not to stop)	0.000
CVOFSTP	Driving Breaks on a longer trip during COVID (1 if only when tired, 2 if a stop is made every 2-3 hours, 4 if a stop is made every 3-4 hours on a longer trip, 5-7, 8 if driver tries not to stop)	
Truck Configuration		
LSCOM8	Primary products carried before COVID (1 if metal, 0 otherwise)	0.018
CVCOM8	Primary products carried after COVID (1 if metal, 0 otherwise)	
LSCOM13	Primary products carried before COVID (1 if vehicles, 0 otherwise)	0.001
CVCOM13	Primary products carried after COVID (1 if vehicles, 0 otherwise)	

5.1. Driver Characteristics

Participation in team driving was one of the events found to be most impacted by the pandemic. There was strong evidence of a difference in responses from before and during COVID-19 ($p = 0.00$). The median response changed from “around half the time” before to only “sometimes” during the pandemic. Figure 5.1 shows the distribution of responses for driving as a team before and during COVID-19. The responses for “around half the time” decreased by about 25 percent, whereas the choice “never” increased 340 percent during the pandemic. This could be a reflection of social distancing mandates not allowing two drivers in the same cab for several hours at a time. It is very likely that team drivers were separated.

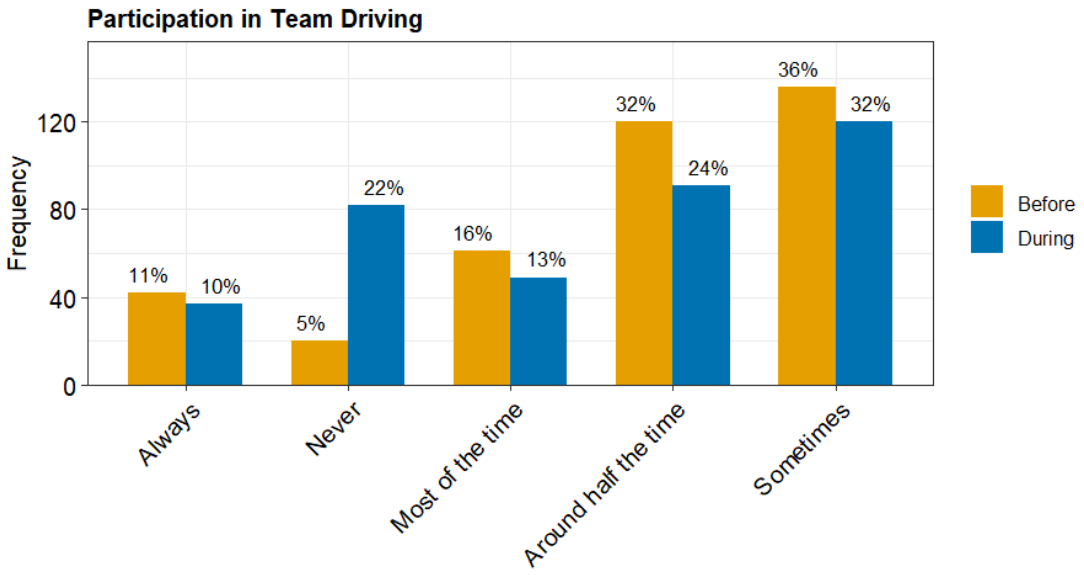

Figure 5.1 Changes in team driving

5.2. Driving Characteristics

Lapses of concentration was another characteristic for which surveyed drivers reported a significant difference during the pandemic. The changes in responses are displayed in figure 5.2. The response “sometimes” increased approximately 11 percent during the pandemic, yet responses for “very often” decreased 16 percent, and “never” increased 75 percent. Truck drivers appear to have been more attentive during the pandemic than before. This could also be related to the finding presented by the ATRI and OOIDA survey of the shift toward local trucking. Local trips under 100 miles more than doubled because of the mass reduction of container imports, which significantly decreased long haul trucking (American Transportation Research Institute and The OOIDA Foundation, 2020).

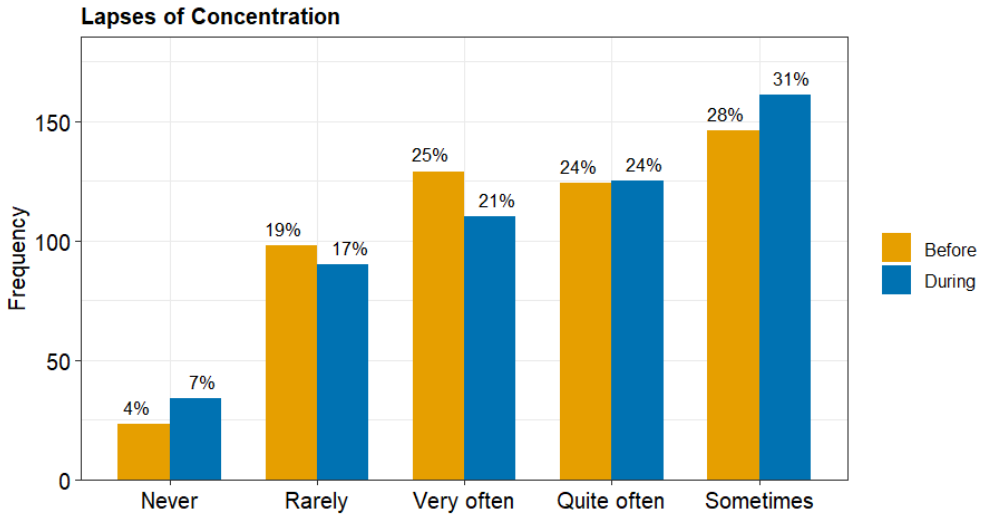

Figure 5.2 Changes in frequency of lapses of concentration

5.3. Time of Day Operations

Based on the results from the statistical tests, time-of-day operations were overall the most significantly impacted by COVID-19. Of the 13 characteristics found to be statistically significant, 7 were under time-of-day operations. During the pandemic, 34 percent fewer drivers started driving in the morning, whereas 50 percent more started driving at mid-day, and 140 percent more started in the afternoon. The significant changes in driving start time were likely correlated with decreases in passenger vehicle traffic and congestion levels. This is also supported by the finding from the ATRI and OOIDA survey, in which approximately 87 percent of the respondents indicated congestion was either “much shorter” or “somewhat shorter” (American Transportation Research Institute and The OOIDA Foundation, 2020).

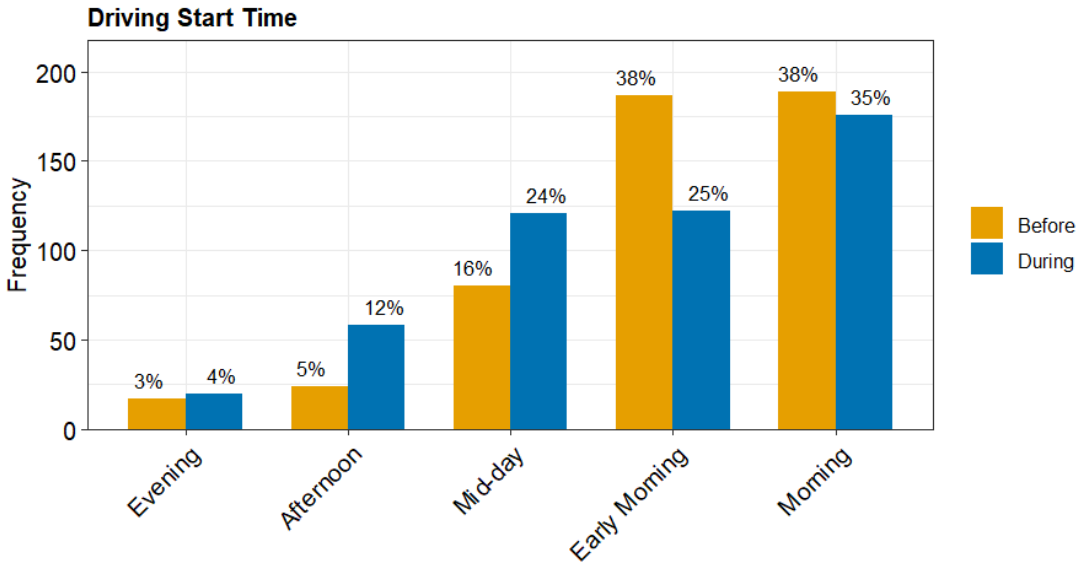

Figure 5.3 Changes in driving start time

In fact, the survey responses provided evidence of the services that were significantly affected at both public and private rest areas. Figures 5.4 and 5.5 illustrate the perceived disruptions caused by closures of private and public facilities. Regarding private truck stops, 13 percent of drivers agreed that closed facilities had an effect before the pandemic. Once the COVID-19 restrictions had been implemented, that percentage of drivers increased to 19 percent, an approximately 66 percent difference. Similarly, 15 percent of respondents reported that closed public facilities had an effect before the pandemic, and this increased approximately 33 percent during the pandemic. Along with this, the sampled drivers reported a significant change in dine-in food services and vending machine access and supply at public truck stops (figures 5.6 and 5.7). For these specific services, the pandemic is attributed a 26% and 23% increase in disruptions, respectively.

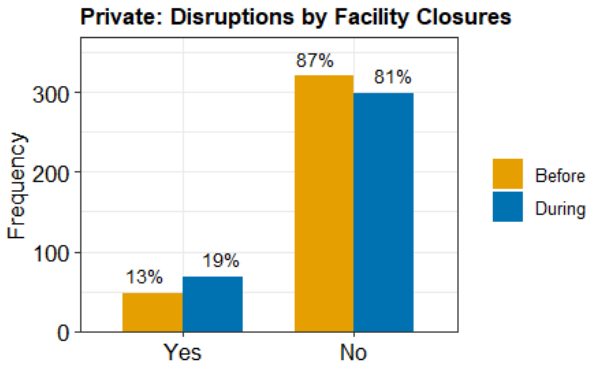

Figure 5.4 Changes in disruptions caused by private facility closures

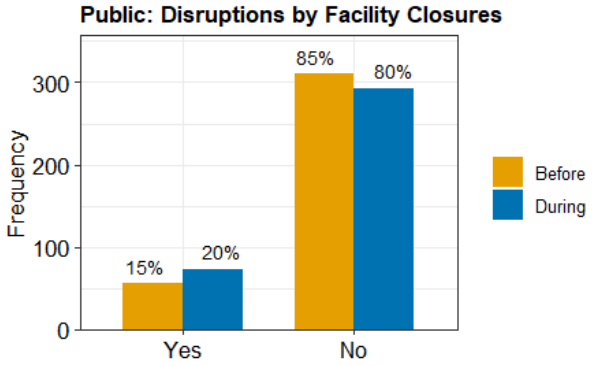

Figure 5.5 Changes in disruptions caused by public facility closures

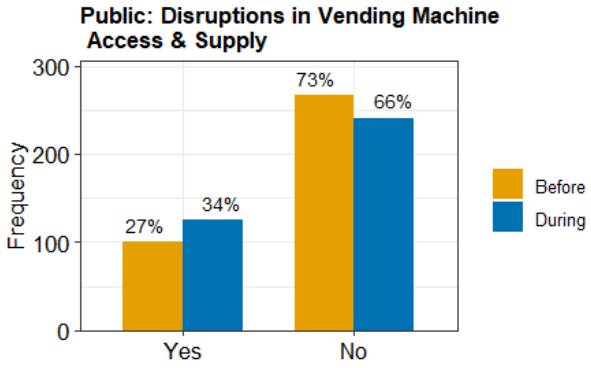

Figure 5.6 Changes in disruptions of vending machine access and supply at public facilities

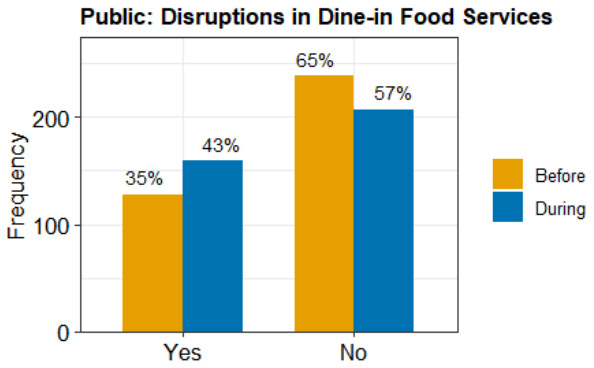

Figure 5.7 Changes in disruptions of dine-in food services at public facilities

Another operational characteristic for which drivers recognized significant differences was HOS adherence problems caused by a lack of parking. Twice the number of drivers reported that a lack of parking never caused problems in adhering to HOS limitations during the pandemic, and in general drivers noticed fewer issues (figure 5.8). This finding could possibly be related to a shift toward local parking due to the significant decrease in long-haul demand caused by a mass reduction of container imports, as found in the COVID-19 survey administered by ATRI and OOIDA (American Transportation Research Institute, 2020). At the same time, the findings of the current study revealed that 39 percent of surveyed drivers admitted that a lack of parking still caused problems in adhering to HOS limitations most of the time or always. The study by ATRI and OOIDA corroborated this finding; nearly 44 percent of the respondents in their survey perceived finding parking to be “somewhat harder” or “much harder” during the pandemic. That study recognized that, in general, the longer the length of the haul, the more likely the trucking operation was to report greater difficulty in finding parking (The American Transportation Research Institute and The OOIDA Foundation, 2020). Federally funded programs such as the Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) and Jason’s Law have been recently implemented to minimize these issues and support more truck parking projects (Federal Highway

Administration, 2012). Parking issues are expected to subside as projects introduced by these policies are completed.

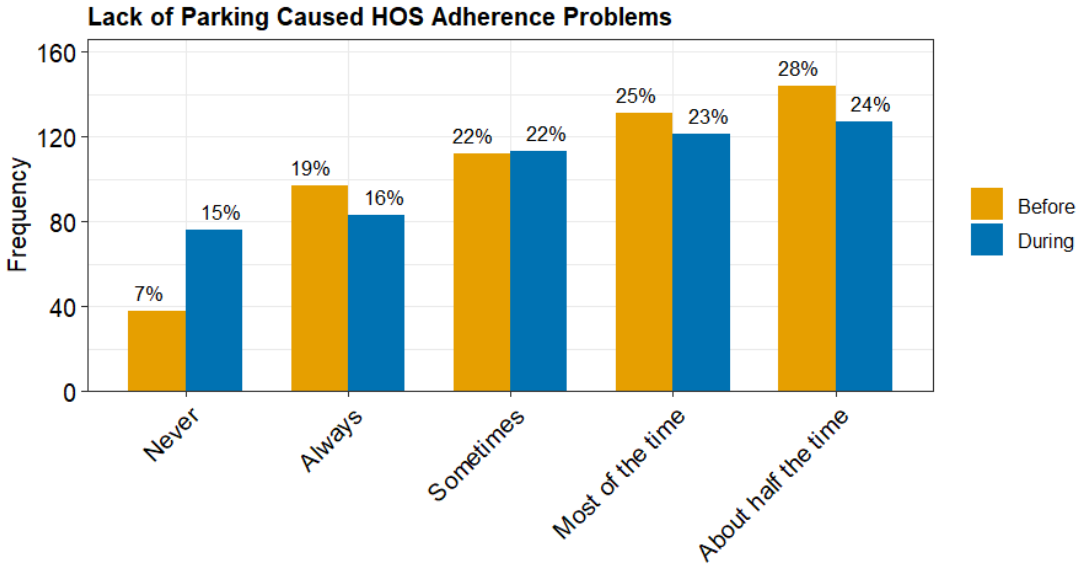

Figure 5.7 Changes in HOS adherence problems caused by a lack of parking

5.4. Management Characteristics

The next set of variables found to be significant was related to management characteristics. The first variable corresponded to how often truck drivers drove while fatigued. The distributions of answers from before and during COVID-19 are shown in figure 5.9. Most drivers reported that they drove less tired during the pandemic. The response “very often” decreased about 38 percent, while the rest of the responses increased by some percentage.

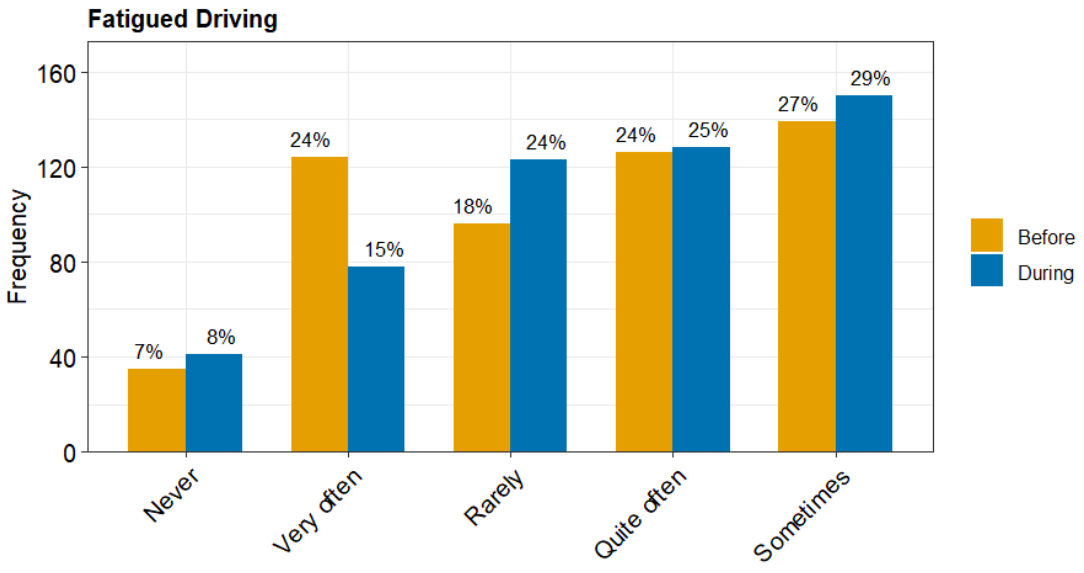

Figure 5.8 Changes in fatigued driving

A significant change was also found in the frequency of breaks taken during longer trips. The largest discrepancy was for the choice “every 2-3 hours,” which decreased 32 percent during the pandemic, as shown in figure 5.10. In general, drivers reported longer periods in-between breaks after the changes in regulatory rules and the implementation of COVID-19 restrictions. Drivers seemed to be more likely to drive when they should rest instead. This could also be related to the finding from the COVID-19 survey administered by ATRI and OODIA that detention times had increased for 34 percent of respondents (American Transportation Research Institute and The OOIDA Foundation, 2020). The longer periods in-between breaks could have been a result of additional time spent loading/unloading.

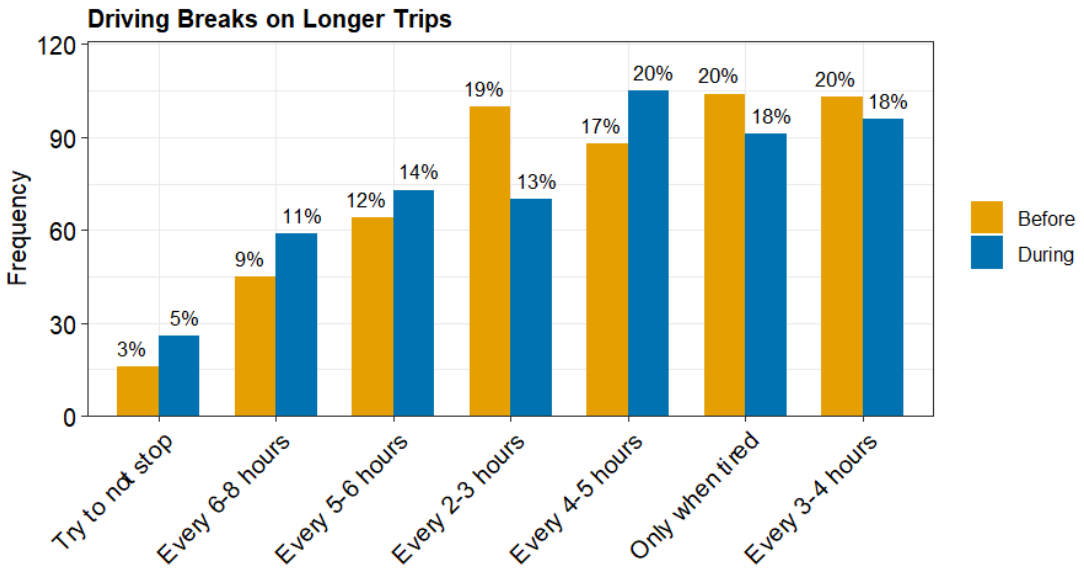

Figure 5.9: Changes in frequency of driving breaks on longer trips

5.5. Truck Configuration Characteristics

The final set of variables found to be significant was related to truck configuration characteristics. As a result of the sudden shift in demand for essential goods, the primary products carried by the majority of truck drivers changed during the pandemic. Metal and vehicle products were significantly affected. The changes are represented in figures 5.10 and 5.11. The percentage of metal carried decreased nearly 30 percent, while the percentage of vehicles transported decreased 27 percent.

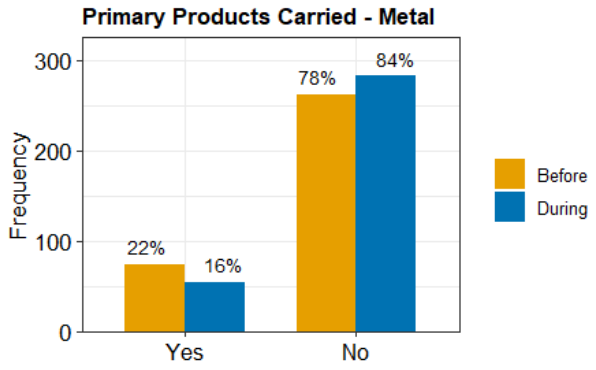

Figure 5.10 Changes in metal products carried

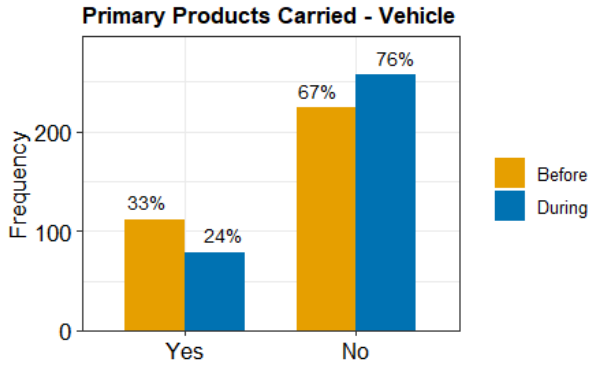

Figure 5.11 Changes in vehicle products carried

5.6. Summary

Truck drivers conveyed significant changes in their driving behavior including fewer lapses of concentration and less fatigued driving. The relaxation of regulatory rules granted drivers more flexibility. Drivers said that they experienced fewer issues in adhering to HOS limitations due to a lack of parking. Twice the number of drivers reported that a lack of parking never causing HOS adherence problems during the pandemic. In fact, for the first time in ten years, hours of service ranked at the bottom of ATRI's Top Industry Issues List, below its usual ranking in the top three (Ronan, 2020).

Time of day operations were the most significantly impacted by COVID-19. Drivers began driving at midday or in the afternoon after the pandemic began, as opposed to before, when most drove in the early morning. Drivers might have felt comfortable to drive in the afternoon because of the significant decrease in passenger vehicle traffic and congestion levels. The changes in start times could also be related to the surge in demand of essential goods at grocery stores. Deliveries are usually made early in the morning or at night when most grocery stores restock their shelves.

The relaxation of HOS regulations did raise some concern regarding trucking operations and road safety. Approximately 39 percent of surveyed drivers admitted that a lack of parking still caused problems in adhering to HOS limitations most of the time or always, which has been an ongoing issue for truck drivers throughout the United States. Additionally, the COVID-19 survey administered by ATRI and OOIDA revealed that nearly 34 percent of drivers experienced increased detention times during the pandemic. These factors raise concerns about the pressures placed on truck drivers, given that average truck travel speeds increased by as much as 25 miles per hour during the pandemic (American Transportation Research Institute, 2020). In addition, concerns remain regarding a persistent shortage of drivers, lack of adequate parking, and supply chain delays.

Furthermore, the safety restrictions implemented place during the pandemic exacerbated the challenges faced by truck drivers. The closures of private and public trucking facilities created the greatest challenges. Drivers lost access to fuel, food, showers, repair services, and opportunities to rest. As of April 1, 2020, three states—Illinois, Massachusetts, and Pennsylvania—had enacted partial closures of rest stops and at least three more—Michigan, Nebraska, and Texas—had closed rest stops temporarily before trucking companies, drivers, and

groups such as OOIDA and the American Trucking Association (ATA) disputed the closures (Permack, 2020). In a press release, the President and CEO of the National Association of Truck Stop Operators (NATSO), Lisa Mullings, confirmed that member facilities will remain open to serve the nation's truck drivers. And even though the FMCSA lacks preemptive authority over states that elect to close rest stops, the agency is "working closely with the states to ensure adequate truck parking and facilities are available" (Permack, 2020). Given the overall economy and that the trucking industry will continue to see substantial growth for at least the next year, it is imperative truck drivers have a key role in the development of future trucking policies (Ronan, 2021). The unique insights and perspectives of truck drivers provide a greater understanding of the effects of changes in regulatory rules, especially because it is the first time in history they have been suspended at the national level.

CHAPTER 6. Conclusions

This study serves to quantify the significant impacts that the COVID-19 pandemic has had on truck drivers and the trucking industry. The stated-preference survey distributed to truck drivers collected data specifically regarding changes in characteristics of the trucking industry. The paired and dependent nature of these responses necessitated a nonparametric statistical analysis. As such, the Related-Samples Wilcoxon Signed Rank test was the most appropriate for using the responses of the questions. Through this rank sum procedure, 13 of the comparisons were found to be significant, indicating that various factors were impacted by the pandemic and changes in regulations.

Understanding how drivers' experiences changed and how they perceived the changes in regulatory rules can assist federal and state agencies in planning and adopting appropriate solutions. During events like pandemics or similar system disruptions, these findings can be used to implement more effective policy and regulation changes that provide the needed relief without compromising road safety.

This study is one of the first to examine the relationship between HOS adherence and large truck safety, particularly with the added pressures and challenges that arise during a pandemic. In addition, the work of this study presents several opportunities for future research. This study not only built on the applicability of using survey data and applying statistical techniques, but it can also initiate further experimentation of other analyses. More investigations into these topics can help provide needed relief to drivers and motor carriers. Additionally, this study prompts further investigation into the factors that are affected by changes in trucking-related regulations. Identifying additional influential factors, such as regional or industry-specific characteristics, that affect driver behavior can help create and develop practical, effective solutions that reduce unsafe driver practices and improve roadway safety for all users.

CHAPTER 7. References

Ahart, M., 2021. *FMCSA releases COVID-19 HOS Emergency Declaration (Periodic updates included)* |. [online] Omnitracs. Available at: <https://www.omnitracs.com/blog/fmcsa-releases-covid-19-hos-emergency-declaration-periodic-updates-included> [Accessed 21 Aug. 2021].

American Transportation Research Institute, 2020. *Truck Movement in Response to Demands of COVID-19*. [online] Available at: <https://truckingresearch.org/2020/03/24/truck-movement-in-response-to-demands-of-covid-19-march-24-2020/> [Accessed 27 Jan. 2021].

Date, S., 2021. *Testing For Normality of Residual Errors Using Skewness And Kurtosis Measures – Time Series Analysis, Regression and Forecasting*. [online] Available at: <https://timeseriesreasoning.com/contents/skewness-and-kurtosis-measures/> [Accessed 28 Oct. 2021].

Derrick, B. and White, P., 2017. Comparing two samples from an individual Likert question. *International Journal of Mathematics and Statistics*, 18(3), pp.1–13.

Desai, Y., 2020. *Navigating the COVID-19 impact to U.S. transportation and logistics ecosystems*. [online] KPMG . Available at: <https://advisory.kpmg.us/content/dam/advisory/en/pdfs/2020/covid-19-impact-transportation-logistics.pdf> [Accessed 23 Feb. 2021].

Dillman, D.A., Smyth, J.D. and Christian, L.M., 2014. *Internet, Phone, Mail, and Mixed-Mode Surveys: The Tailored Design Method*. Hoboken: Wiley.

Federal Highway Administration, 2012. *Commercial Motor Vehicle Parking Shortage*.

Federal Highway Administration, 2020. *Notice of Enforcement Discretion*. [online] Available at: <https://www.fhwa.dot.gov/media/noe.cfm> [Accessed 27 Jan. 2021].

Federal Motor Carrier Safety Administration, 2020. *National Emergency Declaration*. [online] Available at: <https://www.transportation.gov/briefing-room/us-department-transportation-expands-national-emergency-declaration-commercial> [Accessed 27 Jan. 2021].

Federal Register, 2005. *Hours of Service of Drivers Final Rule*.

Del Gatto, B. and Cons, D.T., 2020. *COVID-19: Symptoms Felt across the Trucking Industry*. [online] National Law Review, Volume X, Number 154. Available at: <https://www.natlawreview.com/article/covid-19-symptoms-felt-across-trucking-industry> [Accessed 23 Feb. 2021].

Geyer, C.J., 2003. Nonparametric Tests and Confidence Intervals. *In Practice*, pp.1–14.

Haake, D., 2020. *Examining the COVID-19 Impact on Freight Transportation*. [online] ITE Journal - November 2020. Available at: <https://www.hdrinc.com/insights/examining-covid-19-impact-freight-transportation> [Accessed 23 Feb. 2021].

Lamb, E., 2020. *States Suspend Weight Limits for Trucks Involved in Coronavirus Relief | Transport Topics*. [online] Available at: <https://www.ttnews.com/articles/states-suspend-weight-limits-trucks-involved-coronavirus-relief> [Accessed 27 Jan. 2021].

McCartt, A.T., Hellinga, L.A. and Solomon, M.G., 2008. Work schedules of long-distance truck drivers before and after 2004 hours-of-service rule change. *Traffic Injury Prevention*, [online] 9(3), pp.201–210. Available at: <https://www.tandfonline.com/doi/abs/10.1080/15389580802040287> [Accessed 6 Feb. 2021].

Mokhtarian, P.L., Samaniego, F.J., Shumway, R.H. and Willits, N.H., 2002. Revisiting the notion of induced traffic through a matched-pairs study. *Transportation*, [online] 29(2), pp.193–220. Available at: <https://link.springer.com/article/10.1023/A:1014221024304> [Accessed 18 Feb. 2021].

NCSS Statistical Software, n.d. *Paired Wilcoxon Signed-Rank Tests*.

Ohlms, P.B. and Kweon, Y.J., 2018. Facilitating bicycle travel using innovative intersection pavement markings. *Journal of Safety Research*, 67, pp.173–182.

Permack, R., 2020. *Some Pennsylvania Rest Stops Closing, and Truckers Have Few Options*. [online] Business Insider. Available at: <https://www.businessinsider.com/coronavirus-rest-stops-closing-truckers-few-options-2020-3> [Accessed 22 Aug. 2021].

Roberts, J., 2020. *The Pandemic Highway: Drivers Report in as COVID-19 Rages On - Drivers - Trucking Info*. [online] Heavy Duty Trucking. Available at: <https://www.truckinginfo.com/353692/the-pandemic-highway-drivers-report-in-as-covid-19-rages-on> [Accessed 6 Feb. 2021].

Ronan, D., 2020. *ATRI Top 10 Report Finds Driver Shortage Top Issue* . [online] Transport Topics. Available at: <https://www.ttnews.com/articles/atri-top-10-report-finds-driver-shortage-top-issue-fourth-year-row> [Accessed 1 Sep. 2021].

Ronan, D., 2021. *Economy, Trucking Industry Roar Back* . [online] Transport Topics. Available at: <https://www.ttnews.com/articles/economy-trucking-industry-roar-back> [Accessed 22 Aug. 2021].

Smith, S.M., 2013. Determining Sample Size. *Qualitative Health Research*, 10(1), pp.3–5.

The American Transportation Research Institute and The OOIDA Foundation, 2020. *COVID-19 Impacts on the Trucking Industry*. [online] Available at: <https://truckingresearch.org/2020/05/05/joint-research-confirms-covid-19-impact-on-trucking/> [Accessed 1 Feb. 2021].

U.S. Bureau of Labor Statistics, 2020. *Employment Situation Summary*. [online] Available at: <https://www.bls.gov/news.release/empsit.nr0.htm#> [Accessed 27 Jan. 2021].

Appendix A

Variable	Description	P-value	Result
Driver Characteristics			
LSTMDRV	Participation in team driving before COVID (1 if never – 5 if always)	0.000	Different
CVTMDRV	Participation in team driving during COVID (1 if never – 5 if always)		
LSTYSHP	Shipment Type before COVID (1 if LNL, 2 if truckload, 3 if parcel, 4 if distribution and warehousing, 5 if air freight specialist, 6 if freight forward, 7 if drayage)	0.533	Not different
CVTRPTYP	Shipment Type during COVID (1 if LNL, 2 if truckload, 3 if parcel, 4 if distribution and warehousing, 5 if air freight specialist, 6 if freight forward, 7 if drayage)		
Driving Characteristics			
LSCNLAPS	Frequency of lapses of concentration before COVID (1 if very often – 5 if never)	0.024	Different
CVCNLAPS	Frequency of lapses of concentration during COVID (1 if very often – 5 if never)		
Time of Day Operations			
LSSTRDRV	Start driving time before COVID (4 if early morning between 12AM and 6AM – 8 if evening between 9PM and 11:59PM)	0.000	Different
CVSTRDRV	Start driving time during COVID (4 if early morning between 12AM and 6AM – 8 if evening between 9PM and 11:59PM)		
LSADHOS	Lack of parking caused problems adhering to HOS limitations before COVID (1 if always – 5 if never)	0.000	Different
CVADHOS	Lack of parking caused problems adhering to HOS limitations during COVID (1 if always – 5 if never)		
LSDYMN	Most difficult day of the week to locate safe truck parking before COVID (1 if Monday, 0 otherwise)	0.072	Not different
CVDYMN	Most difficult day of the week to locate safe truck parking during COVID (1 if Monday, 0 otherwise)		
LSDYTUE	Most difficult day of the week to locate safe truck parking before COVID (1 if Tuesday, 0 otherwise)	0.761	Not different
CVDYTUE	Most difficult day of the week to locate safe truck parking during COVID (1 if Tuesday, 0 otherwise)		
LSYDYWED	Most difficult day of the week to locate safe truck parking before COVID (1 if Wednesday, 0 otherwise)	0.132	Not different
CVDYWED	Most difficult day of the week to locate safe truck parking during COVID (1 if Wednesday, 0 otherwise)		
LSDYTHUR	Most difficult day of the week to locate safe truck parking before COVID (1 if Thursday, 0 otherwise)	0.849	Not different

Variable	Description	P-value	Result
CVDYTHUR	Most difficult day of the week to locate safe truck parking during COVID (1 if Thursday, 0 otherwise)		
LSDYFR	Most difficult day of the week to locate safe truck parking before COVID (1 if Friday, 0 otherwise)	0.050	Not different
CVDYFR	Most difficult day of the week to locate safe truck parking during COVID (1 if Friday, 0 otherwise)		
LSDYSAT	Most difficult day of the week to locate safe truck parking before COVID (1 if Saturday, 0 otherwise)	0.425	Not different
CVDYSAT	Most difficult day of the week to locate safe truck parking during COVID (1 if Saturday, 0 otherwise)		
LSDYSUN	Most difficult day of the week to locate safe truck parking before COVID (1 if Sunday, 0 otherwise)	0.016	Different
CVDYSUN	Most difficult day of the week to locate safe truck parking during COVID (1 if Sunday, 0 otherwise)		
LSSVDSFL	Service disruptions encountered at private truck stops before COVID (1 if fuel services, 0 otherwise)	0.626	Not different
CVSVDSFL	Service disruptions encountered at private truck stops during COVID (1 if fuel services, 0 otherwise)		
LSSVDSDS	Service disruptions encountered at private truck stops before COVID (1 if dine-in food services, 0 otherwise)	0.541	Not different
CVSVDSDS	Service disruptions encountered at private truck stops during COVID (1 if dine-in food services, 0 otherwise)		
LSSVDSTO	Service disruptions encountered at private truck stops before COVID (1 if take out and/or drive thru food services, 0 otherwise)	0.596	Not different
CVSVDSTO	Service disruptions encountered at private truck stops during COVID (1 if take out and/or drive thru food services, 0 otherwise)		
LSSVDSVM	Service disruptions encountered at private truck stops before COVID (1 if vending machine access and supply, 0 otherwise)	0.086	Not different
CVSVDSVM	Service disruptions encountered at private truck stops during COVID (1 if vending machine access and supply, 0 otherwise)		
LSSVDSSH	Service disruptions encountered at private truck stops before COVID (1 if showers, 0 otherwise)	0.194	Not different
CVSVDSSH	Service disruptions encountered at private truck stops during COVID (1 if showers, 0 otherwise)		
LSSVDSRT	Service disruptions encountered at private truck stops before COVID (1 if restrooms, 0 otherwise)	0.353	Not different
CVSVDSRT	Service disruptions encountered at private truck stops during COVID (1 if restrooms, 0 otherwise)		
LSSVDSTW	Service disruptions encountered at private truck stops before COVID (1 if truck wash stations, 0 otherwise)	0.692	Not different
CVSVDSTW	Service disruptions encountered at private truck stops during COVID (1 if truck wash stations, 0 otherwise)		

Variable	Description	P-value	Result
LSSVDSCI	Service disruptions encountered at private truck stops before COVID (1 if computer and/or internet services, 0 otherwise)	0.751	Not different
CVSVDSCI	Service disruptions encountered at private truck stops during COVID (1 if computer and/or internet services, 0 otherwise)		
LSSVDSFC	Service disruptions encountered at private truck stops before COVID (1 if facility closed, 0 otherwise)	0.010	Different
CVSVDSFC	Service disruptions encountered at private truck stops during COVID (1 if facility closed, 0 otherwise)		
LSSVDSOT	Service disruptions encountered at private truck stops before COVID (1 if other, 0 otherwise)	0.083	Not different
CVSVDSOT	Service disruptions encountered at private truck stops during COVID (1 if other, 0 otherwise)		
LSSVDPFL	Service disruptions encountered at public truck stops before COVID (1 if fuel services, 0 otherwise)	0.522	Not different
CVSVDPFL	Service disruptions encountered at public truck stops during COVID (1 if fuel services, 0 otherwise)		
LSSVDPDS	Service disruptions encountered at public truck stops before COVID (1 if dine-in food services, 0 otherwise)	0.008	Different
CVSVDPDS	Service disruptions encountered at public truck stops during COVID (1 if dine-in food services, 0 otherwise)		
LSSVDPTO	Service disruptions encountered at public truck stops before COVID (1 if take out and/or drive thru food services, 0 otherwise)	0.788	Not different
CVSVDPTO	Service disruptions encountered at public truck stops during COVID (1 if take out and/or drive thru food services, 0 otherwise)		
LSSVDPVM	Service disruptions encountered at public truck stops before COVID (1 if vending machine access and supply, 0 otherwise)	0.028	Different
CVSVDPVM	Service disruptions encountered at public truck stops during COVID (1 if vending machine access and supply, 0 otherwise)		
LSSVDPSH	Service disruptions encountered at public truck stops before COVID (1 if showers, 0 otherwise)	0.241	Not different
CVSVDPSH	Service disruptions encountered at public truck stops during COVID (1 if showers, 0 otherwise)		
LSSVDPRT	Service disruptions encountered at public truck stops before COVID (1 if restrooms, 0 otherwise)	0.703	Not different
CVSVDPRT	Service disruptions encountered at public truck stops during COVID (1 if restrooms, 0 otherwise)		
LSSVDPTW	Service disruptions encountered at public truck stops before COVID (1 if truck wash stations, 0 otherwise)	0.571	Not different
CVSVDPTW	Service disruptions encountered at public truck stops during COVID (1 if truck wash stations, 0 otherwise)		
LSSVDPCI	Service disruptions encountered at public truck stops before COVID (1 if computer and/or internet services, 0 otherwise)	0.448	Not different

Variable	Description	P-value	Result
CVSVDPCI	Service disruptions encountered at public truck stops during COVID (1 if computer and/or internet services, 0 otherwise)		
LSSVDPFC	Service disruptions encountered at public truck stops before COVID (1 if facility closed, 0 otherwise)	0.047	Different
CVSVDPFC	Service disruptions encountered at public truck stops during COVID (1 if facility closed, 0 otherwise)		
LSSVDPOT	Service disruptions encountered at public truck stops before COVID (1 if facility closed, 0 otherwise)	0.617	Not different
CVSVDPOT	Service disruptions encountered at public truck stops during COVID (1 if facility closed, 0 otherwise)		
Driving Management			
FTMNBRK	Management encourages breaks when needed before COVID (0 if strongly agree – 5 if strongly disagree)	0.164	Not different
CVMNBRK	Management encourages breaks when needed during COVID (0 if strongly agree – 5 if strongly disagree)		
FTMNSTM	Allowed sufficient time to reach destination before COVID (0 if strongly agree – 5 if strongly disagree)	0.998	Not different
CVMNSTM	Allowed sufficient time to reach destination during COVID (0 if strongly agree – 5 if strongly disagree)		
FTMNSCH	Schedule allows breaks when needed before COVID (0 if strongly agree – 5 if strongly disagree)	0.209	Not different
CVMNSCH	Schedule allows breaks when needed during COVID (0 if strongly agree – 5 if strongly disagree)		
LSDRVTR	Driving while tired before COVID (6 if very often – 10 if never)	0.000	Different
CVDRVTR	Driving while tired before COVID (6 if very often – 10 if never)		
LSOFSTP	Driving Breaks on a longer trip before COVID (1 if only when tired, 2 if a stop is made every 2-3 hours, 4 if a stop is made every 3-4 hours on a longer trip, 5-7, 8 if driver tries not to stop)	0.000	Different
CVOFSTP	Driving Breaks on a longer trip during COVID (1 if only when tired, 2 if a stop is made every 2-3 hours, 4 if a stop is made every 3-4 hours on a longer trip, 5-7, 8 if driver tries not to stop)		
Truck Configuration			
LSCOM1	Primary products carried before COVID (1 if agricultural products, 0 otherwise)	0.191	Not different
CVCOM1	Primary products carried after COVID (1 if agricultural products, 0 otherwise)		
LSCOM2	Primary products carried before COVID (1 if livestock or live animals, 0 otherwise)	0.825	Not different
CVCOM2	Primary products carried after COVID (1 if livestock or live animals, 0 otherwise)		
LSCOM3	Primary products carried before COVID (1 if chemicals, 0 otherwise)	0.437	Not different
CVCOM3	Primary products carried after COVID (1 if chemicals, 0 otherwise)		
LSCOM4	Primary products carried before COVID (1 if prepared foodstuffs preparations, 0 otherwise)	0.632	Not different
CVCOM4	Primary products carried after COVID (1 if prepared foodstuffs preparations, 0 otherwise)		

Variable	Description	P-value	Result
LSCOM5	Primary products carried before COVID (1 if meat, seafood, and their preparations, 0 otherwise)	0.495	Not different
CVCOM5	Primary products carried after COVID (1 if meat, seafood, and their preparations, 0 otherwise)		
LSCOM6	Primary products carried before COVID (1 if logs and other wood products, 0 otherwise)	0.732	Not different
CVCOM6	Primary products carried after COVID (1 if logs and other wood products, 0 otherwise)		
LSCOM7	Primary products carried before COVID (1 if paper goods, 0 otherwise)	0.748	Not different
CVCOM7	Primary products carried after COVID (1 if paper goods, 0 otherwise)		
LSCOM8	Primary products carried before COVID (1 if metal, 0 otherwise)	0.018	Different
CVCOM8	Primary products carried after COVID (1 if metal, 0 otherwise)		
LSCOM9	Primary products carried before COVID (1 if nonmetallic minerals, 0 otherwise)	0.332	Not different
CVCOM9	Primary products carried after COVID (1 if nonmetallic minerals, 0 otherwise)		
LSCOM10	Primary products carried before COVID (1 if durable manufactured goods like furniture, 0 otherwise)	0.336	Not different
CVCOM10	Primary products carried after COVID (1 if durable manufactured goods like furniture, 0 otherwise)		
LSCOM11	Primary products carried before COVID (1 if machinery, 0 otherwise)	0.602	Not different
CVCOM11	Primary products carried after COVID (1 if machinery, 0 otherwise)		
LSCOM12	Primary products carried before COVID (1 if coal, 0 otherwise)	0.686	Not different
CVCOM12	Primary products carried after COVID (1 if coal, 0 otherwise)		
LSCOM13	Primary products carried before COVID (1 if vehicles, 0 otherwise)	0.001	Different
CVCOM13	Primary products carried after COVID (1 if vehicles, 0 otherwise)		
LSCOM14	Primary products carried before COVID (1 if crude petroleum, 0 otherwise)	0.085	Not different
CVCOM14	Primary products carried after COVID (1 if crude petroleum, 0 otherwise)		
LSCOM15	Primary products carried before COVID (1 if fuel/gasoline, 0 otherwise)	0.540	Not different
CVCOM15	Primary products carried after COVID (1 if fuel/gasoline, 0 otherwise)		
LSCOM16	Primary products carried before COVID (1 if hazardous waste, 0 otherwise)	0.346	Not different
CVCOM16	Primary products carried after COVID (1 if hazardous waste, 0 otherwise)		
LSCOM17	Primary products carried before COVID (1 if non-hazardous waste and scrap, 0 otherwise)	0.299	Not different
CVCOM17	Primary products carried after COVID (1 if non-hazardous waste and scrap, 0 otherwise)		

Variable	Description	P-value	Result
LSCOM18	Primary products carried before COVID (1 if mail and courier parcels, 0 otherwise)	0.913	Not different
CVCOM18	Primary products carried after COVID (1 if mail and courier parcels, 0 otherwise)		
LSCOM19	Primary products carried before COVID (1 if mixed freight, 0 otherwise)	0.617	Not different
CVCOM19	Primary products carried after COVID (1 if mixed freight, 0 otherwise)		
LSCOM20	Primary products carried before COVID (1 if other, 0 otherwise)	0.072	Not different
CVCOM20	Primary products carried after COVID (1 if other, 0 otherwise)		