TRENDS AND CHALLENGES POSED BY MEDIUM-DUTY TRUCKS TO THE OPERATION AND SAFETY OF OREGON HIGHWAYS

Final Report

SPR-846

RESEARCH

Oregon Department of Transportation

TRENDS AND CHALLENGES POSED BY MEDIUM-DUTY TRUCKS TO THE OPERATION AND SAFETY OF OREGON HIGHWAYS

Final Report

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16. Abstract: This study evaluates medium-duty vehicle operations and safety in Oregon to understand impact of e-commerce growth and logistics changes. The objectives were to analyze trends, assess safety risks, and provide policy recommendations. Data from the Oregon Department of Transportation (ODOT) Crash Data System, the Commercial Motor Vehicle crash database, and the DEQ Medium- and Heavy-Duty Fleet Reporting survey were combined. The DEQ data offered insights into medium-duty truck operations. Notably, although Amazon was a top-three carrier in the survey, no Amazon vehicles appeared in crash data, likely due to subcontracting practices limiting safety monitoring. The analysis revealed higher crash rates for medium-duty trucks, especially delivery vehicles, in employment areas and on arterials, with peaks on weekdays and in December due to holiday demand. Recommendations include safety campaigns in high-crash areas, advanced crash data analytics, and stricter regulations for delivery vehicles. Collaboration among state agencies, local governments, and private stakeholders is essential for effective safety strategies.

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		LENGTH					**LENGTH**		
in	inches	25.4	millimeters	mm	mm	millimeters	0.039	inches	in
ft	feet	0.305	meters	m	m	meters	3.28	feet	ft
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mi	miles	1.61	kilometers	km	km	kilometers	0.621	miles	mi
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ac	acres	0.405	hectares	ha	ha	hectares	2.47	acres	ac
mi^2	square miles	2.59	kilometers squared	km^2	km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME					**VOLUME**		
fl oz	fluid ounces	29.57	milliliters	ml	ml	milliliters	0.034	fluid ounces	fl oz
gal	gallons	3.785	liters	L	L	liters	0.264	gallons	gal
ft^3	cubic feet	0.028	meters cubed	m^3	m^3	meters cubed	35.315	cubic feet	ft^3
yd^3	cubic yards	0.765	meters cubed	m^3	m^3	meters cubed	1.308	cubic yards	yd^3
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		MASS					**MASS**		
oz	ounces	28.35	grams	g	g	grams	0.035	ounces	oz
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*SI is the symbol for the International System of Measurement

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1.0 INTRODUCTION

The freight industry in Oregon is undergoing notable changes, as evidenced by recent traffic data indicating a shift towards increased freight movement via medium trucks, while heavy truck freight has remained relatively constant. This trend is likely driven by the rise of e-commerce and evolving supply chain logistics, where large delivery companies have optimized last-mile logistics by utilizing smaller vehicles to navigate metropolitan areas efficiently. According to the Highway Cost Allocation Study (HCAS), total truck Vehicle Miles Traveled (VMT) in Oregon increased by 9% from 2007 to 2018, with medium-duty truck VMT surging by 35% and heavy-duty truck VMT growing by a mere 2%.

This shift towards medium-duty trucks has coincided with a period of robust economic recovery in Oregon following the Great Recession of 2007-09. This recovery is reflected in a 13% rise in medium-duty truck registrations since 2012. While this increase aligns partially with population growth, the substantial rise in VMT per capita for medium-duty trucks, up 20%, contrasts sharply with a 2% decline in heavy-duty truck per capita VMT over the same period.

Further compounding these trends are the classifications set by the Federal Motor Carrier Safety Administration (FMCSA), which defines vehicles over 10,000 pounds as Commercial Motor Vehicles (CMVs). However, only those over 26,000 pounds require a Commercial Driver's License (CDL). The significant growth in medium-duty truck VMT suggests a burgeoning number of truck drivers operating without a CDL, raising concerns about potential safety implications. Non-CDL drivers are exempt from DOT drug and alcohol testing and do not undergo the comprehensive DOT and OSHA training essential for safe driving, accident reporting, hazardous materials handling, and vehicle maintenance. This lack of training may pose increased safety risks on Oregon’s roads.

1.1 PROJECT OBJECTIVES

The primary goal of this study was to provide the agency with a comprehensive understanding of medium-duty truck operations, identify potential risk areas, forecast future operational growth, and monetize the costs associated with these changes. To achieve this goal, the research methodology focused on the following objectives:

- Estimating the number of medium-duty trucks operating in Oregon, including categorization by industry and/or commodities/services utilizing these trucks, general trip characteristics and logistic patterns, and regional patterns based on population density.
- Evaluating safety data to compare and contrast crash rates, incidents, and other relevant safety metrics involving medium trucks versus heavy trucks requiring CDL drivers, to determine if there is a statistical difference between the two groups.
- Developing a monitoring methodology for ODOT to implement, ensuring ongoing tracking of medium-duty truck safety and performance.

This study aims to ascertain whether the increasing use of medium trucks poses a risk to the safety of Oregon highway users. Should the evidence point to an emerging risk area, ODOT will have the opportunity to formulate new policies and regulations to mitigate these risks, thereby preventing societal costs associated with property damage, personal injuries, fatalities, and reduced transportation system reliability. The long-term benefits may include improved safety compliance and more effective enforcement.

2.0 LITERATURE REVIEW

The literature on medium-duty truck operations, safety, and forecasting analysis is sparse, highlighting a need for more focused research in this area. While various studies have examined the distinct operational characteristics and safety concerns of medium-duty trucks compared to their heavy-duty counterparts, they reveal that medium-duty trucks often exhibit higher accident risks due to factors such as higher speeds and more aggressive driving behaviors. Additionally, there has been significant progress in freight modeling and forecasting, with researchers developing innovative methodologies to estimate truck volumes, track flow patterns, and integrate multiple data sources for comprehensive freight planning. However, there remains a notable gap in the literature specifically focusing on medium-duty trucks, underscoring the need for further research to develop targeted safety regulations and monitoring methodologies. The current study aims to fill this gap by evaluating the implications of medium-duty truck operations on highway safety and informing policy development to mitigate associated risks.

This section provides a comprehensive review of literature pertaining to ecommerce impact on medium-duty vehicle numbers, safety, and freight forecasting studies. The goal of this review is to identify potential areas of risk, future operational growth, and costs associated with medium-duty trucks. This is part of the overall objective of the current study to assess the risk to highway safety posed by the increasing freight movement via medium-duty trucks.

2.1 BACKGROUND MOTIVATION

The motivation for this study comes from recent traffic data, which revealed the number of medium-duty trucks has increased significantly in recent years. Based on data reported over the last decade in the Oregon Highway Cost Allocation Study (HCAS), the total truck vehicle miles traveled (VMT) in Oregon has increased by 9 percent from 2007 to 2018 (Oregon Office of Economic Analysis, 2021). More specifically, medium-duty truck VMT increased by 35 percent while heavy-duty truck VMT increased by only 2 percent. These increasing trends could be partially due to Oregon's population growth, which has consistently increased since 2009. Additionally, the freight industry has rapidly grown in recent years due to the development and continued growth of e-commerce. Since 2010, freight-related jobs have increased by 35.3 percent in Oregon (Sawyer, 2020). Considering Oregon's population growth during this period, the medium-duty truck per capita VMT increased by 20 percent, while the heavy-duty truck per capita VMT decreased by 2 percent. Figure 2.1 displays the major change in medium-duty truck per capita VMT in comparison to heavy-duty trucks and its overall impact on the truck per capita VMT in Oregon. It is clear that medium-sized commercial vehicles have become a distinct sector of transportation users in recent years.

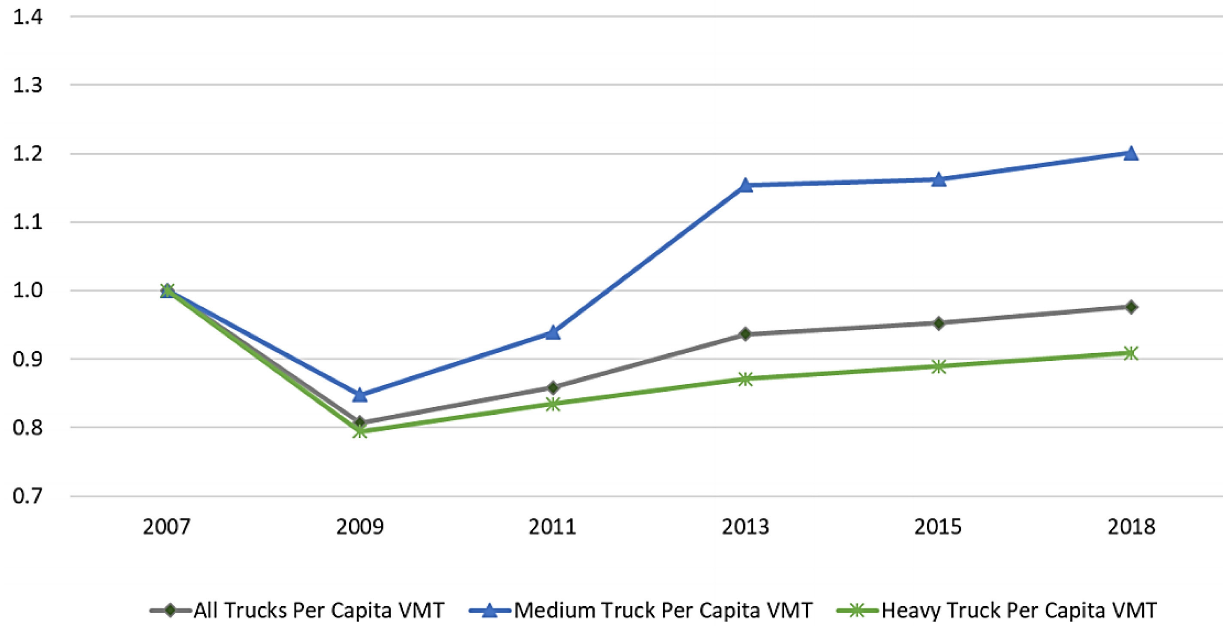

Figure 2.1 Change in Per Change in Per Capita Truck VMT 2007-2018, Indexed to 2007
(Source: Oregon 2020 Statewide Congestion Overview)

Many factors could be influencing businesses to use more medium-duty trucks, including last-mile delivery, the driver shortage, autonomous vehicles, new emissions regulations, electrification, and alternative fuels (Fletcher, 2019). It is important to note that the Federal Motor Carrier Safety Administration (FMCSA) defines a commercial motor vehicle (CMV) as "any self-propelled or towed motor vehicle used on a highway in interstate commerce to transport passengers or property when the vehicle has a gross vehicle weight or gross combination weight of 10,000 pounds or greater." This includes vehicles in Classes 3 through 8 based on the Federal Highway Administration (FHWA) vehicle classifications, shown in Figure 2.2. However, by requirements set by FMCSA under 49 CFR 383.5, a commercial driving license (CDL) is only required for operators of motor vehicles greater than 26,000 pounds, or only for vehicles in Classes 7 or 8. Therefore, drivers of medium-duty trucks are not required to obtain a CDL. This indicates there is an increasing number of commercial truck drivers operating without a CDL, who are not subject to DOT drug and alcohol testing requirements, or to DOT and Occupational Safety and Health Administration (OSHA) training that prepares drivers with defensive driving, accident reporting, hazardous materials management, vehicle inspections, and maintenance. This raises major concern because of the increase in medium-duty truck operations and its unknown impact on highway safety and operations. Relatively few investigations have considered medium-duty trucks as a separate category from heavy trucks. For this reason, the purpose of this research project is to address the gaps in the research and gain a comprehensive understanding of medium-duty truck operations in Oregon. The following sub-chapters describe some of the recent studies related to medium-duty truck safety, related costs, and freight forecasting.

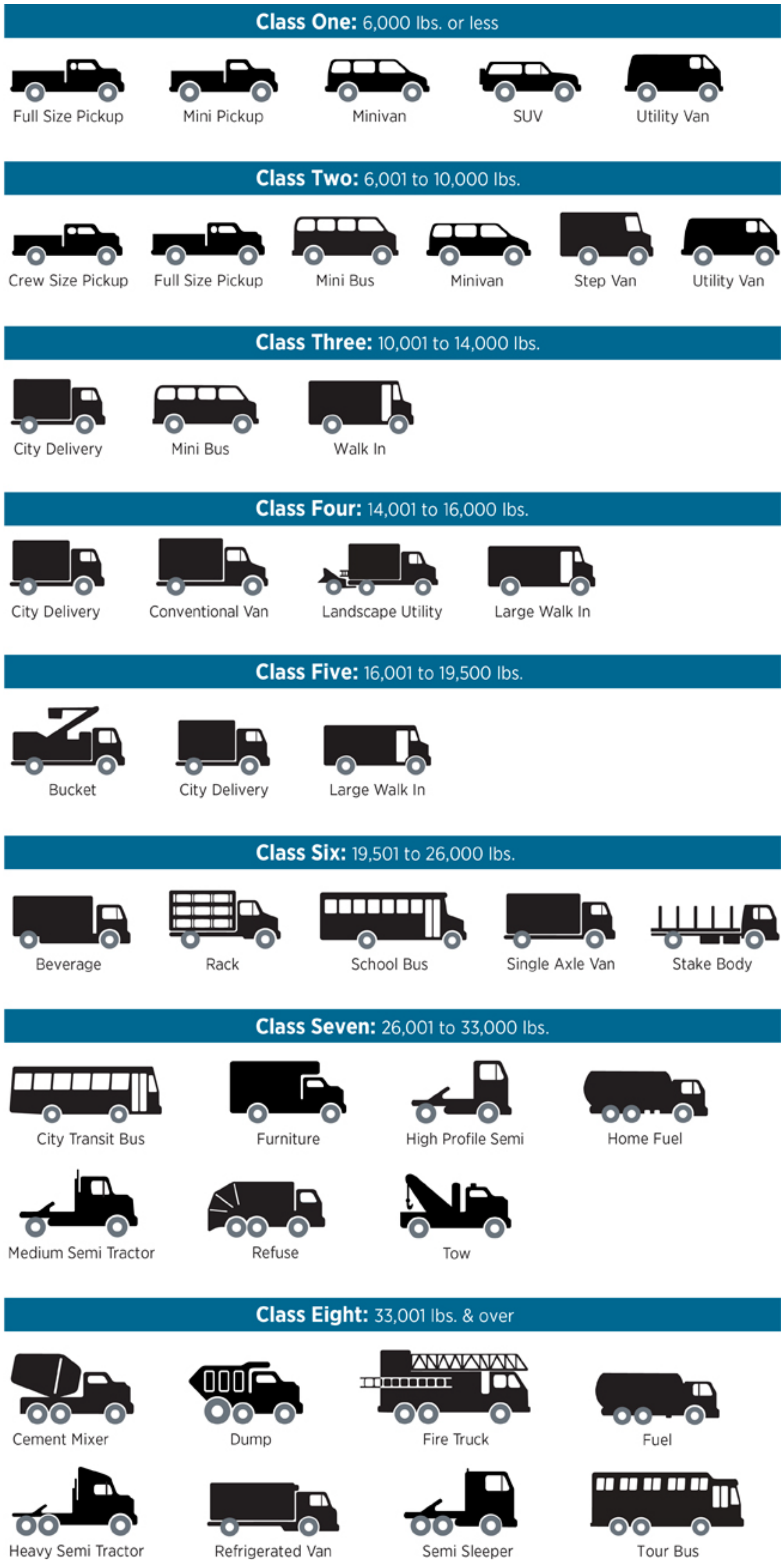

Figure 2.1 FHWA Vehicle Classifications

The following sub-chapters describe some of the recent studies related to ecommerce impacts on medium-duty vehicle numbers, safety, related costs, and freight forecasting. The next sections will delve into safety-based studies and freight modeling and forecasting of medium-duty vehicles, providing insights and methodologies that can help in understanding and mitigating the risks associated with these vehicles.

2.2 E-COMMERCE AND THE INCREASING NUMBERS OF MEDIUM-DUTY VEHICLES

Many studies have explored the impacts of e-commerce on urban transportation, highlighting the significant rise in delivery trucks and the associated challenges of traffic congestion, emissions, and urban infrastructure adaptation. Research has developed innovative methodologies to model and predict the effects of online shopping on vehicle miles traveled (VMT) and environmental impacts. Despite these advancements, there remains a gap in understanding the specific implications for medium-duty trucks. This section summarizes key studies on e-commerce's influence on urban freight transport, logistics, and last-mile delivery operations to provide a comprehensive understanding of the procedures and methodologies employed in this evolving field.

2.2.1 Medium-Duty Vehicle Relevant Literature

The rapid growth of e-commerce has significantly transformed urban transportation dynamics, leading to an increase in delivery trucks on city roads and contributing to traffic congestion and environmental challenges. This section explores various studies that delve into the multifaceted impacts of e-commerce on urban freight systems, emphasizing the need for effective management strategies to mitigate negative effects.

In the study by Jaller and Pahwa (2020) they delve into the effects of e-commerce on urban transportation, particularly focusing on how increased online shopping leads to more delivery trucks on the roads. Using data from the American Time Use Survey, the study develops behavioral models to understand shopping patterns and their impact on vehicle miles traveled (VMT) and emissions in cities like Dallas and San Francisco. The findings highlight that e-commerce results in increased traffic congestion and pollution, stressing the need for better urban freight management to mitigate these negative effects.

Building on the insights from Jaller & Pahwa (2020), Taniguchi and Kakimoto (2004) present simulation models to further assess the impact of e-commerce on urban freight traffic and the environment. The models reveal that the rise of e-commerce, particularly business-to-consumer (B2C) transactions, leads to increased traffic and environmental degradation. However, strategies such as cooperative freight systems, designated delivery time windows, and pickup points can mitigate these impacts by reducing total costs, travel times, and emissions.

Expanding the discussion on urban freight, Somasundram (2019) explores the broader implications of e-commerce on urban logistics, warehousing, and retail experiences. It highlights the significant rise in delivery trucks due to home deliveries, contributing to traffic congestion and environmental hazards. The study suggests that while e-commerce can lead to more efficient logistics, it also necessitates changes in urban infrastructure, such as increased demand for warehousing space and adjustments in retail spaces to accommodate new shopping behaviors.

To address some of the environmental concerns, Siragusa et al. (2022) evaluate the feasibility of using electric vehicles (EVs) for last-mile deliveries in e-commerce. The study compares EVs with internal combustion engine vehicles (ICEVs) based on economic and environmental metrics, concluding that EVs are more cost-effective over an eight-year period despite higher initial costs. Environmentally, EVs significantly reduce greenhouse gas emissions, making them a sustainable option for urban deliveries.

Continuing with the theme of last-mile delivery, Allen et al. (2018) investigate the increase in light goods vehicle activity in urban areas due to the growth of e-commerce. It highlights the challenges of last-mile delivery operations, such as poor vehicle utilization, congestion, and the impact on urban infrastructure. The study emphasizes the importance of managing delivery operations efficiently to minimize the negative impacts on urban centers, suggesting potential solutions like optimizing delivery routes and consolidating shipments.

Finally, Laghaei et al. (2016) examine the effects of home shopping on vehicle operations and greenhouse gas emissions over several years. It finds that while home shopping reduces individual shopping trips, it increases the number of delivery trucks on the road, leading to higher traffic volumes and emissions. The simulation results indicate that home shopping adds significant strain to transportation networks, highlighting the need for sustainable logistics practices to mitigate these impacts.

2.2.2 Summary

In summary, the research highlights the significant impact of e-commerce on urban transportation, notably the increase in delivery trucks leading to traffic congestion and pollution. Studies using behavioral models and simulation models reveal that online shopping drives higher vehicle miles traveled (VMT) and emissions, stressing the need for improved urban freight management. Solutions such as cooperative freight systems, designated delivery time windows, and pickup points can mitigate these effects. Additionally, the shift to electric vehicles (EVs) for last-mile deliveries offers economic and environmental benefits over internal combustion engine vehicles. Effective management of delivery operations is crucial to address challenges like poor vehicle utilization and congestion. Lastly, home shopping's increase in delivery trucks adds strain to transportation networks, underscoring the need for sustainable logistics practices. These findings collectively emphasize the necessity for comprehensive strategies to manage the growing influence of e-commerce on urban transportation and sustainability.

2.3 SAFETY BASED STUDIES

This section presents summaries of recent studies related to medium-duty truck safety. This review is intended to develop an understanding and familiarity with the procedures and methodologies used in the past to gain insight into how to better accomplish the current study’s objectives.

2.3.1 Medium-Duty Vehicle Relevant Literature

The safety and operational efficiency of medium- and heavy-duty trucks on highways have garnered increasing attention in transportation research, driven by their significant role in freight movement and the associated risks of traffic incidents. With the rise of e-commerce and the growing presence of medium-duty trucks, understanding the unique challenges and safety implications for these vehicles has become crucial. This section reviews key studies that investigate crash trends, safety regulations, and the impact of operational characteristics on medium- and heavy-duty truck safety. By examining comprehensive data analyses, regulatory evaluations, and cost-benefit assessments, this review aims to highlight the current understanding of truck safety and identify areas for future research and policy development. The insights from these studies provide a foundation for addressing the evolving safety needs of medium- and heavy-duty trucks in the context of modern transportation systems.

In 2013, the American Transportation Research Institute (ATRI) released the most comprehensive quantitative review published on the topic to date. Park & Pierce (2013) analyzed national large truck crash data from 2000 to 2010 to evaluate common trends and factors in the crash data. The data for this research came from the FMCSA Motor Carrier Management Information System (MCMIS) crash dataset. The research team examined medium- and heavy-duty truck crash trends separately based on a crash rate index (CRI). The CRI allowed them to track specific variables such as vehicle type, crash location, and weather to determine the degree to which certain factors influenced crash trends for medium- and heavy-duty trucks. Several distinctions between medium- and heavy-duty truck crash trends were recognized. Crashes involving heavy-duty trucks ranged between 1,870 and 2,589 a year, whereas medium-duty truck crashes ranged between 392 and 685 a year. Heavy-duty trucks have greater exposure to crashes because they travel more miles than medium-duty trucks. Heavy-duty trucks generally experienced a decline in CRI of 24.6 percent from 2000 to 2010, while medium-duty trucks had a 38.3 percent increase over that same period. Park and Pierce (2013) also found that medium-duty trucks often travel at higher speeds and display more aggressive driving behaviors. Additionally, the differential operational characteristics and accident environments for medium-duty trucks lead to a higher risk of accidents and more severe accidents. Non-interstate carrier crashes exhibited a steep increase in CRI compared to interstate carriers, particularly among medium-duty truck crashes. Increases in medium-duty truck crashes on roads in urban core counties were responsible for much of the increase in medium-duty CRI numbers. This study was able to determine the varying levels of safety among medium- and heavy-duty trucks and provides a reliable method to distinguish between the two types of trucks.

Under contract with the National Highway Traffic Safety Administration (NHTSA), Woodrooffe & Blower (2015) analyzed truck driver injuries and fatalities in truck crashes related to cab crashworthiness. They assembled information on truck driver casualties in crashes to gain a better understanding of the injury mechanisms and to review regulatory and industry initiatives in relation to truck occupant protection. The primary focus of this study is on truck-tractors and single-unit vehicles in the NHTSA Class 7 and 8 weight range, but the survey file used for this research revealed crash trends for both heavy- and medium-duty trucks. From the Trucks Involved in Fatal Accidents (TIFA) survey file developed by the University of Michigan Transportation Research Institute (UMTRI), detailed descriptions of each truck-involved fatal crash were compiled, as well as data on the truck operator and on the truck's role in the crash.

Based on this data from 2006 through 2010, occupants of medium-duty trucks are at a greater risk of fatal injury than occupants of heavy trucks: 16.9 percent of occupants of medium-duty trucks were killed in these crashes compared with 14.0 percent of occupants of heavy-duty trucks. The current study will evaluate Oregon large truck crash data to assess if the trends found in this study are consistent with Oregon truck crash data.

Corsi et al. (2014) examined whether medium-duty commercial trucks should adhere to the same safety standards as heavy-duty trucks. They assessed the cost-effectiveness of the FMCSA's roadside inspection program for medium-duty CMVs, considering direct program costs and expenses incurred by truck operators during inspections. Benefits of the program included savings from preventing crashes by addressing violations uncovered during inspections. Using motor carrier data, the researchers estimated crash risk reductions for specific violations, projecting annual crash prevention numbers per violation. They evaluated cost savings based on crash estimates from a FMCSA-sponsored study (Zaloshnja and Miller, 2006). Further, their analysis indicated the FMCSA program annually prevented around 3,882 crashes involving medium-duty CMVs. Moreover, medium-duty trucks exhibited higher driving performance and traffic violation rates compared to heavy-duty trucks in the U.S. (see Table 2.1 from Corsi et al. (2014)). For every dollar spent, the program yielded approximately $8.86 in benefits for medium-duty CMVs in 2011 dollars. The researchers concluded that current safety regulations for medium-duty trucks were justified and should be upheld. Since then, medium-duty trucks have significantly expanded within the CMV sector in the U.S. This study will adopt a similar approach to evaluate the implications of this growth and future expansions on highway safety.

Table 2.1 Performance Difference between Medium- and Heavy-Duty CMVs, 2008

Vehicle Class	Number of Driver Inspections	Driver OOS	Fatigued Driver (Basic)	Driver Fitness (Basic)	Substance and Alcohol Abuse
10,001-26,000 lbs	185,657	0.090	0.054	0.037	0.003
26,001-80,000 lbs	555,252	0.080	0.056	0.027	0.001
Vehicle Class	**Number of Vehicle Inspections**	**Vehicle OOS**	**Vehicle Maintenance (Basic)**		**Improper Loading (Basic)**
10,001-26,000 lbs	168,256	0.203	0.156		0.069
26,001-80,000 lbs	423,194	0.248	0.201		0.066

Note: Table source Corsi et al. (2014)

2.3.2 Summary

In general, the few studies that have investigated medium-duty truck safety agree that, compared to heavy trucks, medium-duty trucks experience higher accident risk due to various factors differentiating the two groups (e.g., higher speeds with more severe results in the case of an accident, more aggressive driving, and drivers who are often not required to possess a commercial driver's license). The current study will evaluate safety data for medium-duty vehicles on crash rates, incidents, and any other relevant safety data involving medium-duty vehicles.

2.4 FREIGHT MODELING AND FORECASTING

Many studies have developed innovative ideas to model or predict freight traffic characteristics, as well as methodologies for quality assurance of the data. However, there is a gap in the research specifically investigating medium-duty trucks. This section summarizes research on freight modeling and forecasting for other specific truck types or weight categories to gain insight into the procedures and methodologies used.

2.4.1 Medium-Duty Vehicle Relevant Literature

Understanding and accurately modeling truck flows, particularly for medium- and heavy-duty vehicles, is crucial for effective freight planning and transportation management. Recent studies have leveraged advanced data collection technologies and innovative modeling techniques to enhance the accuracy and granularity of truck flow estimations. This section reviews significant contributions to this field.

Hernandez, Chern, Tok, & Ritchie (2013) conducted one of the first studies in freight modeling literature estimating truck flows of specific weight categories. The researchers were able to produce high-resolution truck data by integrating WIM systems and advanced inductive loop detectors (ILD). They found that these two collection devices are exceptionally complementary to each other. For each vehicle traversing a WIM site, an inductive signature was collected along with WIM measurements such as axle spacing and weight. The data collected is detailed, link-specific, temporally continuous, up-to-date, and representative of the full truck population.

Further, Hernandez et al. (2013) performed a case study using data from four sites in California, ranging geographically: (1) Redding, (2) Willows, (3) Fresno, and (4) Irvine. Using the Vehicle Inventory and Use Survey (VIUS), conducted by the U.S. Census Bureau, the researchers created a classification scheme to capture the diversity of truck body types for the most common truck axle configuration, the five-axle tractor trailer corresponding to FHWA class 9. This body classification model could predict 35 different trailer body types for FHWA class 9 semi-tractors, achieving an 80 percent correct classification rate. Generally, integrating the WIM site data with inductive signature capabilities allows the body classification model to predict among body types found within an axle configuration class.

Building upon this research, Hernandez, Tok, & Ritchie (2015) adopted the multiple classifier systems (MCS) method to increase the classification accuracy for minority body classes and to ensure spatial and temporal transferability of the model. Eight separate body classification models were developed from an extensive data set of 18,967 truck records, distinguishing an unprecedented total of 23 single-unit truck and 31 single and semi-trailer body configurations, each with over 80% correct classification rates (CCR). The body class model for five-axle semi-tractor trailers achieved CCRs above 85% for several industry-specific classes, including refrigerated and non-refrigerated intermodal containers, livestock, and logging trailers.

Similarly, Hyun et al. (2015) developed a modified decision tree model and Gaussian mixture model using WIM data to estimate truck volumes and gross vehicle weight (GVW) distributions by body configuration. The focus of this study was on five-axle semi-tractor trailers. WIM data was collected from three locations in California: (1) Fresno, (2) Redding, and (3) Willows. A fourth location was selected to test for spatial and temporal transferability. A total of 10,904 truck records were collected across multiple days. A sensitivity analysis was performed to account for potential errors in the WIM data. Each measurement was increased by a constant 10 percent. The results show that the errors are acceptable, and the proposed methods are spatially and temporally transferable. In addition, the model can capture daily variations (i.e., time-of-day) of truck travel movements. Ultimately, the proposed methodologies provided accurate predictions of freight operations.

To develop detailed truck flow pattern data, Hyun et al. (2017) developed a truck tracking algorithm and model to estimate flow paths. They accomplished this by implementing a linear data fusion methodology with WIM data and data from inductive loop point sensors. To develop the model, data was obtained from two WIM sites spanning 26 miles on I-5 in California: (1) San Onofre (upstream) and (2) Leucadia (downstream). Over this 26-mile stretch, there are two major highway intersections and 17 on/off ramps. Additionally, still images of license plates of vehicles were collected and manually linked to the WIM data and inductive loop signatures. Over two days, Hyun et al. (2017) collected 5.5 hours of data and split it into test and training datasets. Using the collected data, they matched vehicles to detail truck flow. To match individual vehicles with better performance, key feature variables were chosen and weighted through a Bayesian model. Results showed that the proposed methodology correctly matched 81% of the through trucks. Moreover, the Bayesian approach (using both data sources) can successfully track and identify trucks over a long distance.

Eluru et al. (2018) developed a fused database using various data sources commonly used for freight planning purposes. The goal was to combine them all into one accessible source to better understand transportation network flows for freight planning. The datasets used for their analysis included the Freight Analysis Framework (FAF), the Transearch dataset, GPS data from ATRI, WIM data, and land use data, all for the state of Florida. The Transearch dataset is a proprietary carrier-centric comprehensive freight database owned and maintained by Global Insight Inc. It provides detailed information on commodity type, tonnage, value, ton-mile, origin-destination, and mode used for freight movement. A Transearch domestic commodity flow database for Florida was purchased from Global Insight by Florida DOT. The data sources were fused by developing algorithms to disaggregate FAF data, using Transearch data, at a traffic analysis zone scale. The researchers then used optimization methods and econometric methods to estimate county-level commodity flow behavior. WIM data was used to generate origin-destination flows by various weight categories. The proposed optimization approach estimated truck traffic volumes for three weight categories within 25 percent error of the observed values. The researchers concluded that the integration of these data sources can serve as a viable tool for freight planning.

2.4.2 Summary

Although there are no studies specifically investigating the operations of medium-duty , the reviewed studies provide insights into modeling and forecasting for other specific truck types or weight categories using either public and/or private data sources. These studies serve as a basis for the current study in the development of a monitoring methodology to track medium-duty truck safety and performance into the future.

2.5 SUMMARY OF LITERATURE REVIEW

The literature on medium-duty truck operations and safety highlights a growing body of research that addresses the specific challenges and risks associated with these vehicles. Various studies have examined the distinct operational characteristics and safety concerns of medium-duty trucks compared to their heavy-duty counterparts, revealing that medium-duty trucks often exhibit higher accident risks due to factors such as higher speeds and more aggressive driving behaviors. Additionally, there has been significant progress in freight modeling and forecasting, with researchers developing innovative methodologies to estimate truck volumes, track flow patterns, and integrate multiple data sources for comprehensive freight planning. Research on e-commerce has further shown the substantial impact of online shopping on urban freight traffic and environmental degradation, underscoring the need for effective urban freight management strategies. However, work specifically focusing on medium-duty vehicles, their impacts on safety, and understanding commodities is very limited and sparse. This gap underscores the need for further research to develop targeted safety regulations and monitoring methodologies. The current study aims to fill this gap by evaluating the implications of medium-duty truck operations on highway safety and informing policy development to mitigate associated risks.

To effectively address these challenges, the following section (Section 3) will focus on the data and data gaps relevant to this study. It will provide an overview of the available data sources, identify existing gaps, and outline the methodology for collecting and analyzing the necessary data to support this research.

3.0 DATA AND DATA GAPS

This section introduces the data utilized for the study and discusses some of the challenges and limitations in obtaining the data. The data consists of information used for establishing a potential baseline of medium-duty vehicle inventory and characteristics in the state, as well as for conducting safety analysis.

3.1 DATA SOURCES

To address the objectives outlined in section one—(1) providing a comprehensive overview of medium-duty trucks operating in Oregon by estimating their numbers, categorizing them by industry and commodities/services they utilize, examining general trip characteristics, logistic patterns, and regional distribution by population density, and (2) evaluating safety data to compare and contrast crash rates, incidents, and other relevant safety information involving medium-duty trucks and heavy trucks requiring CDL drivers—two different sets of data were collected and analyzed.

The first data set was a comprehensive statewide survey conducted by the Oregon Department of Environmental Quality (DEQ). This survey provided an initial attempt at developing a baseline understanding of medium-duty truck operational characteristics in the state. The second source of data was a combination of information from both the Oregon Department of Transportation (ODOT) Crash Data System (CDS) crash database and the Oregon Commercial Motor Vehicle Division crash database. These databases were combined to obtain commercial vehicle crash data that could be filtered by vehicle class, company, and location. Additionally, the Oregon DOT Place Types were used to examine the relationship between land and commercial vehicle crashes. The datasets covered the years 2007 to 2021, which was the period considered in this interim report.

The following sections will discuss these datasets in further detail.

3.1.1 DEQ Medium- and Heavy-Duty One-Time Fleet Reporting Survey Data

The Oregon Department of Environmental Quality (DEQ) conducted a comprehensive survey to assess the potential for adopting alternative fuels in medium- and heavy-duty (MHD) vehicle fleets across Oregon, driven by the state's commitment to reducing greenhouse gas emissions and addressing climate change. The survey aimed to identify barriers to adopting cleaner energy sources such as electricity, hydrogen, and renewable natural gas, providing valuable insights for policymakers.

3.1.1.1 The DEQ MHD Survey

The data collection process involved gathering information from "Organizations," which encompassed fleet owners, businesses, government agencies, municipalities, and brokers that own, operate, or oversee the movement of vehicles such as trucks, buses, or vans. In this context, the term "vehicle" referred to on-road vehicles with a gross vehicle weight rating (GVWR) exceeding 8,500 lbs., regardless of fuel type or usage. The collected data included details about the organization, such as its name, contact person information, fleet owner, tax ID, operating authority, annual revenue, and sustainability plans. The one-time reporting mandate applied to large entities and government fleets operating on-road vehicles with a GVWR greater than 8,500 lbs, including trucks, buses, and delivery vans. The reporting deadline was June 30, 2022, and included entities with gross annual revenues exceeding $50 million, operating or dispatching five or more vehicles in Oregon in 2021. Military or emergency vehicles and vehicles awaiting sale were exempt.

The collected data is vital for DEQ to develop policies accelerating the transition to zero-emission MHD vehicle fleets. Entities submitted information through Excel spreadsheets, detailing fleet profiles, fuel types, body styles, vehicle ages, and turnover rates. The Clean Trucks Rule, adopted by DEQ in November 2021, supported this effort, aiming to inform policy development for cleaner vehicles and improved air, land, and water quality in Oregon.

3.1.1.2 Summary

Prior to the DEQ-mandated survey, information on medium-duty vehicles was sparse. This survey provides valuable insights into the operational characteristics of these vehicles. Although the survey does not collect detailed information on specific commodities, it presents information on parcel delivery vehicles, which are of particular interest to this study, especially for three of the largest parcel delivery companies: United Parcel Service, Federal Express, and Amazon.

The DEQ-mandated survey data will be utilized in Section 4 to better understand medium-duty vehicles in Oregon. This section will analyze the detailed information from the DEQ survey, providing a comprehensive overview of the current landscape and offering recommendations for future monitoring and data collection to enhance the estimation of medium-duty vehicle numbers and categories.

3.1.2 Safety Analysis Data

To analyze crash trends and understand the evolution and patterns of freight-related safety crashes, particularly those involving medium-duty vehicles in Oregon, data were collected from an array of sources. This analysis included examining yearly trends as well as seasonal, weekly, and hourly crash patterns by commercial vehicle type. Additionally, the study investigated crash severity trends by disaggregating data by injury levels and fatality rates, analyzing overall crash rates, and separating them by urban and rural areas as well as by functional class.

3.1.2.1 Datasets utilized in Safety Analysis

Given that specific data on medium-duty vehicles was sparse, particularly within the current data collected by the agency, attempts were made to best represent this class of vehicle within the available data. This effort aimed to ensure that the analysis accurately reflected the safety trends and challenges associated with medium-duty vehicles in Oregon. The following two points describe the two data sets used:

- **ODOT Crash Database System (CDS)**: For the safety analysis portion of this study, data were derived from the ODOT Crash Database System (CDS) covering the years 2007 to 2021. This data is segmented into three sets: a crash database, a vehicle database, and a participant database. The CDS assigns a crash ID number to each incident, linking these databases together. The Oregon Crash Database System (CDS) is maintained by ODOT's Transportation Data Section - Crash Analysis and Reporting (CAR) Unit.

- **Commercial Motor Vehicle (CMV) Crash Database**: The second set of data is from the commercial vehicle crash database maintained by the Commercial Motor Vehicle (CMV) Department, spanning from 2002 to 2023. This database uses a different ID number system to identify crashes compared to the CDS. Each dataset has its unique advantages and disadvantages. A primary goal was to integrate these datasets to combine all available information about commercial vehicle crashes, thereby providing a more comprehensive view.

The two datasets helped address most of the analyses intended for Objective 2; however, these datasets lacked the information necessary to conduct a crash rate analysis. To specifically address and analyze the crash rate of medium-duty vehicles, an additional data source was utilized. To study crashes by land use, an additional dataset called Place Type was used in this study. Place Type data, which is at the Census Block level for Oregon for the year 2010, was put together by the Oregon Department of Transportation using travel data and the 2019 US Census American Community Survey (ACS) data. With this data, the crash rate analysis could be conducted.

3.1.2.2 Advantages and Disadvantages of CDS and CMV Datasets

An advantage of the CDS dataset was that many data entries included latitude and longitude coordinates, allowing crashes to be easily and accurately plotted to see spatial trends. It also included more detailed information about the severity level of the crash. However, the disadvantages of the CDS were that it did not include a Vehicle Identification Number (VIN), a company name for commercial vehicles, or more than a general category for vehicle type, making it impossible to determine crashes by the type of commercial activity.

Conversely, the CMV data had the main disadvantage of not having latitude and longitude information. The location information for the CMV data was limited to a description written by the reporting police officer that offered the nearest intersection along with the direction and distance to the site of the accident. While this information may be descriptive enough to find the site of an accident, it was very time-consuming to translate these descriptions to coordinates by hand for nearly 42,000 records. However, the advantages of the CMV data were that it included a VIN for each vehicle participant, as well as the name of the company responsible for the vehicle.

3.1.2.3 Summary

By merging these datasets, the study aimed to provide a more comprehensive analysis of medium-duty vehicle crashes in Oregon, thereby offering valuable insights into safety trends and informing future policy and intervention strategies. The merged datasets will be utilized in Section 5 to better understand the safety trends and patterns of medium-duty vehicle crashes in Oregon. This section will analyze the detailed information from both the ODOT Crash Database System (CDS) and the Commercial Motor Vehicle (CMV) crash database, providing a comprehensive overview of the current safety landscape. It will also offer recommendations for future data collection and monitoring to improve the accuracy and completeness of medium-duty vehicle crash data, thereby informing policy and intervention strategies.

3.1.3 Data Gaps and Limitations

The following sections describe the specific data gaps and limitations to addressing the study objectives.

3.1.3.1 Objective One

For objective one, despite the comprehensive nature of the DEQ Medium- and Heavy-Duty One-Time Fleet Reporting Survey and the ODOT Crash Database System (CDS) data, there were notable gaps and limitations that needed to be addressed to meet the study's first two objectives. The DEQ survey provided valuable insights into the operational characteristics of medium- and heavy-duty vehicle fleets across Oregon. However, it did not collect detailed information on specific commodities, limiting the ability to analyze the operational impact of different types of goods transported by these vehicles. Additionally, while the survey covered large entities and government fleets, it excluded smaller operators and specific vehicle types such as military or emergency vehicles, and those awaiting sale. These omissions may result in an incomplete picture of the medium-duty vehicle landscape in Oregon. Although the DEQ data provided a good overview of the medium-duty vehicle inventory in the state, the ability to link this data source to enrich its potential use in the safety analysis did not exist. Nevertheless, the data provided a solid baseline of what currently existed as of the survey's end date.

3.1.3.2 Objective Two

For objective two, the safety analysis data were derived from two main sources: the ODOT Crash Database System (CDS) and the Commercial Motor Vehicle (CMV) crash database. The CDS dataset, while rich in detail with latitude and longitude coordinates and severity levels of crashes, lacked crucial identifiers such as Vehicle Identification Numbers (VINs) and company names. This absence made it challenging to determine the specific commercial activities involved in crashes. Conversely, the CMV data included VINs and company names, which are critical for linking crashes to specific vehicles and operators. However, this dataset did not contain latitude and longitude information, and the location descriptions provided by police officers were often not precise enough for easy spatial analysis. Manually translating these descriptions to coordinates for nearly

42,000 records would be extremely time-consuming and prone to errors. These two datasets provided the majority of information necessary to address Objective Two. However, to address crash rates, a third dataset was required: the Place Type data.

3.1.3.3 Summary

By merging these datasets, the study aimed to provide a more comprehensive analysis of medium-duty vehicle crashes in Oregon, offering valuable insights into safety trends and informing future policy and intervention strategies. However, the limitations of each dataset underscore the need for improved data collection practices. Future efforts should focus on enhancing the granularity and completeness of the data, including detailed commodity information, precise location data, and comprehensive coverage of all vehicle types and operators. This will enable more accurate and actionable analysis, ultimately supporting better policy development and safety interventions.

3.2 SUMMARY

This section introduces the data utilized for the study and discusses some of the challenges in obtaining the data. To provide a comprehensive overview of medium-duty trucks operating in Oregon and evaluate safety data, two primary datasets were collected and analyzed. The first dataset came from the Oregon Department of Environmental Quality (DEQ) survey, which aimed to assess the potential for a baseline forecast of existing conditions in regard to medium duty vehicles in the State. This survey provided valuable insights into fleet profiles, fuel types, body styles. However, the survey lacked detailed information on specific commodities and excluded smaller operators and certain vehicle types, leading to potential gaps in the data.

The second dataset was derived from the Oregon Department of Transportation (ODOT) Crash Database System (CDS) and the Commercial Motor Vehicle (CMV) crash database. The CDS data included detailed information about crash locations and severity levels but lacked Vehicle Identification Numbers (VINs) and company names. Conversely, the CMV data included VINs and company names but lacked precise location information. By merging these datasets, the study aimed to provide a more comprehensive analysis of medium-duty vehicle crashes in Oregon. Despite the limitations, the combined data offers valuable insights into safety trends and informs future policy and intervention strategies.

Future efforts should focus on enhancing data granularity and completeness, including detailed commodity information, precise location data, and comprehensive coverage of all vehicle types and operators, to support better policy development and safety interventions.

4.0 COMPREHENSIVE ANALYSIS OF MEDIUM-DUTY VEHICLE OPERATIONS IN OREGON USING DEQ SURVEY DATA

To address the first objective of this study, this section aims to describe medium-duty vehicles in the State of Oregon using data collected and compiled from the Oregon Department of Environmental Quality (DEQ) Medium- and Heavy-Duty One-Time Fleet Reporting survey. Although there is currently no mechanism in place to track commodity and industry types for these vehicles in the state, this chapter utilizes the DEQ survey to provide an overview of this vehicle type. Additionally, this section will derive recommendations for future monitoring procedures and identify additional data needs that can be collected to further improve the estimation of medium-duty vehicle numbers and categories.

4.1 INTRODUCTION TO DATA

The Oregon Department of Environmental Quality (DEQ) initiated its data collection effort in response to the Oregon Advanced Clean Trucks regulation, which was adopted in November 2021. The data collection process involves gathering information from "Organizations", encompassing fleet owners, businesses, government agencies, municipalities, and brokers that own, operate, or oversee the movement of vehicles such as trucks, buses, or vans. In this context, the term "vehicle" refers to on-road vehicles with a gross vehicle weight rating exceeding 8,500 lbs., regardless of fuel type or usage. The collected data includes details about the organization, such as its name, contact person information, fleet owner, tax ID, and operating authority, as well as annual revenue and sustainability plans. Furthermore, if the organization is a motor carrier or broker, information about the number of subhaulers and vehicles operated by subhaulers is also collected.

Besides organizational information, data on facilities, which serve as "home bases" for vehicles, is also captured. A "home base" refers to the location where a vehicle is domiciled - a business site where a vehicle is typically stored when not in use. For vehicles kept at a personal residence or at a location not operated by the organization, they are registered using the location from which they are dispatched or where they undergo repair or maintenance.

Finally, DEQ collected data on vehicles associated with each home base and their respective usage. On-road vehicles reported under the DEQ data collection include:

- Class 2b-3 (8,501-14,000 lbs.),
- Class 4-5 Trucks (14,000-19,500 lbs.),
- Class 6 and 7 Trucks (19,500-33,000 lbs.),
- Class 8a and 8b Trucks (Greater than 33,000 lbs.),
- Class 7-8 (Over 26,000 lbs.).

Over 1000 organizations were surveyed in the state with a total fleet over 142,000 vehicles. This data will serve as a valuable source of information for estimating and forecasting future growth and commodities carried by medium-duty trucks. Additionally, it will offer insights into origins, which can be utilized to determine network usage patterns.

4.2 DATA DESCRIPTION

The survey conducted by the Oregon Department of Environmental Quality (DEQ) gathered data in three distinct categories: organization, facility, and vehicle. Organization-related data such as business information, geographic location, and fleet size were gathered. In the facility category, general information including industry type, facility ownership, and fueling infrastructure was collected. Lastly, gross vehicle weight rating, fleet body type, fuel type, vehicle usage, and characteristics were collected under the vehicle category.

The responses from the three categories were consolidated into a single database by matching facility names, resulting in a total of 6030 entries. To provide a more detailed analysis, each vehicle group and weight class within the same facility were presented individually. For example, in the agricultural sector, 'Simplot Grower Solutions – Independence' reported two types of pickup bed trucks: one gasoline-based and the other diesel-based. The database recorded this information separately, along with the total number of vehicles in each vehicle group.

Additionally, a separate disaggregated database was created to estimate the total number of vehicles based on the number of vehicles in each group. This dataset, consisting of 26,068 units, which represents the total number of vehicles derived from the survey responses.

4.3 RESULTS

4.3.1 Number of Medium Duty Vehicles by Weight Class

Table 4.1 and Figure 4.1 display the distribution of medium-duty vehicles based on weight class. For this project, a filtering process was carried out to include vehicles with weights ranging from 8,501 lbs. to 33,000 lbs. in the original database. This data serves as a foundation for determining the number of medium-duty trucks in Oregon.

The graph analysis reveals that most surveyed vehicles belong to the weight class 2B-3, representing 55.2% of the overall medium-duty vehicles. Furthermore, approximately 24.4% of the vehicles fall within the weight class 4-5 trucks, while around 20.4% are categorized as weight class 6-7 trucks. It's important to note that these vehicles serve various industries, such as agriculture, cargo handling, and food and beverage distribution.

Table 4.1 Weight Class Distribution of Medium Duty Vehicles

Weight Class Bin	Count	% of Overall Medium Duty Vehicles
Class 6 and 7 Trucks (19,500 lbs - 33,000 lbs)	5318	20.4%
Class 4-5 Trucks (14,000 lbs - 19,500 lbs)	6364	24.4%
Class 2B-3 (8,501 - 14,000lbs)	14386	55.2%

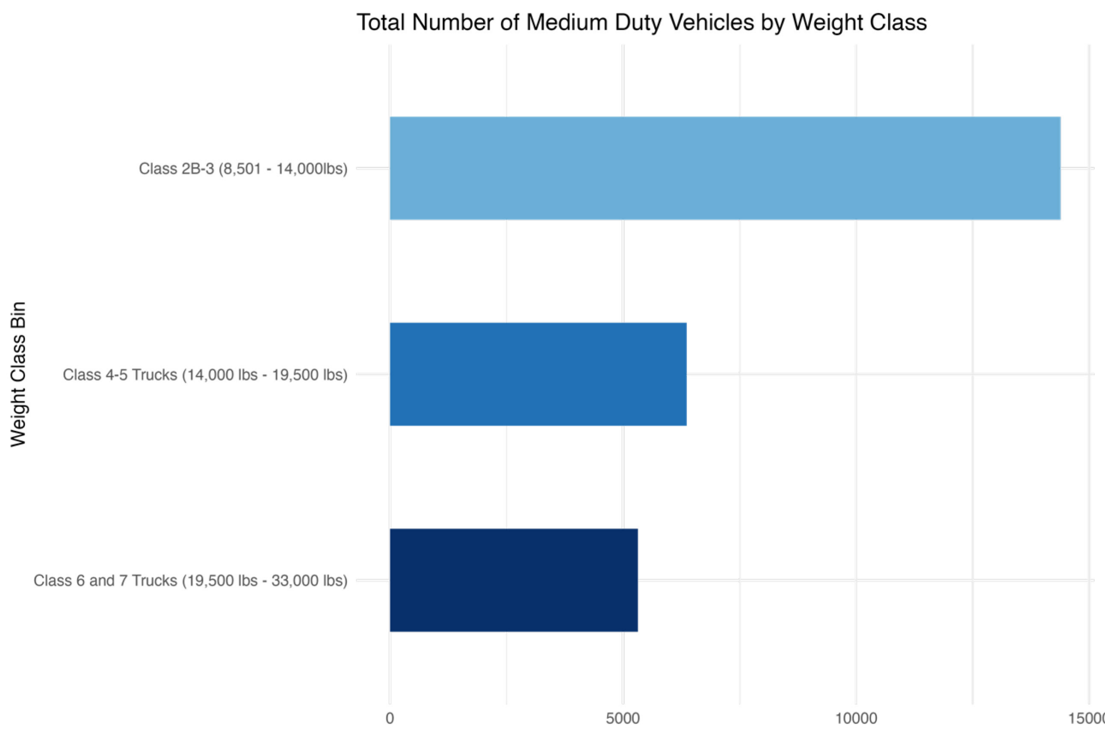

Figure 4.1 Distribution of Medium Duty Vehicles by Weight Class

4.3.2 Annual Mileage

Figure 4.2, presented here, illustrates the average annual mileage of vehicles, categorized according to their weight class. The survey data used in this analysis contained numerous outliers, which were subsequently excluded to provide more meaningful insights into the average annual mileage of the vehicles.

Upon examining the figure, it is evident that the median annual mileage for weight class 2B-3 and Class 6 and 7 trucks is comparable. In contrast, weight class 4-5 trucks display a slightly higher median compared to other weight classes. This category also has fewer outliers compared to others. Notably, most delivery vehicles fall under this weight class, indicating their more extensive use.

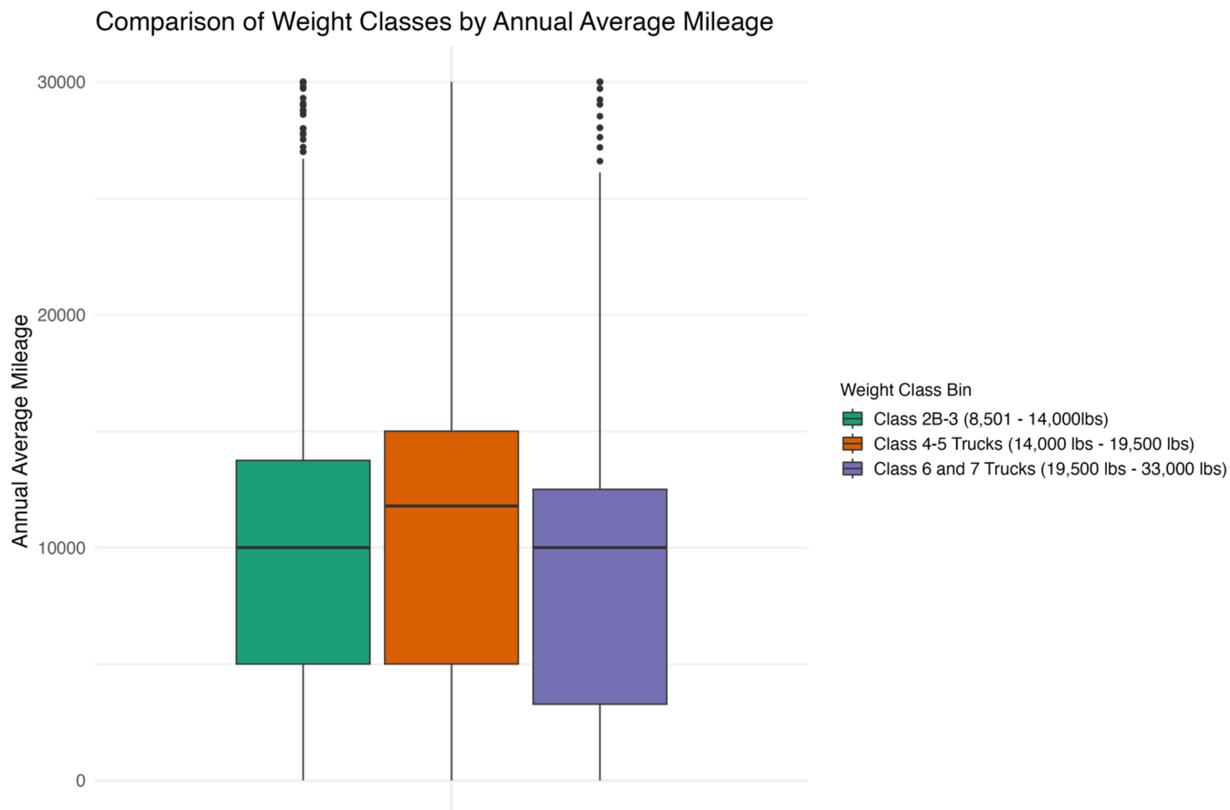

Figure 4.2 Average Annual Mileage of Vehicles Based on Weight Class

4.3.3 Number of Vehicles by Fleet Sector

The survey covered a total of 39 sectors, but analysis revealed that 13 of these sectors accounted for approximately 97% of the total vehicles surveyed. Figure 4.3 and Table 4.2 presented here show that the "Construction" sector had the highest number of vehicles, highlighting the significant role of this industry in fleet composition. The "Other, Please Specify in Comments Field" category also had a high number of vehicles, likely representing various sectors not specifically listed.

The parcel delivery, cargo handling and food distribution sectors also featured prominently, indicating their importance in the overall fleet composition. Additionally, industries such as transit, food or beverage distribution and agriculture exhibited substantial numbers of vehicles, further highlighting the diversity of fleet usage.

The weight class distribution across these sectors varied. For example, the construction and parcel delivery sectors had a higher occurrence of lighter vehicle classes. Notably, delivery vehicles were reported across different fleet sectors such as cargo handling, parcel delivery, and regional shipping, making it challenging to pinpoint the exact number of vehicles dedicated to goods delivery. This data illustrates the need for detailed, sector-specific analysis to fully understand vehicle deployment and its implications for transportation planning.

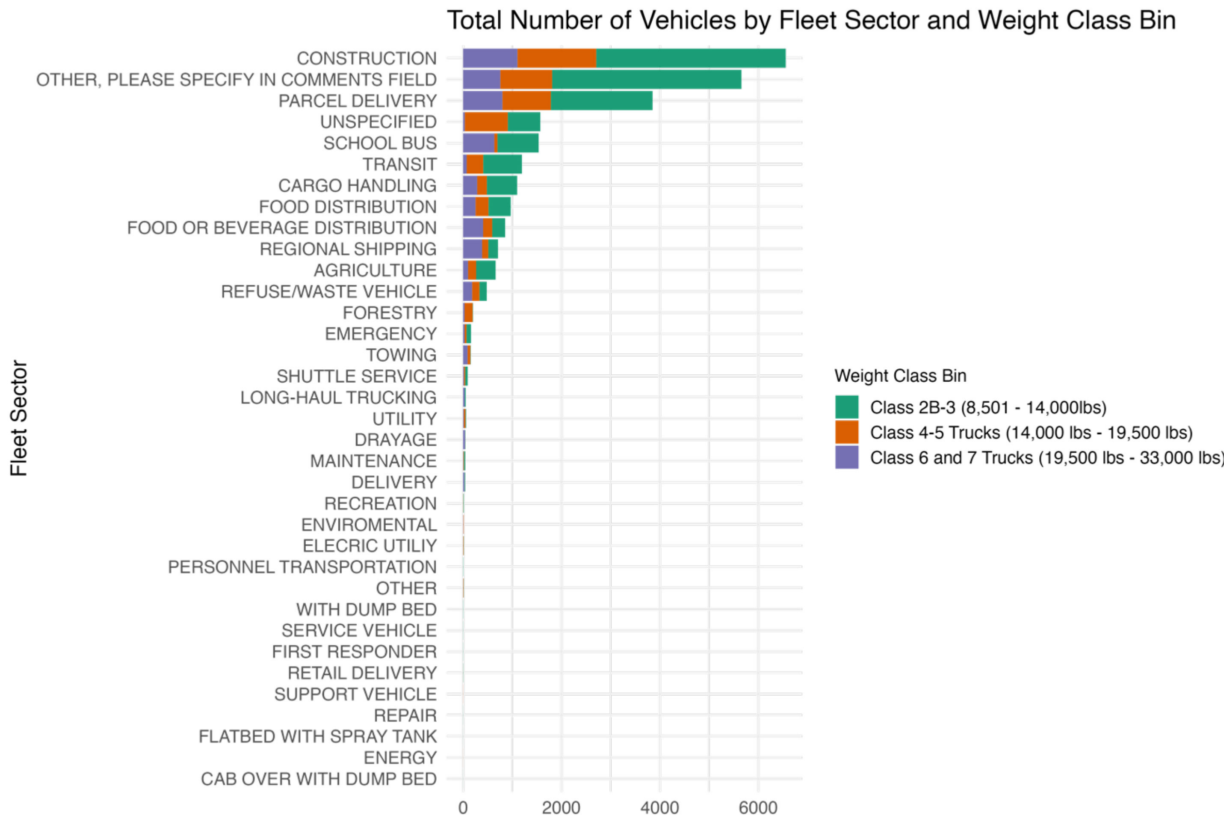

Figure 4.3 Vehicle Distribution of Significant Fleet Sectors

Table 4.2 Summary of the Vehicle Distribution of Major Fleet Sectors

Fleet Sector	Class 2B-3 (8,501 - 14,000lbs)	Class 4-5 Trucks (14,000 lbs - 19,500 lbs)	Class 6 and 7 Trucks (19,500 lbs - 33,000 lbs)	Total Count	% of Grand Total
Construction	3851	1602	1105	6558	25.2%
Other, please specify in comments field	3847	1053	757	5657	21.7%
Parcel delivery	2067	984	800	3851	14.8%
Unspecified	661	873	35	1569	6.0%
School bus	836	66	633	1535	5.9%
Transit	785	337	73	1195	4.6%
Cargo handling	615	198	285	1098	4.2%
Food distribution	451	263	254	968	3.7%
Food or beverage distribution	262	185	407	854	3.3%
Regional shipping	197	126	386	709	2.7%
Agriculture	395	164	101	660	2.5%
Refuse/waste vehicle	148	150	182	480	1.8%
Forestry	7	163	30	200	0.8%
Total				**25334**	
Grand Total				**26068**	

4.3.4 County of Origin Location

Table 4.3 and Figure 4.4 illustrate the distribution of medium-duty vehicles by county in Oregon, as reported in the data collected by DEQ. For the figure the x-axis represents the number of vehicles, and the y-axis lists the counties. Each bar corresponds to the number of vehicles reported in each county. Multnomah, Washington, and Lane counties show the highest numbers of reported vehicles, suggesting these areas have a significant concentration of the fleet included in the survey. Conversely, counties like Wheeler, Gilliam, and Sherman have the fewest vehicles reported, indicating either a lower presence of qualifying vehicles or potentially less participation in the survey.

The data's granularity provides a comprehensive view of vehicle distribution across the state, highlighting the regions with the most significant medium duty vehicle fleet sizes. This information is crucial for understanding regional variations in vehicle usage and can inform decisions related to transportation infrastructure, environmental policy, and economic planning in Oregon. The "Out-of-State" category reflects vehicles registered to organizations outside Oregon but operating within the state, adding an extra layer of detail to the dataset's geographical scope.

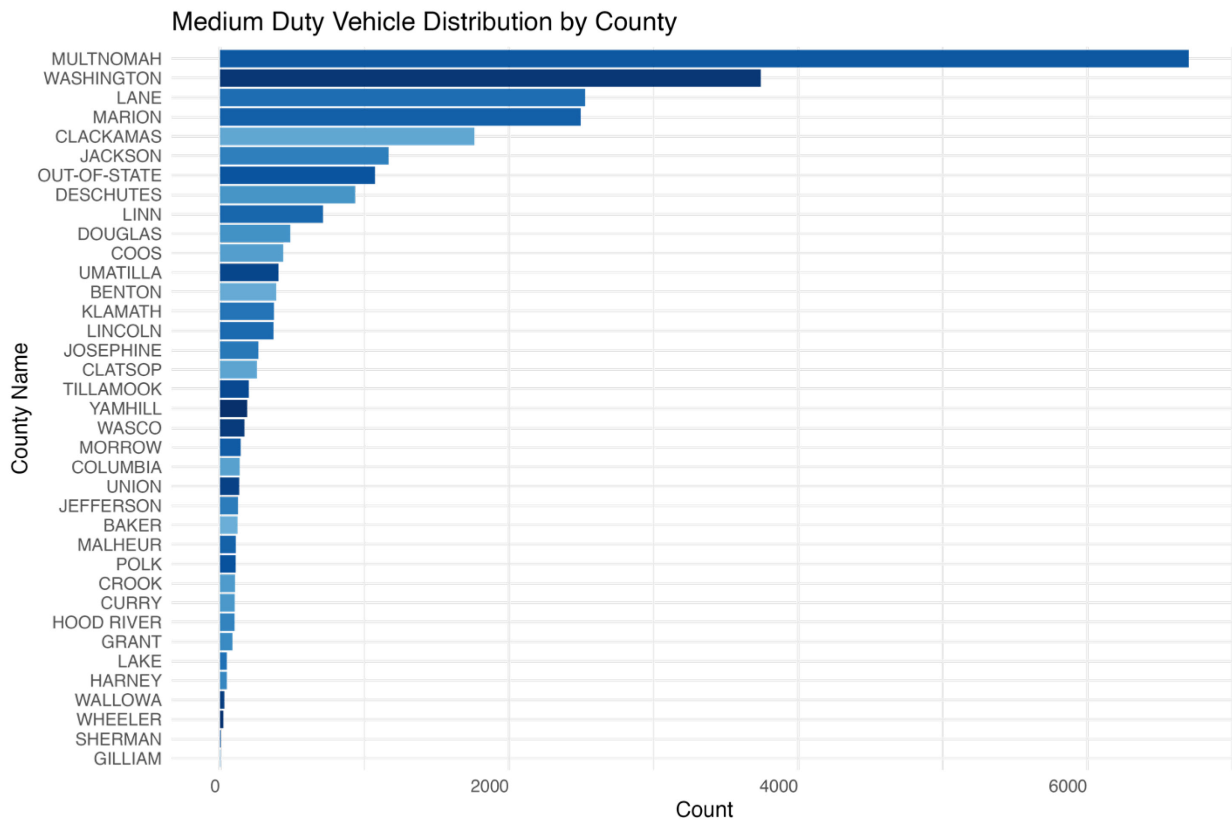

Figure 4.4 Vehicle Distribution by County Location of All Medium Duty Vehicles

Table 4.3 provides a summary of the distribution of medium-duty vehicles across the top 10 counties, categorized by weight class. The weight classes include Class 2B-3 (8,501 - 14,000 lbs), Class 4-5 Trucks (14,000 lbs - 19,500 lbs), and Class 6 and 7 Trucks (19,500 lbs - 33,000 lbs). The total number of vehicles for each county is also presented. The data highlights that Multnomah County has the highest count of medium-duty vehicles, followed by Washington and Lane counties.

Table 4.3 Top 10 Counties Distribution of Medium-Duty Vehicles by Weight Class

County Name	Class 2B-3 (8,501 - 14,000lbs)	Class 4-5 Trucks (14,000 lbs - 19,500 lbs)	Class 6 and 7 Trucks (19,500 lbs - 33,000 lbs)	Total Count	% of Grand Total
Multnomah	3757	1619	1326	6702	25.7%
Washington	1851	1138	752	3741	14.4%
Lane	1194	648	684	2526	9.7%
Marion	1475	530	490	2495	9.6%
Clackamas	947	419	394	1760	6.8%
Jackson	707	265	194	1166	4.5%
Out-of-State	494	228	350	1072	4.1%
Deschutes	550	215	170	935	3.6%
Linn	390	125	198	713	2.7%
Douglas	312	115	59	486	1.9%
Total				**21596**	
Grand Total				**26068**	

4.3.5 Facility Origin Location Distribution

Figure 4.5 shows the distribution of vehicles across various facility types as part of the data collected by the Oregon Department of Environmental Quality (DEQ). The x-axis represents the number of vehicles, while the y-axis lists different facility types where these vehicles are based. The "Truck/equipment yard" category has the highest number of vehicles, indicating its primary role in housing and maintaining a large number of vehicles. This is followed by "Administrative/office buildings" and "Distribution center/warehouse" facilities, which also have substantial vehicle counts, highlighting their importance in fleet management and logistics operations.

Further down the chart, "Any Other Facility Type" and "Service Center" categories also report significant vehicle numbers, showcasing the diversity of facility types involved in vehicle operations. "Manufacturer/factory/plant" and "Store" facilities are next, reflecting the integration of vehicle fleets in production and retail operations. The "Multi-building campus/base" and "Unknown" categories, though having fewer vehicles, still represent a notable part of the dataset. Smaller facility types such as "Medical/hospital/care," "Bakery," and "Hotel/motel/resort" have the least number of vehicles, indicating their lesser role in the overall vehicle distribution. This detailed breakdown provides valuable insights into the varied infrastructure supporting vehicle fleets across Oregon, essential for informed decision-making in transportation planning and policy development.

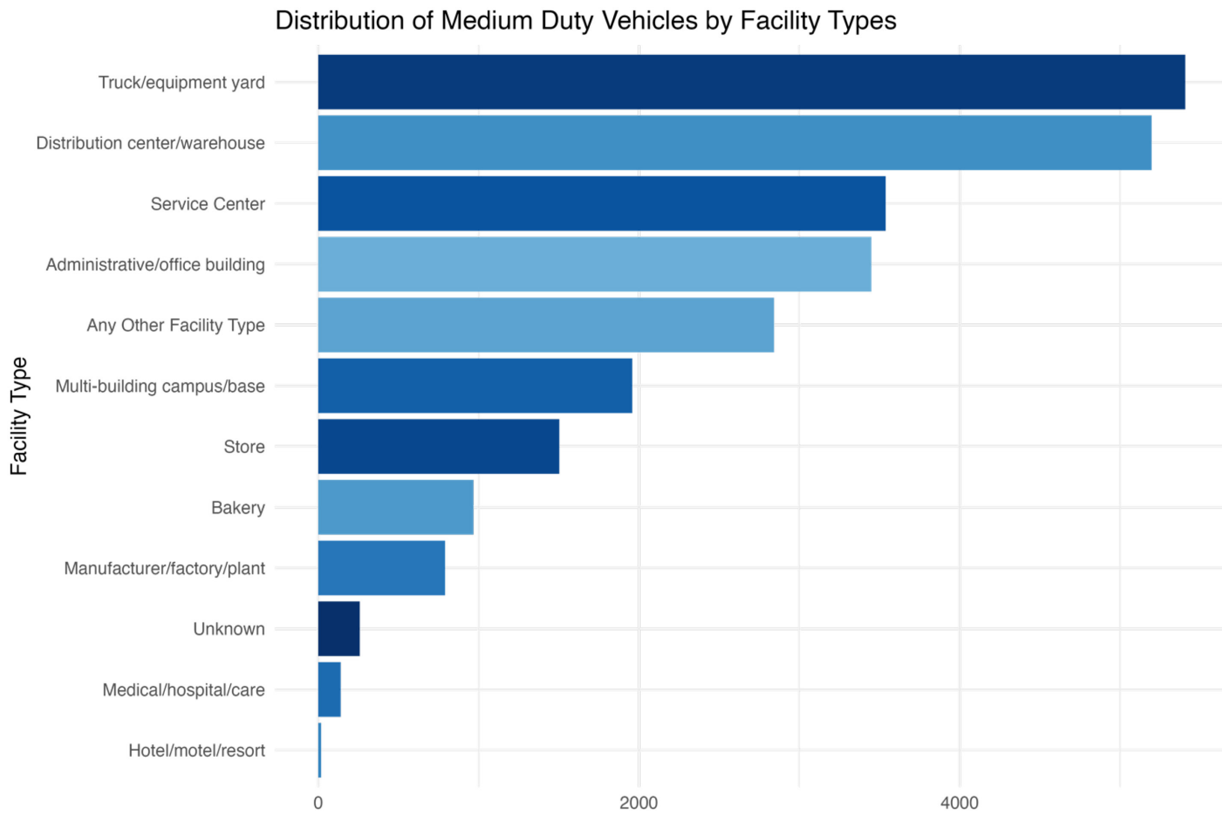

Figure 4.5 Distribution of Medium Duty Vehicles Across Various Facility Types

4.3.6 Body type

Figure 4.6 depicts the distribution of vehicles by body type, as part of the data collected by the Oregon Department of Environmental Quality (DEQ). The x-axis represents the number of vehicles, while the y-axis lists various vehicle body types. The "Pickup Bed" body type has the highest number of vehicles, indicating its widespread use across different sectors. This is followed by "Route Truck" and "Flatbed or Stake Bed," which also show substantial vehicle counts, highlighting their importance in transportation and logistics operations.

Further, body types like "Service Body," "Box/Dry Van," and "Van-Cargo" also report significant numbers, reflecting their diverse applications in different industries. Specialized vehicle types such as "Boom/Bucket," "Dump," and "Reefer" (refrigerated trucks) are also prominently represented, emphasizing their specific roles in construction, waste management, and perishable goods transportation, respectively. The wide range of body types, including niche categories like "Garbage Truck," "Water," and "Vacuum," illustrates the extensive variety of vehicles operating within the state. This detailed breakdown provides critical insights into the composition of the vehicle fleet by body type, essential for understanding the functional diversity and operational requirements of these vehicles in Oregon.

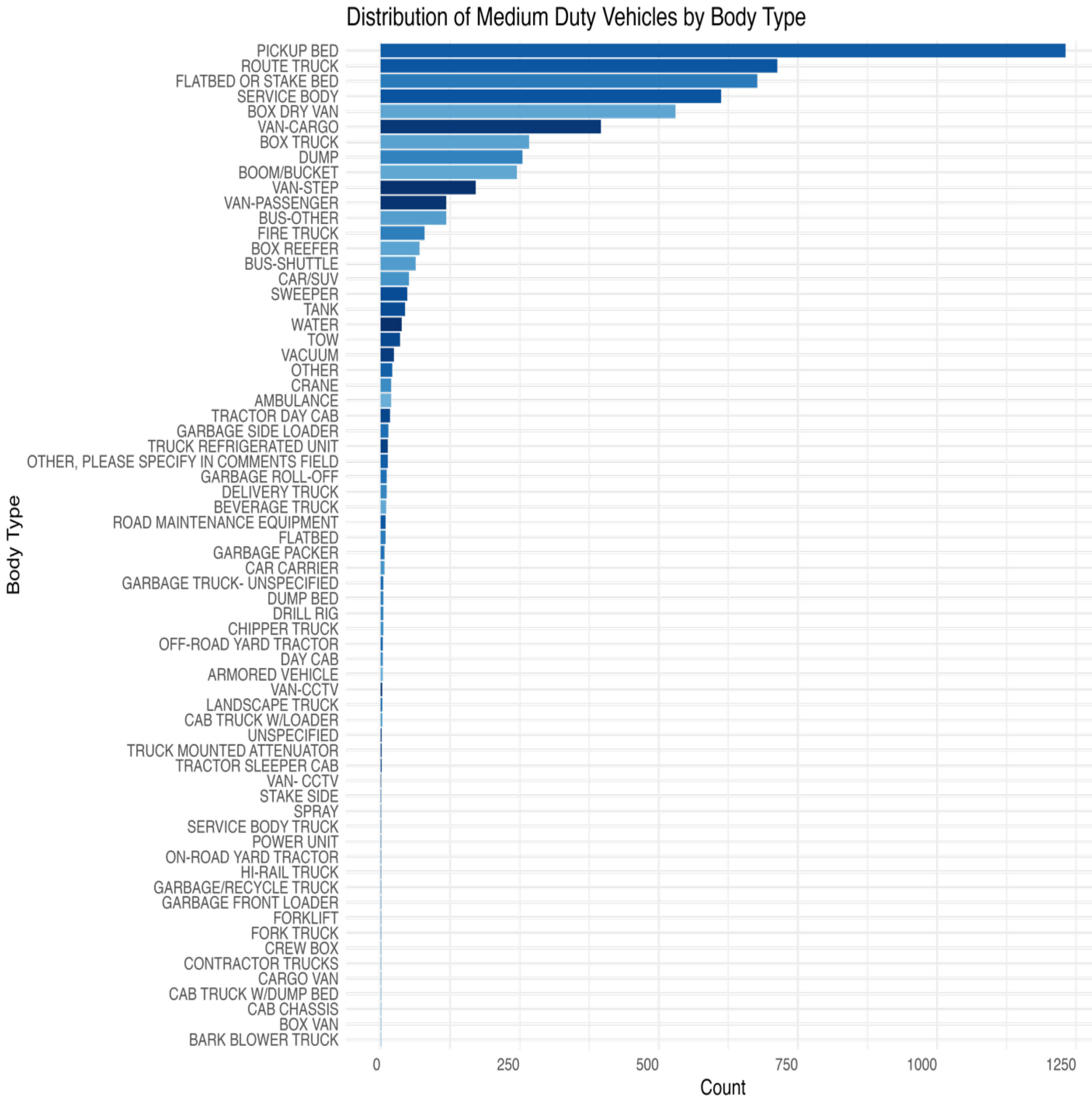

Figure 4.6 Distribution of Medium Duty Vehicles Across Various Body Types

Delving a bit deeper into the body type of interest, Figure 4.7 illustrates the frequency of the number of units owned by Parcel Delivery companies in the DEQ dataset. United Parcel Service (UPS), Amazon Logistics Inc, and Federal Express Corporation stand out as the top three companies, with UPS and Amazon Logistics Inc each having over 1000 units, and Federal Express Corporation following closely. These three companies dominate the chart, highlighting their significant presence in the Parcel Delivery data. While Amazon's fleet is included in the data, it's important to recognize that many of Amazon's transportation needs are met by independent third-party logistics providers. Beyond these three, the frequency of occurrences drops sharply, with companies like Rexel USA, Inc., North Coast Electric, and Life International Companies having more moderate counts. This distribution highlights the concentration of activities among the leading logistics companies, emphasizing their predominant role in parcel delivery (see Figure 4.7).

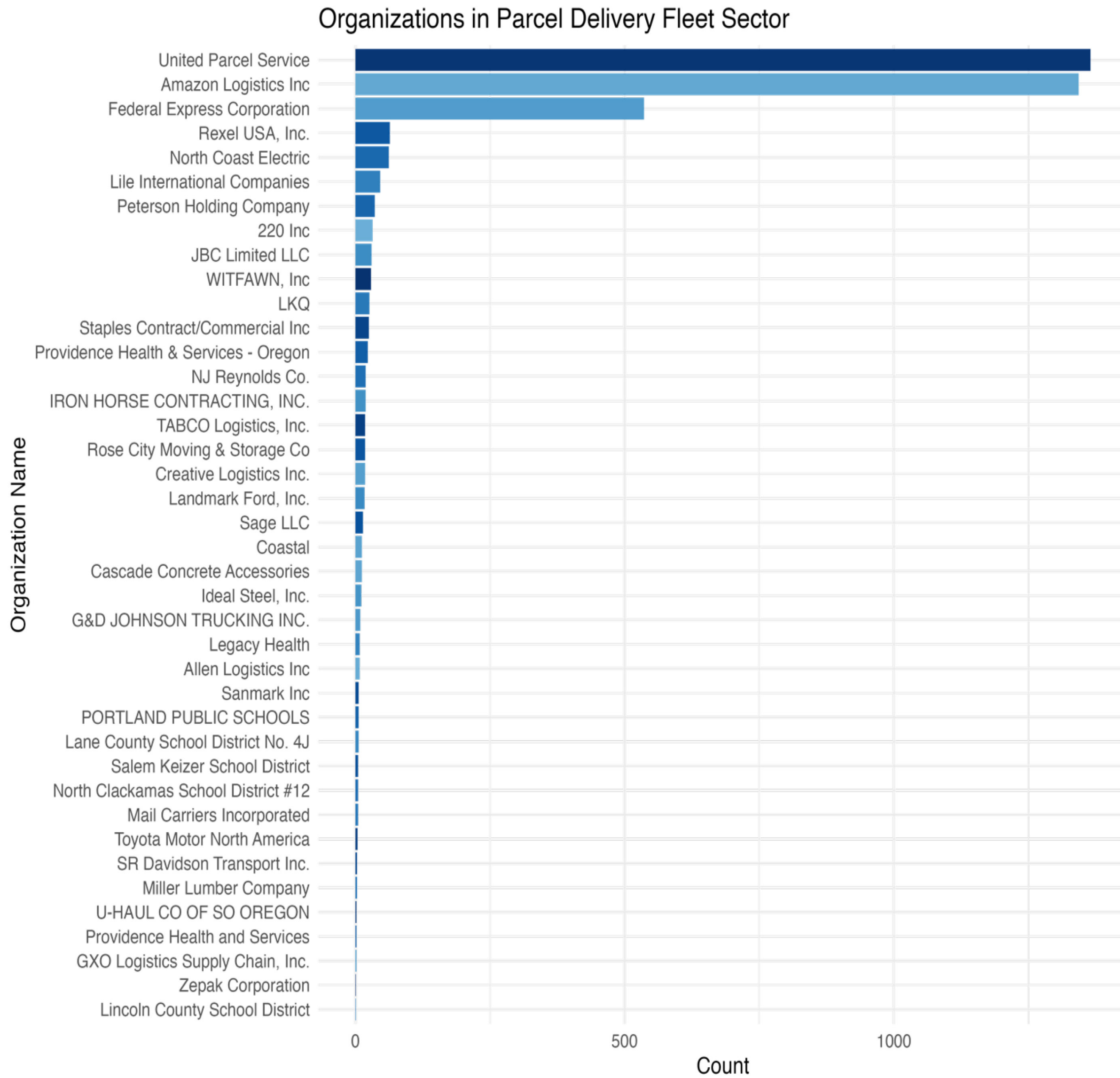

Figure 4.7 Frequency of the Number of Units Owned by Parcel Delivery Companies

Table 4.4 presents the distribution of medium-duty vehicles among the top 5 parcel delivery companies in Oregon, highlighting their significant presence in the sector. United Parcel Service (UPS) leads with 1,365 vehicles, accounting for 35.45% of the parcel delivery segment and 5.24% of the overall medium-duty vehicles in the state. Amazon Logistics Inc. follows closely with 1,343 vehicles, representing 34.87% of parcel delivery and 5.15% of the total medium-duty fleet. Federal Express Corporation (FedEx) holds a smaller yet substantial share with 536 vehicles, which constitutes 13.92% of parcel delivery vehicles and 2.06% of the overall medium-duty fleet. Rexel USA, Inc., and North Coast, Inc., each contribute 64 and 62 vehicles respectively, making up 1.66% and 1.61% of the parcel delivery vehicles, and 0.25% and 0.24%

of the total medium-duty vehicles. This data underscores the dominance of UPS, Amazon Logistics, and FedEx in the parcel delivery market, while also illustrating the contributions of smaller companies to the medium-duty vehicle landscape in Oregon. It is important to note that while some company names may not immediately appear relevant to parcel deliveries, they are reported as such, which could be a limitation of the dataset.

Table 4.4 Distribution of Medium-Duty Vehicles Among Top Parcel Delivery Companies in Oregon

Organization Name	Count	% of Parcel Delivery	% of Overall Medium Duty Vehicles
United Parcel Service	1365	35.45%	5.24%
Amazon Logistics Inc	1343	34.87%	5.15%
Federal Express Corp.	536	13.92%	2.06%
Rexel USA, Inc.	64	1.66%	0.25%
North Coast, Inc.	62	1.61%	0.24%

4.4 SUMMARY

The aim of this section was to provide a detailed analysis of medium-duty truck operations in Oregon, based on data collected by the DEQ in response to the Oregon Advanced Clean Trucks regulation adopted in November 2021. The analysis utilized data from the DEQ Medium- and Heavy-Duty One-Time Fleet Reporting survey, which collected detailed information from over 1,000 organizations, including fleet owners, businesses, government agencies, and brokers. This data included organizational details, facility information, and vehicle-specific data such as weight class, body type, and usage.

The findings highlight the significant presence of major logistics companies like United Parcel Service (UPS), Amazon Logistics Inc, and Federal Express Corporation, each operating fleets exceeding 1,000 units. Although Amazon's fleet was present in the data, it is important to note that many Amazon transportation providers are independent third-party logistics providers. The data also revealed that most medium-duty vehicles fall into the weight class 2B-3 (8,501-14,000 lbs.), with significant numbers in classes 4-5 and 6-7.

The findings highlight the concentration of activities among leading logistics companies and the importance of key sectors like construction, parcel delivery, and food distribution in the overall fleet composition. The analysis also identified the need for future monitoring procedures and additional data collection to enhance the estimation of medium-duty vehicle numbers and categories. Recommendations include tracking commodity and industry types, increasing data granularity for sector-specific analysis, and expanding the survey scope to include vehicles with a gross vehicle weight rating between 8,501 lbs. and 10,000 lbs. This detailed analysis aids in the development of targeted transportation policies and infrastructure planning in Oregon, providing critical insights into vehicle distribution, usage patterns, and the operational landscape.

5.0 SAFETY ANALYSIS

In meeting objective 2 of this study, the objective of this section was to evaluate, compare, and contrast crash datasets with commercial vehicle data to gain a comprehensive understanding of freight-related safety crashes in Oregon. This analysis focused on three primary aspects: (a) the examination of crash trends to understand the evolution and patterns of freight-related safety incidents by commercial vehicle type, (b) the analysis of crashes in urban versus rural areas, disaggregated by functional class and place type, and (c) the trends specifically associated with delivery vehicles operated by UPS and FedEx.

To achieve these goals, this study utilized data from the Oregon Department of Transportation (ODOT) Crash Data System (CDS) and the Oregon Commercial Motor Vehicle Division crash database. These datasets were meticulously integrated to filter and analyze commercial vehicle crash data by vehicle class, company, and location. Additionally, the Oregon DOT Place Types were employed to investigate the relationship between land use and commercial vehicle crashes. The analysis covered data from 2007 to 2021, providing a detailed temporal scope for this interim report, unless specified otherwise.

The methodology for processing, linking, and filtering the data was detailed in Section 5.1. Crash counts by vehicle type and severity were discussed in Section 5.2, while trends by various time periods (year, season, month, day of the week, and hour of the day) were analyzed in Section 5.3. Section 5.4 presented a spatial analysis of commercial vehicle crashes. Finally, the conclusions derived from this comprehensive analysis were summarized in Section 5.5.

5.1 DATA SOURCES AND DATA REFINEMENT

The data for this study came from two sources within the Oregon Department of Transportation. The first set of data was the ODOT crash database or Crash Database System (CDS) from 2007 to 2021. This data came as three sets: a crash database, a vehicle database, and a participant database. The CDS uses a crash ID number assigned to each crash to link these databases. The Oregon crash database or Crash Database System (CDS) is put together by ODOT's Transportation Data Section - Crash Analysis and Reporting (CAR) Unit.

The second set of data is the commercial vehicle crash database from the Commercial Motor Vehicle (CMV) Department from 2002 to 2023. This database uses an ID number system to identify crashes that is different from the ID used by the CDS. Each data set has advantages and disadvantages for this study, and as such, a goal became to find a way to join the datasets to have all available information about commercial vehicle crashes combined. An advantage of the CDS dataset was that that many data entries included latitude and longitude coordinates so that the crash could be easily and accurately plotted to see spatial trends. It also included much more detailed information about the level of severity of the crash. The disadvantages of the CDS were that it did not include a Vehicle Identification Number (VIN), a company name for commercial vehicles, or more than a general category for vehicle type, making it impossible to determine crashes by type of commercial activity.

The CMV data had the main disadvantage of not having latitude and longitude information. The location information for the CMV data was limited to a description written by the reporting police officer that offered the nearest intersection along with the direction and distance to the site of the accident. While this information may be descriptive enough to find the site of an accident, it is very time consuming to translate by hand these descriptions to coordinates for nearly 42,000 records. The advantages of the CMV data were that it included a VIN for each vehicle participant, as well as the name of the company responsible for the vehicle.

5.1.1 Place Type of Data

The work plan asks to analyze overall crash rates as well as separating them by urban and rural areas. To study crashes by land use, an additional dataset called Place Type is used in this study. Place Type data is at the Census Block level for Oregon for the year 2010 and it was put together by the Oregon Department of Transportation using travel data and US Census 2019 American Community Survey (ACS) data

5.1.2 VIN Data

It was also necessary to use the VINs in the CMV dataset to get accurate information about each commercial vehicle that participated in a crash. This was done by using the application programming interface (API) service for decoding VINs hosted by the National Highway Traffic Safety Administration (NHTSA). The information gathered on each vehicle included data elements like the weight class of the vehicle, as well as the make and model of the vehicle. This information was added to the CMV database using a matching process.

5.1.3 Join the Crash Datasets

Finding links between the CDS and CMV datasets became the key to unlocking the full potential of all available data for this study. Since each department/database uses a different ID system for their crash databases and the CMV data does not include coordinate location information, creative solutions had to be found.

Both datasets include time of crash information and therefore for both databases columns of year, month, day, and hour were added. Both databases included county code information and city where the crash occurred, and these categories were prepared appropriately for matching purposes.

The algorithm created to match the two datasets involved several steps. One record at a time was taken from the CMV dataset and compared to a temporary copy of the CDS database. This temporary database could be reduced until only one record remained, and a dictionary was created to keep the matched CDS and CMV crash IDs. The matching sequence is as follows:

1. Filter temporary data by county code of CMV record.
2. Filter temporary data by crash year of CMV record.
3. Filter temporary data by crash month of CMV record.
4. Filter temporary data by crash day of CMV record.

5. If the temporary data still has multiple records, filter the temporary data by crash hour of CMV record plus or minus one hour.
    i. If the temporary data has exactly one record, a match is found.
    ii. If the temporary data had zero records, no match is found.
6. If the temporary data still has multiple records, filter the temporary data by *the exact* crash hour of CMV.
    i. If the temporary data had exactly one record, a match is found.
    ii. If the temporary data has zero records, no match is found.
7. If the temporary data still has multiple records, filter the temporary data by the city of the CMV record.
    i. If the temporary data had exactly one record, a match is found.
    ii. If the temporary data has zero records, no match is found.
8. If the temporary data still has multiple records, no match could be found.

This process also revealed that in several instances, multiple commercial vehicles were involved in the same crash. Before a match was added to the IDs dictionary, the CDS crash ID was checked against the dictionary to ensure nothing was overwritten. If a duplicate was found, the duplicate was added to a separate database that only includes these multiple commercial vehicle incidents. A final database was then created using the matched IDs dictionary that included all data from the CDS database and CMV database for each individual crash involving a commercial vehicle.

This joining process was completed twice, once joining the CMV database to the entire CDS crash database, and once joining the CMV database to a CDS crash database that had been filtered to include only crashes involving vehicles over a gross vehicle weight rating of 6,000 pounds. The duplicative process was conducted to be able to compare the number of matches, multiples, and misses as well as the success rates of the joining processes. A graphic description of the matching process and the number of records at each step are later presented in Figure 5.1.

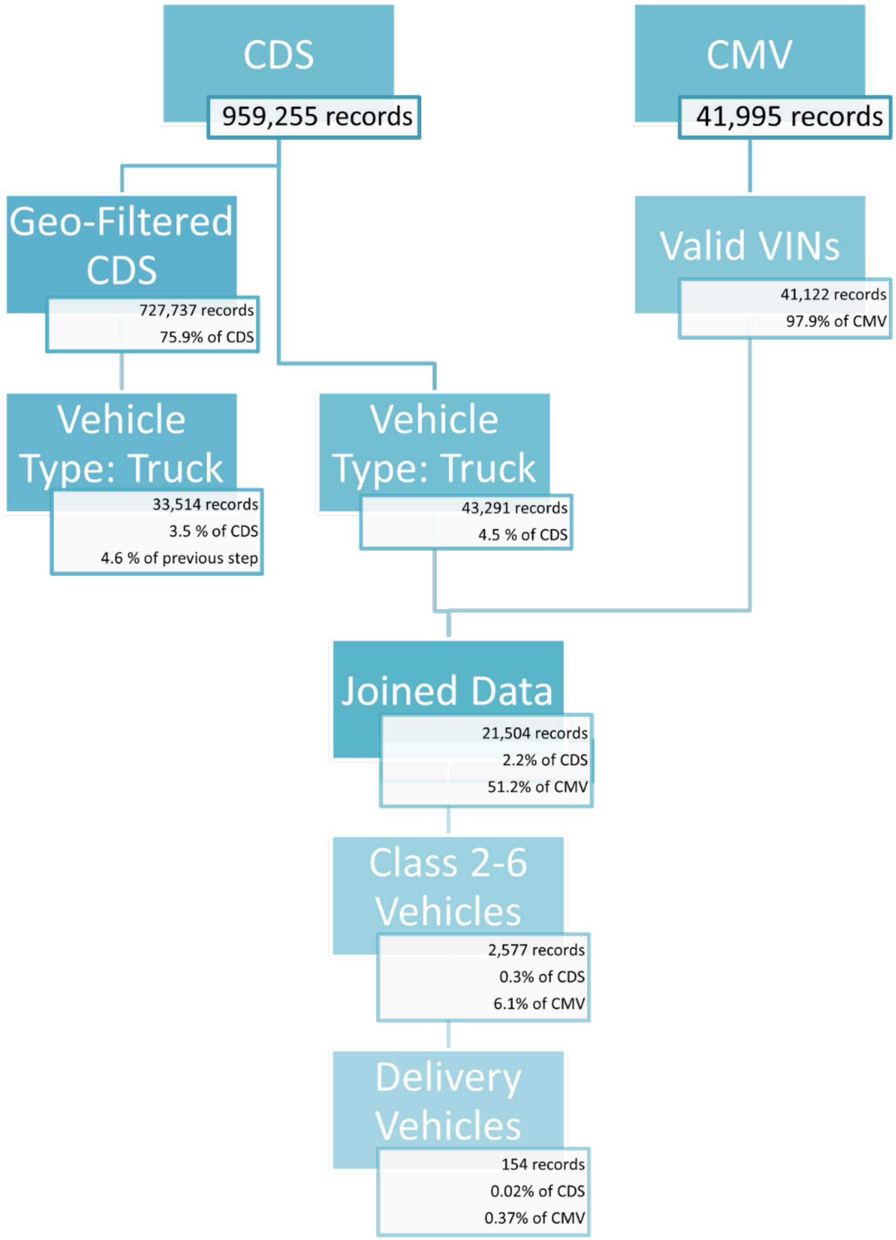

Figure 5.1 Flow chart of Filtering Losses

A high percentage of the records was lost but this should be considered a baseline upon which it may be possible to improve on future research efforts. In particular, it may be useful to explore available matching algorithms that can exploit the geographic nature of the crash data.

5.1.4 Filtering to Delivery Vehicles

There are eight vehicle class ranging from Class 1 (6,000 lb. or less) to Class 8 (33,001 lb. and above) and delivery vehicles are likely to be in Classes 2 to 6 with a weight range of 6,000 to 26,000 lb. The vehicle class retrieved from the NHTSA for each VIN was used for this filter and as seen in Table 5.1, classes 2 through 6 were kept. The second filter was to keep only those vehicles that were owned by UPS or FedEx, herein the data for UPS and FedEx are called "delivery vehicle" crashes.

Table 5.1 Vehicle class by Weight Range

Vehicle Class	Weight Range
Class 1	6,000 lb. or less
Class 2	6,001 – 10,000 lb.
Class 3	10,001 – 14,000 lb.
Class 4	14,001 – 16,000 lb.
Class 5	16,001 – 19,500 lb.
Class 6	19,501 – 26,000 lb.
Class 7	26,001 – 33,000 lb.
Class 8	33,001 lb. and above

5.1.5 Data Filtering

The CDS crash data came with 959,255 records. In the process of converting the latitude and longitude data into Point data, a separate database was created where all records with no geometry data were dropped. This geometry-filtered CDS data set was used for mapping and had 727,737 usable crash records.

The CMV crash data came with 41,995 records. In the process of querying VINs, all records with invalid VINs were dropped, which left 41,122 valid records. Invalid VINs included records that had no data in the VIN category, and VINs that were too short, too long, or did not have the correct pattern.

The CDS data were both filtered to commercial vehicle only databases. This was done by filtering each database by vehicle type, taking only those vehicles over 6,000 pounds. The Commercial CDS includes 43,291 records and the geometry-filtered Commercial CDS includes 33,513 records.

5.1.6 Data Joining

The data joining process was performed as described in Section 5.1.3.

The results for the joining processes are broken down into subcategories of matches and non-matches. Within matches, there are single matches and multiple matches. Single matches represent one CMV crash ID matched to one CDS crash ID, representing that one commercial vehicle was in a crash. Multiple matches represent multiple CMV crash IDs to one CDS crash ID, representing that multiple commercial vehicles were in one crash incident. Within non-matches, there are multiples and misses. Multiples are interpreted as there are multiple events recorded in the CDS database that fulfilled the matching criteria to a CMV record, and therefore a clean match could not be made. Misses are interpreted as there are no events in the CDS database that have data that fulfills the matching criteria to a CMV record, and therefore a match could not be made.

Below are Tables 5.2 and 5.3. Table 5.2 reports the results of the joining process between the entire CDS database and the CMV database, and Table 5.3 reports the results of the joining process between the commercial vehicle filtered CDS database and the CMV database.

Table 5.2 Results of joining the entire CDS database with the CMV database

	Count	Rate
Matches	24,007	58.4%
- Single	22,360	54.4%
- Multiple	1,647	4.0%
Non-Matches	17,115	41.6%
- Misses	7,237	17.6%
- Multiples	9,878	24.0%
Total	41,122	

Table 5.3 Results of joining commercial the vehicle filtered CDS database with the CMV database

	Count	Rate
Matches	24,152	58.7%
- Single	21,504	52.3%
- Multiple	2,648	6.4%
Non-Matches	16,970	41.3%
- Misses	13,881	33.8%
- Multiples	3,089	7.5%
Total	41,122	

The number of matches and the rates were found to be very similar, and the resulting database of the commercial vehicle filtered CDS data and CMV data joining was used to move forward.

5.1.7 Final Data Filtering

The joined data was then filtered by vehicle weight class and company name. The vehicle weight classes chosen were those that include any vehicle between 6,000 and 26,000 pounds GVWR. From the vehicle weight class data that was attained by VIN from the NHSTA, classes 2 through 6 (see Table 5.1) were the desired vehicles.

The data was then filtered by company name, keeping only those records that contained UPS or FEDEX including any variations of those names. A thorough inspection of the entire list of company names revealed that these two companies were the only ones on the list that are clearly engaged in parcel delivery and had a significant number of crashes.

The entire CMV database was also sorted in the same manner to compare crash rates so that inconsistencies could be found if applicable. The results of these filters are shown in Table 5.4 below.

Table 5.4 Results of filtering for delivery vehicles

	Joined Database		CMV Database	
	Count	Percent	Count	Percent
Total	21,504		41,122	
Filtered by Weight Class	2,577	12.0%	5,389	13.1%
Filtered by Company	154	0.7%	232	0.56%

The rates of records kept through filtering were found to be consistent for both databases suggesting that no anomalies occurred.

5.1.8 Filtering Loses

Figure 5.1 shows the process of the data filtration for this study as well as the number of records kept at each step. The number of delivery vehicle records at the end of the process was 154 which was 0.02% of the overall CDS and 0.37% of the overall CMV database. It also represents 0.72% of the joined data set, and 5.98% of the Class 2-6 vehicles within the joined data set.

5.1.9 Summary

A substantial amount of time and effort was needed to input, filter, and join the different datasets. Filtering losses are unavoidable, but this process allows the presentation of novel safety data trends and results for commercial vehicles in the state of Oregon.

5.2 VEHICLE TYPE AND CRASH COUNTS

This section presents crash count data based on vehicle classification, severity, and place type.

5.2.1 Crash by CDS and CMB Vehicle Classifications

The CDS and CMV databases use different systems for describing vehicles. The CDS uses a description that relies on the use and shape of the vehicle, but the CMV simply sorts vehicles into three Gross Vehicle Weight Rating (GVWR) categories. The VIN for each CMV record does allow the retrieval of much more detailed vehicle information. From the VIN, the vehicle's class, weight, body class and vehicle type can be ascertained in addition to the make, model, year, and engine details.

The vehicle types of the CDS are summarized in Table 5.5 (ODOT Transportation Data Section - Crash Analysis and Reporting, 2019). It shows that, as expected, the vast majority of vehicles in crashes are passenger cars, pickups, and vans. It also shows that around 2.5% of vehicles in crashes are commercial vehicles, looking at truck trailers, bobtails, and trucks with non-detachable beds.

Table 5.5 CDS broken down by vehicle description

Code	Vehicle Description	Count	Percentage
01	Passenger car, pickup, van, light delivery, and custom van	1,696,432	95.0%
02	Truck tractor with no trailers (Bobtail)	1,032	0.1%
03	Farm tractor or self-propelled farm equipment (Not truck)	636	0.0%
04	Truck tractor with trailer/mobile home in tow	31,301	1.8%
05	Truck with non-detachable bed: Panel truck, tow truck, fire truck, etc.	10,956	0.6%
06	Moped, mini-bike, motor scooter (seated), or motorized bicycle	708	0.0%
07	School bus, or van used to transport students	2809	0.2%
08	Other bus	3890	0.2%
09	Motorcycle, dirt bike	17,615	1.0%
10	Other vehicle type: Forklift, backhoe, mailster, go-cart, golf cart, lawnmower, snowplow, street cleaner, road grader, ice cream scooter, meter maid scooter	1,430	0.1%
11	Motorhome	1,829	0.1%
12	Motorized streetcar or trolley, not using rails or wires	15	0.0%
13	ATV	199	0.0%
14	Motorized scooter (Standing), E-scooter	86	0.0%
15	Snowmobile	5	0.0%
99	Unknown vehicle type	17,603	1.0%

Table 5.6 presents a breakdown by vehicle type using only the commercial vehicles as classified in the CDS.

Table 5.6 CDS commercial vehicles broken down by vehicle type

Code	Vehicle Description	Count	Percentage
02	Truck tractor with no trailers (Bobtail)	1,032	2.4%
04	Truck tractor with trailer/mobile home in tow	31,301	72.3%
05	Truck with non-detachable bed: Panel truck, tow truck, fire truck, etc.	10,956	25.3%

The GVWRs of the vehicles in the CMV data are shown in Table 5.7. These statistics show that most commercial vehicles involved in crashes are large trucks, over 26,000 lbs. They also show that there are very few commercial vehicles less than 10,000 lbs., which makes sense as the only reason a vehicle under 10,000 lbs. must register as a commercial vehicle is if it is moving hazardous materials (Federal Motor Carrier Safety Administration, 2022).

Table 5.7 CMV data broken down by GVWR category

Category	GVWR Range	Count	Percentage
1	6,000 lb. and under	20	0.0%
2	6,001 – 26,000 lb.	5,111	12.4%
3	26,001 lb. and over	35,988	87.5%

Table 5.8 shows the vehicle counts by the descriptors ascertained from the VIN. These descriptors are set by the NHSTA. Incomplete Vehicle generally refers to a vehicle on a chassis that is built to accommodate several different configurations, so that the buyer can structure the vehicle to their needs (Legal Information Institute - Cornell Law School School, 2022).

Table 5.8 CMV data broken down by NHSTA vehicle type

Vehicle Type	Count	Percentage
Truck	25,321	61.6%
Incomplete Vehicle	12,480	30.3%
Bus	1,977	4.8%
Trailer	188	0.5%
Passenger Car	26	0.1%
Multipurpose Passenger Vehicle (MPV)	24	0.1%
Motorcycle	24	0.1%
Low Speed Vehicle (LSV)	3	0.0%
Off Road Vehicle	1	0.0%
None	1,078	2.6%

In an effort to compare the vehicle types across the CDS and CMV databases, Table 5.6 and Table 5.8 were compared to look for similarities and the results are presented in Table 5.9. As the CMV does not include Semi-truck tractors with no trailers as its own category but the CDS does, it is difficult to know if these would fall into the truck or incomplete vehicle category of the CMV classification. Overall, it would appear that CDS ‘Truck tractor with trailer’ matches up to CMV ‘Truck’ somewhat closely, and CDS ‘Truck with non-detachable bed’ matches up to CMV ‘Incomplete vehicle’. While the percentages support these match ups, it is assumed that these are not perfect matches and that the systems used for classifying vehicles is different enough for each database that this information cannot be used in the joining process.

Table 5.9 CMV data broken down by NHSTA class and weight

Class	Weight Range	Count	Percentage
1	6,000 lb. or less	1	0.0%
1A	3,000 lb. or less	28	0.1%
1B	3,001 – 4,000 lb.	1	0.0%
1C	4,001 – 5,000 lb.	3	0.0%
1D	5,001 – 6,000 lb.	9	0.0%
2	6,001 – 10,000 lb.	4	0.0%
2E	6,001 – 7,000 lb.	6	0.0%
2F	7,001 – 8,000 lb.	2	0.0%
2G	8,001 – 9,000 lb.	22	0.1%
2H	9,001 – 10,000 lb.	179	0.4%
3	10,001 – 14,000 lb.	1,010	2.5%
4	14,001 – 16,000 lb.	1,134	2.8%
5	16,001 – 19,500 lb.	1,042	2.5%
6	19,501 – 26,000 lb.	1,990	4.8%
7	26,001 – 33,000 lb.	3,875	9.4%
8	33,001 lb. and above	29,626	72.0%
None	None	2,190	5.3%

Although the systems of CDS and NHSTA for classifying vehicle type are somewhat similar, the vehicle categories do not align well enough to use vehicle type as a matching variable. In this research project we are most interested in vehicles between 10,000 and 26,000 pounds and this comprises categories 3 to 6 but some delivery vehicles (vans) can have weight between 6,000 and 10,000 pounds.

5.2.2 Commercial Vehicle Crashes By Make and Model

Table 5.10, Table 5.11, and Table 5.12 show the top ten lists by vehicle make, model, and year. The top ten lists represent the make, model, and model years that were most often in an accident recorded by the CMV. This vehicle data is obtained from the NHSTA with the VINs.

Table 5.10 Vehicle makes involved most often in a crash

Make	Count
Freightliner	11,860
Kenworth	6,620
Peterbilt	5,777
International	3,924
Volvo Truck	2,957
Ford	2,161
Mack	745
GMC	543
Chevrolet	530
Blue Bird	525

Table 5.11 Vehicle models involved most often in a crash

Model (Make)	Count
Cascadia (Freightliner)	2,944
379 (Peterbilt)	2,197
VNL (Volvo Truck)	2,008
T800 (Kenworth)	1,804
Columbia (Freightliner)	1,760
USF-1E (Freightliner)	1,216
Long Conv. (Freightliner)	1,189
W900 (Kenworth)	1,124
T8 Series (Kenworth)	966
378 (Peterbilt)	729

Table 5.12 Vehicle model years involved most often in a crash

Model Year	Count
2007	2,446
2000	2,420
2005	2,089
2006	2,080
1999	1,938
2001	1,792
1998	1,659
2003	1,541
2016	1,424
1997	1,378

5.2.3 Class 2-6 Commercial Vehicle Crashes By Make and Model

Table 5.13, Table 5.14, and Table 5.15 show the top ten lists of vehicle make, vehicle model, and vehicle year of light commercial vehicles (LCV) in crashes. In this case, a light commercial vehicle is one from class 2 through 6, with GVWR of between 6,000 lbs. and 26,000 lbs. The top ten lists represent the make, model, and model years that were most often in an accident recorded by the CMV. This vehicle data is obtained from the NHSTA with the VINs.

Table 5.13 LCV vehicle makes involved most often in a crash

Make	Count
Ford	1,719
International	784
Freightliner	736
Chevrolet	502
Isuzu	465
GMC	397
Hino	185
Ram	143
Dodge	122
UD	64

Table 5.14 LCV vehicle models involved most often in a crash

Model (Make)	Count
F-550 (Ford)	342
M2 (Freightliner)	312
E-450 (Ford)	306
F-350 (Ford)	295
MA025 (International)	284
F-450 (Ford)	272
Express (Chevrolet)	210
4700 (International)	207
E-350 (Ford)	190
F-650 (Ford)	142

Table 5.15 LCV vehicle model years involved most often in a crash

Model Year	Count
2007	388
2006	333
2005	326
2000	274
1999	259
2001	257
2004	230
2008	209
2003	199
1998	197

Table 5.16 shows the breakdown of vehicle types within the LCV category. Incomplete Vehicle type shows as the most prominent type of vehicle in this category, which makes sense since Incomplete Vehicle type includes all vehicles that are built as a chassis that can hold different

vehicle setups such as box truck, tow truck, flatbed truck, etc. The term "incomplete vehicle" is misleading since it refers to vehicles that has been customized or "completed" by a secondary manufacturer and tailored to specific job or company needs.

Table 5.16 LCV data broken down by NHSTA vehicle type

Vehicle Type	Count	Percentage
Incomplete Vehicle	4949	91.8%
Truck	403	7.5%
Bus	33	0.6%
Multipurpose Passenger Vehicle (MPV)	4	0.1%

5.2.4 Delivery Vehicles Crashes by Make and Model

The next eight tables show the top ten lists of vehicle type, make, model, and year of FedEx and UPS vehicles in crashes. Table 5.17, Table 5.18, Table 5.19, and Table 5.20 include all vehicle classes used by these two companies. Amazon deliveries are subcontracted and it is not possible to directly link in the CMV data the company name "Amazon" to the crashes of subcontracted vehicles that may be delivering Amazon orders.

Table 5.17 Delivery company vehicles by vehicle type

Vehicle Type	Count
Truck	282
Incomplete Vehicle	217
None	2
Trailer	1
Passenger Car	1

Table 5.18 Delivery company vehicles by vehicle make

Make	Count
Freightliner	221
International	114
Mack	48
Volvo truck	38
Kenworth	21
Ford	19
Isuzu	9
Peterbilt	8
Sterling truck	8
Workhorse	7

Table 5.19 Delivery company vehicles by vehicle model and type

Make	Model	Type	Count
Freightliner	MT 45 Chassis	Urban delivery	74
Freightliner	Cascadia	Long-haul	52
Volvo truck	VNL	Long-haul	37
International	1552-SC	Urban delivery	35
International	1652-SC	Urban delivery	24
Mack	CH	Long-haul	24
Freightliner	MT 45G Front Gas Engine Van	Urban delivery	18
Kenworth	T680	Long-haul	17
Freightliner	MT 55G Front Gas Engine Van	Urban delivery	17
International	L9217	Long-haul	17

Table 5.20 Delivery company vehicles by vehicle year

Model Year	Count
2007	64
1997	40
2006	40
2016	29
2005	25
2018	24
2019	24
2020	23
2000	21
1996	18

Table 5.21, Table 5.22, Table 5.23, and Table 5.24, include only vehicles from 6,000 to 26,000 lbs.

Table 5.21 LCV delivery company vehicles by vehicle type

Vehicle Type	Count
Incomplete Vehicle	215
Truck	17

Table 5.22 LCV delivery company vehicles by vehicle make

Make	Count
Freightliner	127
International	66
Ford	18
Isuzu	9
Workhorse	7
Chevrolet	3
Hino	1
GMC	1

Table 5.23 LCV delivery company vehicles by vehicle model

Make	Model	Count
Freightliner	MT 45 Chassis	74
International	1552-SC	35
International	1652-SC	24
Freightliner	MT 45G Front Gasoline Engine Walk in Van Chassis	18
Freightliner	MT 55G Front Gasoline Engine Walk in Van Chassis	17
Freightliner	MT 55 Chassis	16
Ford	Commercial Chassis	9
Isuzu	NPR/NPR-HD	6
Ford	E-350	5
Workhorse	W42	5
International	1652-UPS	5

Table 5.24 LCV delivery company vehicles by vehicle year

Model Year	Count
1997	33
2007	30
2006	18
1996	17
2005	16
2018	15
2019	12
1999	8
2020	8
2017	7

5.2.5 Crashes by Severity

Delivery crashes by severity are summarized in Table 5.25 alongside commercial vehicle crashes and all vehicle crashes. The standard severity scale is used with K as fatality, A as incapacitating injury, B as non-incapacitating injury, C as possible injury, and O as property damage only.

Table 5.25 Crashes by severity

Severity	Delivery Vehicles		Commercial Vehicles		All Vehicles	
	Count	Percent	Count	Percent	Count	Percent
K	3	2.4%	514	3.2%	5,807	0.8%
A	4	3.2%	669	4.1%	21,796	3.0%
B	23	18.4%	2,918	18.1%	108,490	14.9%
C	40	32.0%	3,937	24.3%	227,073	31.2%
O	55	44.0%	8,148	50.3%	364,571	50.1%
All	125	100.0%	16,186	100.0%	727,737	100.0%

The number of crashes by delivery vehicles is very low to draw strong conclusions but the percentage of fatalities is high but not as high when all commercial vehicles are included. It is clear that the percentage of fatalities (type K) is approximately four times higher for commercial vehicles (3.2% vs 0.8%).

5.2.6 Summary

This section presented crash counts by vehicle type, make, model and year. The results show that it is possible to identify the commercial vehicle type and models that are involved in more crashes. Unfortunately, although the systems of CDS and NHSTA for classifying vehicle type are somewhat similar, the vehicle categories do not align well enough to use vehicle type as a matching variable. The results show that heavier vehicles are involved in crashes with a higher percentage of fatalities. Vehicle make and model of commercial vehicles participating in crashes can be found. Comparing vehicle registrations with vehicle make and models of vehicle participating in crashes may not be meaningful when the number of miles driven by vehicle type differ not only in quantity but also by type of road or land use.

5.3 CRASH TRENDS

This section presents crash trends by vehicle weight, by vehicle type, by time period and by road function classification. To facilitate interpretation and comparison across categories the graphs used in this Section use percentages. Equivalent graphs but showing the total crash counts instead of the percentage of total crashes can be found in Appendix A: Crash Count Graphs.

5.3.1 Trends by Vehicle Weight

The temporal trends were broken down further by vehicle weight. The tally of all crashes by year, season, month, day of week, and hour were broken down into four categories.

1. **All vehicles**: This data set encompasses all vehicles included in the CDS database.

2. **Commercial vehicles**: This data set includes the entire CMV database.
3. **Commercial > 26000 lbs.**: This includes all CMV vehicles of Class 7 or 8.
4. **Commercial 6000 - 26000 lbs.**: This includes all CMV vehicles of Classes 2 through 6.

Please note, as most of the data for comparisons by vehicle weight come from the CMV database, and the CMV data does not include location information, analysis of trends by location and roadway type are not possible for this section.

5.3.1.1 Year

In comparing the yearly trends, shown below, the commercial vehicle data has some odd fluctuations. Despite this oddity for the overall commercial vehicles trend, the trend specific to the 6000 – 26000 lb. category, to be referred to as Light Commercial Vehicles (LCVs) from here, shows a steady increase that does not match the overall trends in crashes, suggesting that this range of vehicle may have seen an increase in proportion of use in commercial activity. Future research efforts should analyze how the trends have evolved after 2021 and whether the differences are statistically significant

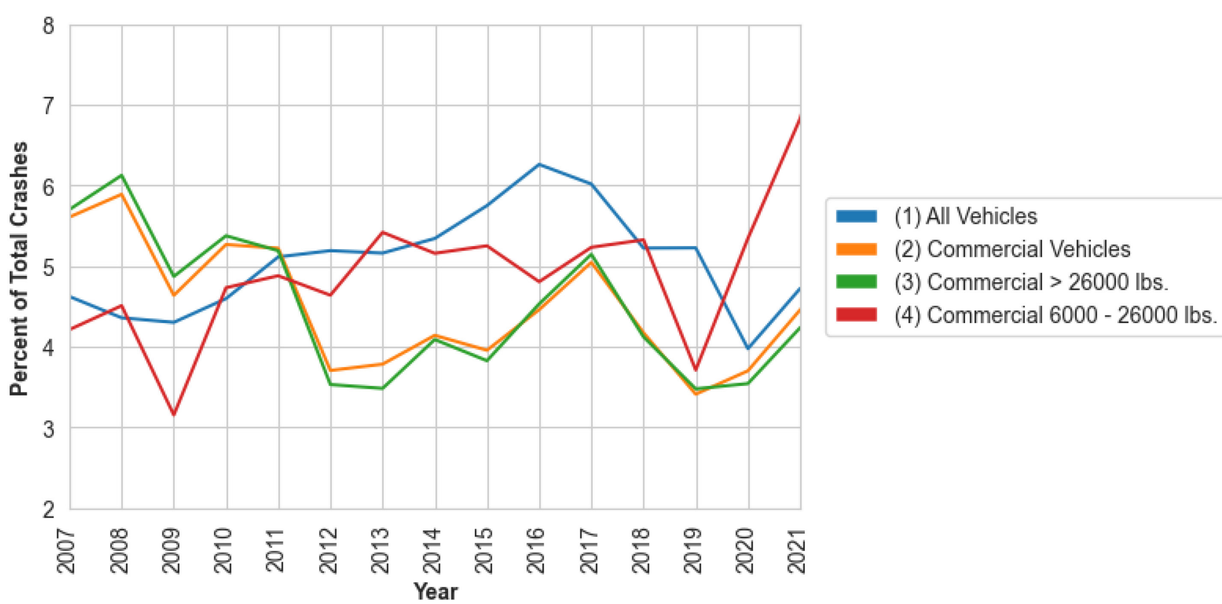

Figure 5.2 Crash percentage by year for vehicle weight

5.3.1.2 Season

The trends by season show that while most commercial vehicle crashes are in the winter, the LCVs trend more closely resembles the 'All Vehicles' trend, with the exception that LCVs have the fewest crashes in winter. One possible reason for this could be that many construction and contractor vehicles may fall in this category and winter may be a slower time of year for their workload and travel needs.

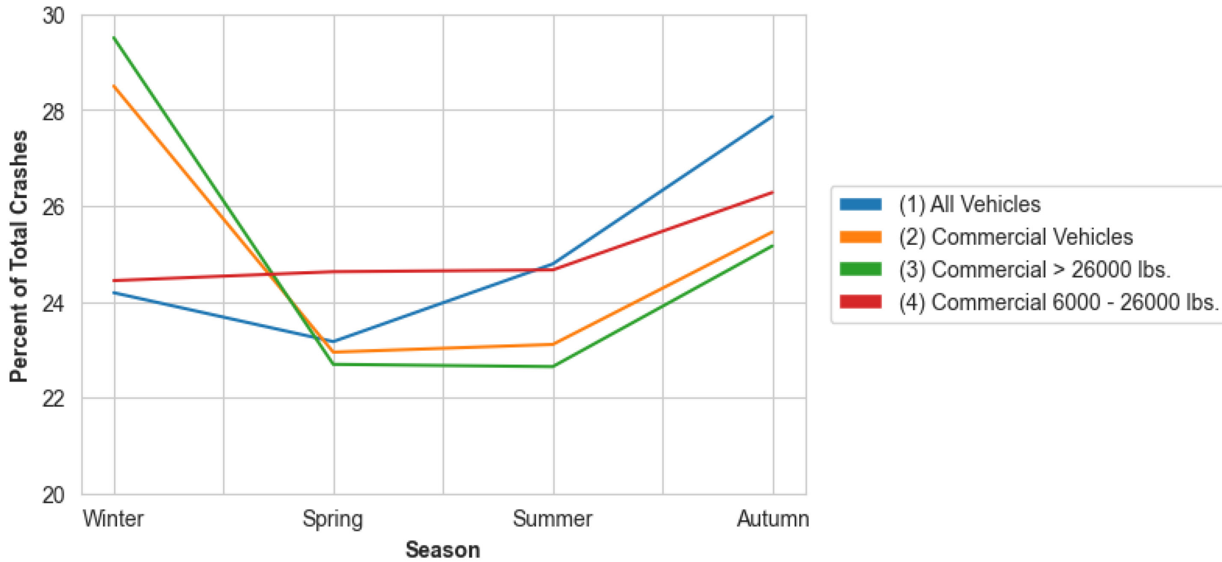

Figure 5.3 Crash percentage by season for vehicle weight

5.3.1.3 Month

The trends by month appear to largely echo the trends shown by season. While most commercial vehicle crashes overall occur in the winter months of December, January, and February, LCVs see a steady number of crashes in spring and summer months, while having a low in February and a high in October. It is also seen that while all other weight categories see December as the highest or second highest number of crashes, the LCVs see crash numbers dip in December. As already discussed, this is likely due to many LCVs being used by construction and contractor businesses, who see a lull in workload in the winter months.

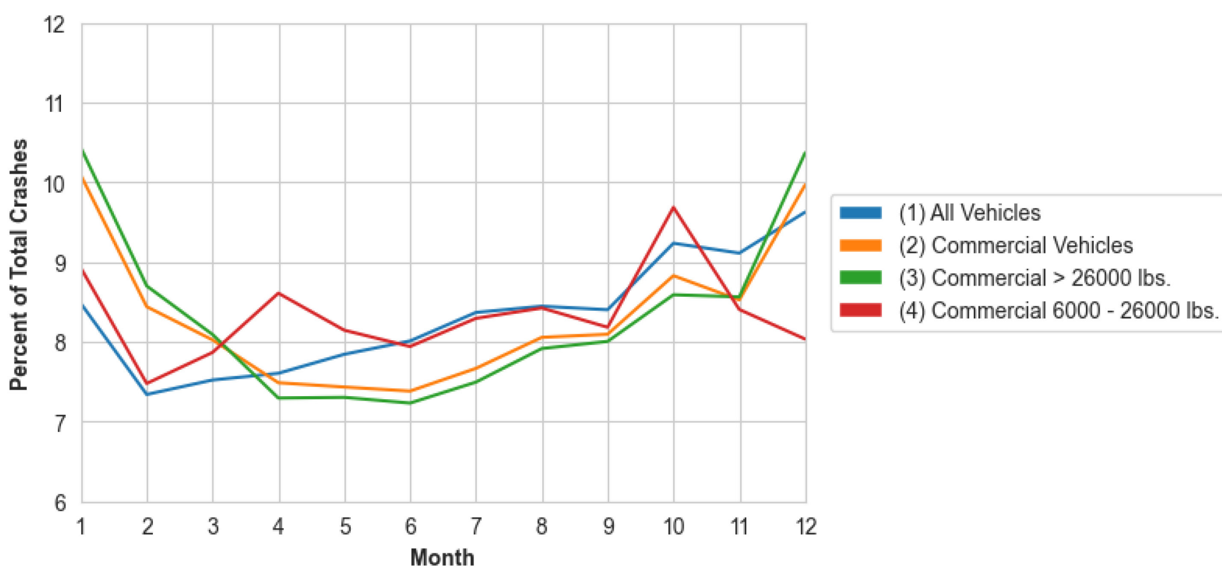

Figure 5.4 Crash percentage by month for vehicle weight

5.3.1.4 Day of the Week

The trends by vehicle weight by day of the week are shown below. They very clearly show that all vehicle weights of commercial vehicles almost entirely crash on weekdays.

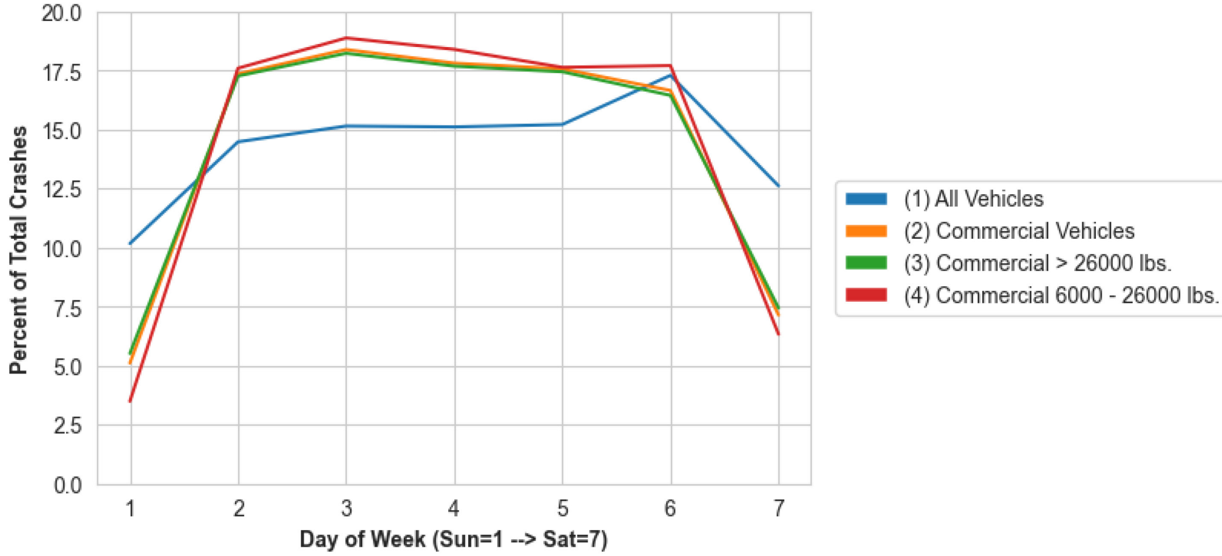

Figure 5.5 Crash percentage by day of the week for vehicle weight

Although LCVs have shared many trends with the All Vehicles category instead of overall Commercial Vehicles, these trends show that LCVs crash mostly on weekdays. This is intuitive as most commercial activity takes place Monday through Friday.

5.3.1.5 Hour

Shown below are the trends of crashes by hour of vehicle weight categories. These show the same relationships as the day of the week trends, that the LCV trends stick closely to those of the other commercial vehicles. This again makes sense as regular working day hours from 6:00 AM to 4:00 PM are observed by most contractor and construction companies, while delivery companies may usually operate between 8:00 AM and 7:00 PM.

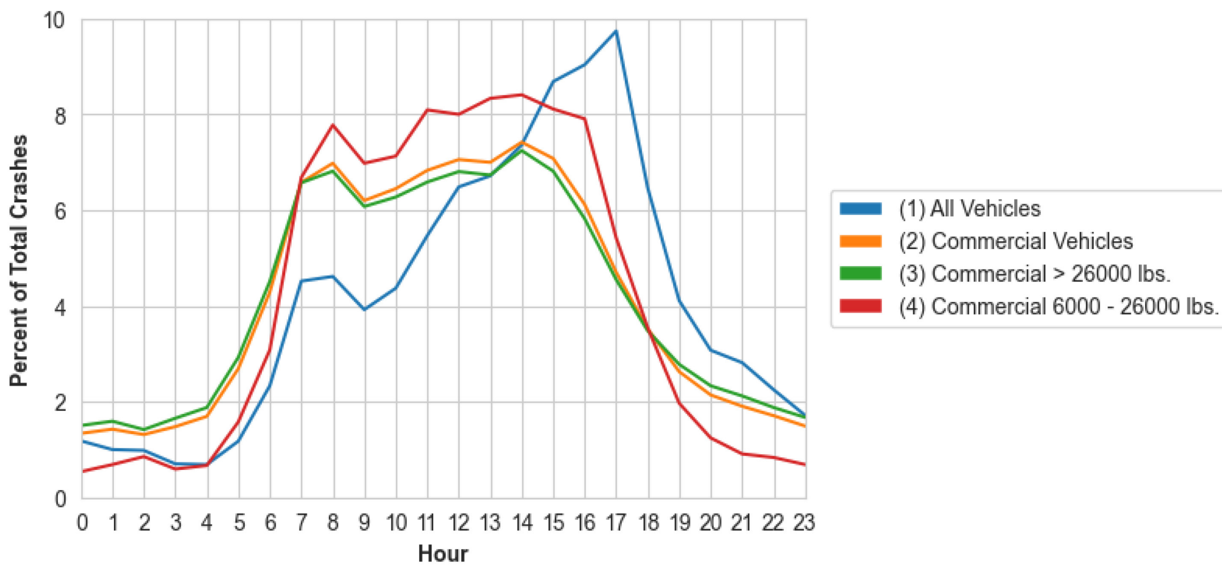

Figure 5.6 Crash percentage by hour for vehicle weight

5.3.2 Trends by Vehicle Type

The temporal trends were also analyzed by vehicle type. This involved ten different datasets broken down across both the CDS and CMV data. The trends of crashes by year, season, month, day of week, hour, location, and roadway type were compiled. The ten datasets compared are as follows:

1. **All Vehicle Types**: This includes all vehicles from the CDS.
2. **Passenger Vehicles**: This includes all vehicles from the CDS of vehicle type 1.
3. **CDS Commercial Vehicles**: All vehicles from the CDS of vehicle types 2, 4, and 5.
4. **CMV Commercial Vehicles**: All vehicles from the CMV data.
5. **CDS Semi Trucks**: All vehicles from the CDS of vehicle type 4.
6. **CMV Trucks**: All vehicles from the CMV of vehicle type 'Truck'.
7. **CDS Trucks**: All vehicles from the CDS of vehicle type 5.
8. **CMV Incomplete Vehicles**: All vehicles from the CMV of vehicle type 'Incomplete Vehicle'.
9. **CDS Bobtails**: All vehicles from the CDS of vehicle type 2.
10. **CDS Unknown**: All vehicles from the CDS of vehicle type 99.

Note, CDS vehicle type codes are listed in Table 5.5.

5.3.2.1 Year

The yearly crash trends for vehicle type are shown below, ten different graphs are shown to easily compare changes (overlapping all the graphs it is hard to see trends). Like the yearly trends by vehicle weight, the CMV trends show some odd fluctuations. This contrasts with the trends shown by CDS data that shows a valley in 2008 – 2009, a peak in 2016 – 2017, a severe drop for the pandemic in 2020, and the start of a rebound in

2021. While it would seem that the CDS commercial vehicles trends should show similarities to the trends of the overall CMV data, the two trend lines do not share any similarities. This would suggest that one of the datasets has an unexplained attribute, such as changing the way data was collected or processed in a certain year. As the CMV trend line is the one that appears less fluid, it seems more likely that the CMV data has some unexplained attribute.

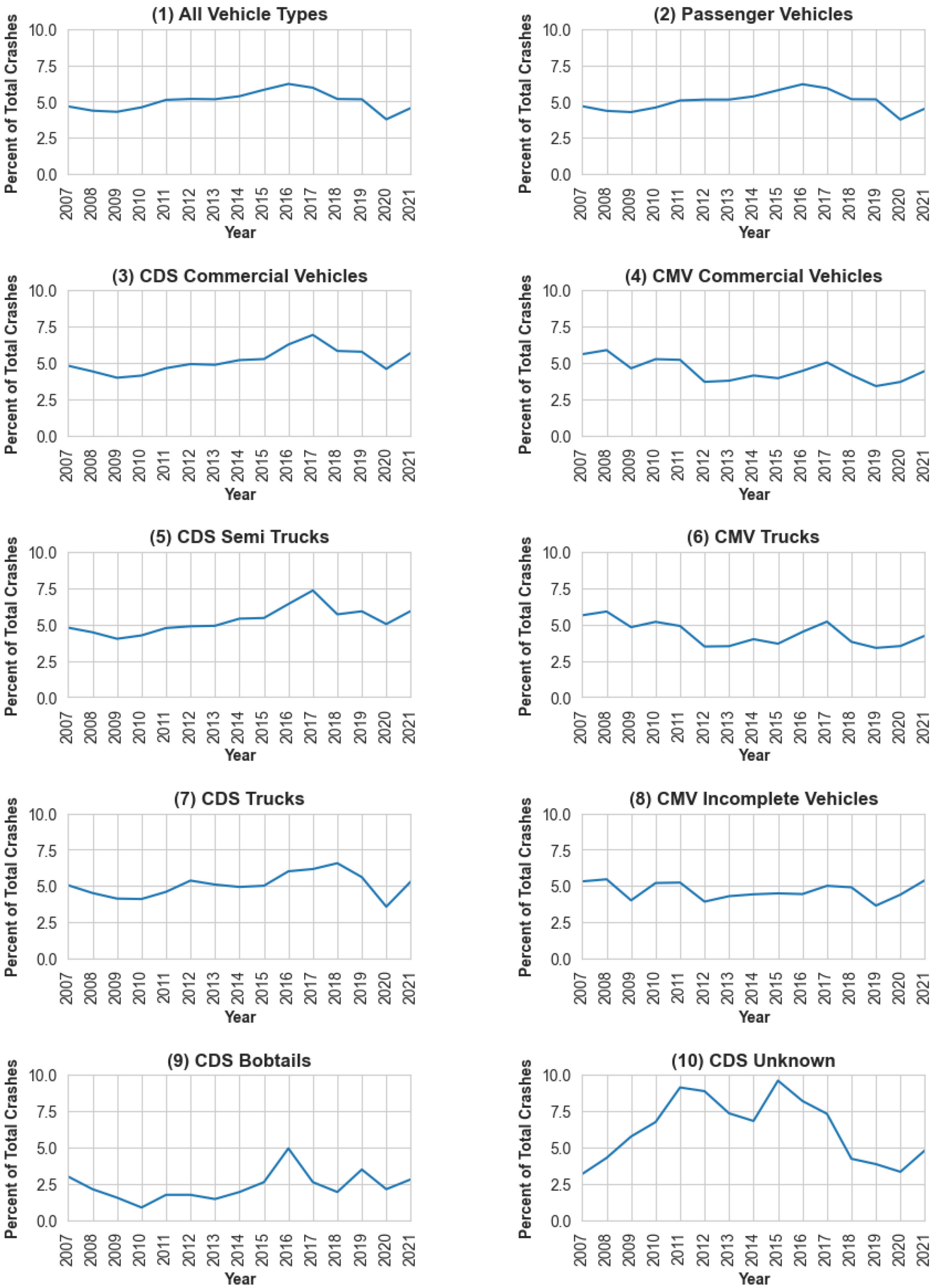

Figure 5.7 Crash percentage by year for vehicle type

5.3.2.2 Season

The trends by season show that commercial vehicles of all vehicle types generally experience the most crashes in the fall and winter seasons. One interesting trend is that of the CDS Trucks, which experience the least number of crashes in the winter and the most in the summer.

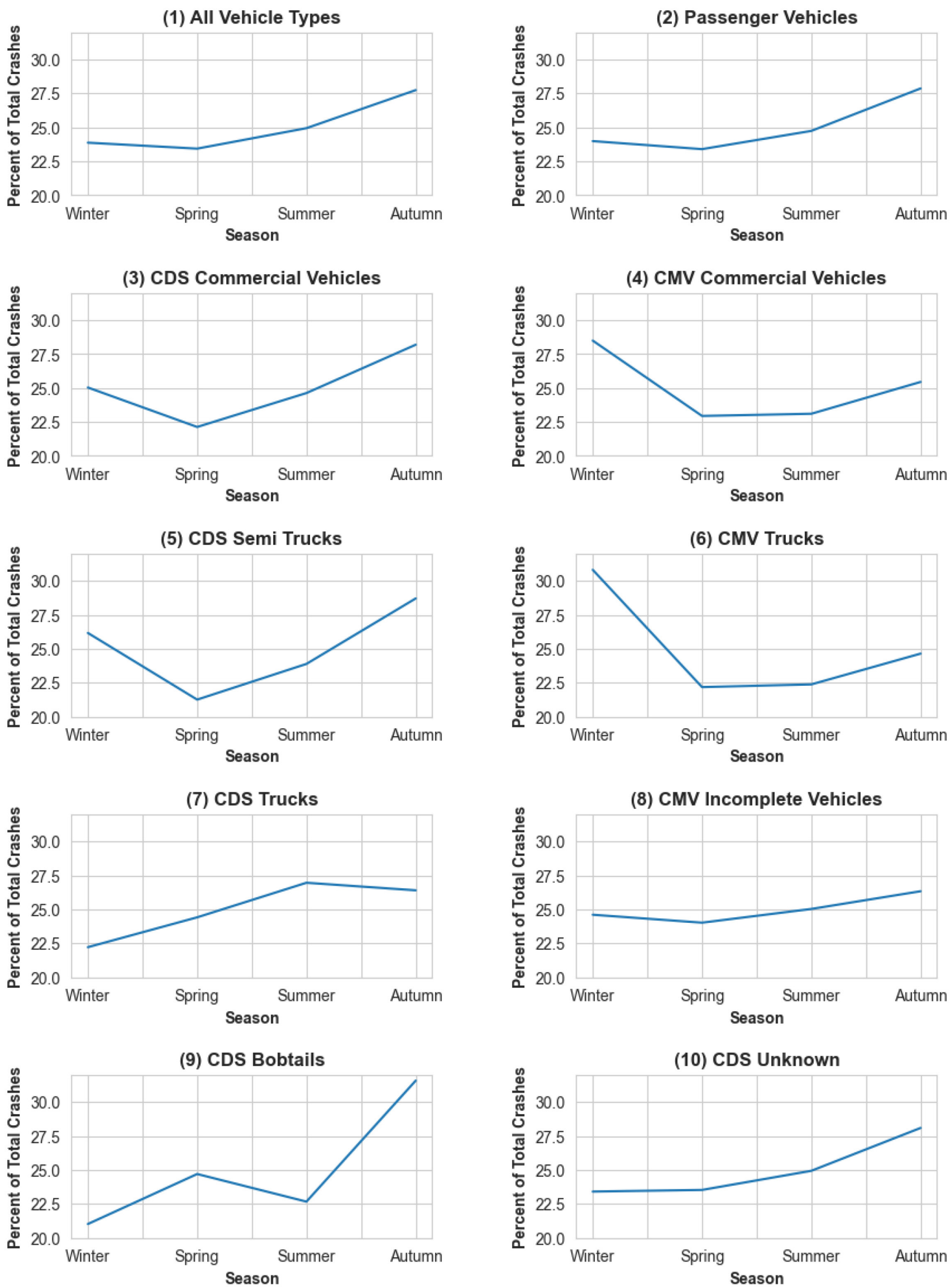

Figure 5.8 Crash percentage by season for vehicle type

5.3.2.3 Month

The trends by month for vehicle type largely show the same trends as the seasonal trends, the monthly trends start to show a clearer relationship between the different vehicle type definitions of the CDS and CMV. The CDS Commercial Vehicles trend appears to match to the CMV Commercial Vehicles trend; the CDS Semi Trucks trend matches well to the CMV Trucks trend; and the CDS Trucks trend roughly matches the CMV Incomplete Vehicles trend.

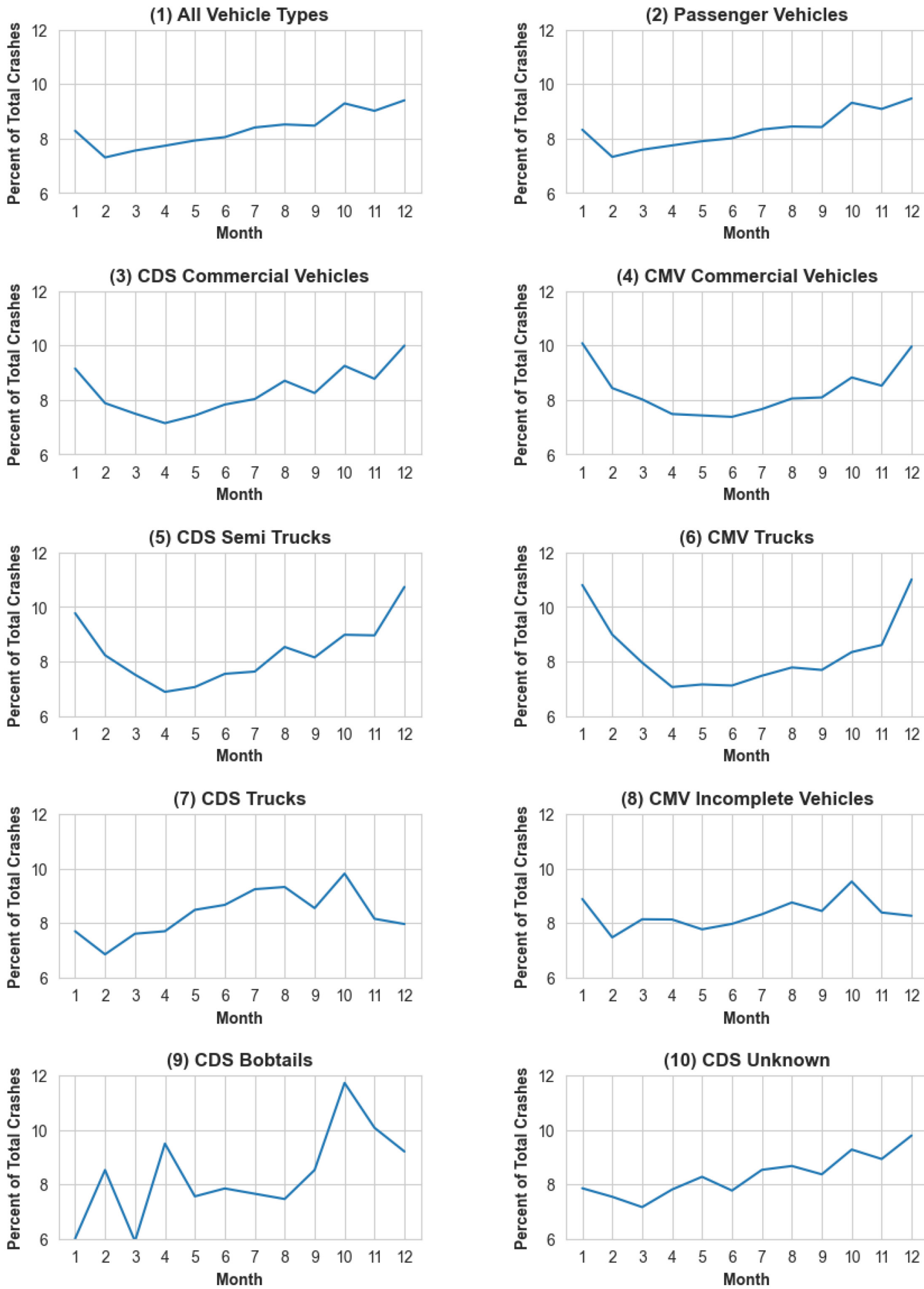

Figure 5.9 Crash percentage by month for vehicle type

5.3.2.4 Day of the Week

The vehicle type breakdown of the day of the week trends show the same trends as in previous sections, that commercial vehicles have their crashes on weekdays. The trends also show the contrast between passenger vehicles and commercial vehicles, where commercial vehicles experience the most crashes at the beginning of the work week, passenger vehicles experience the most crashes on Fridays.

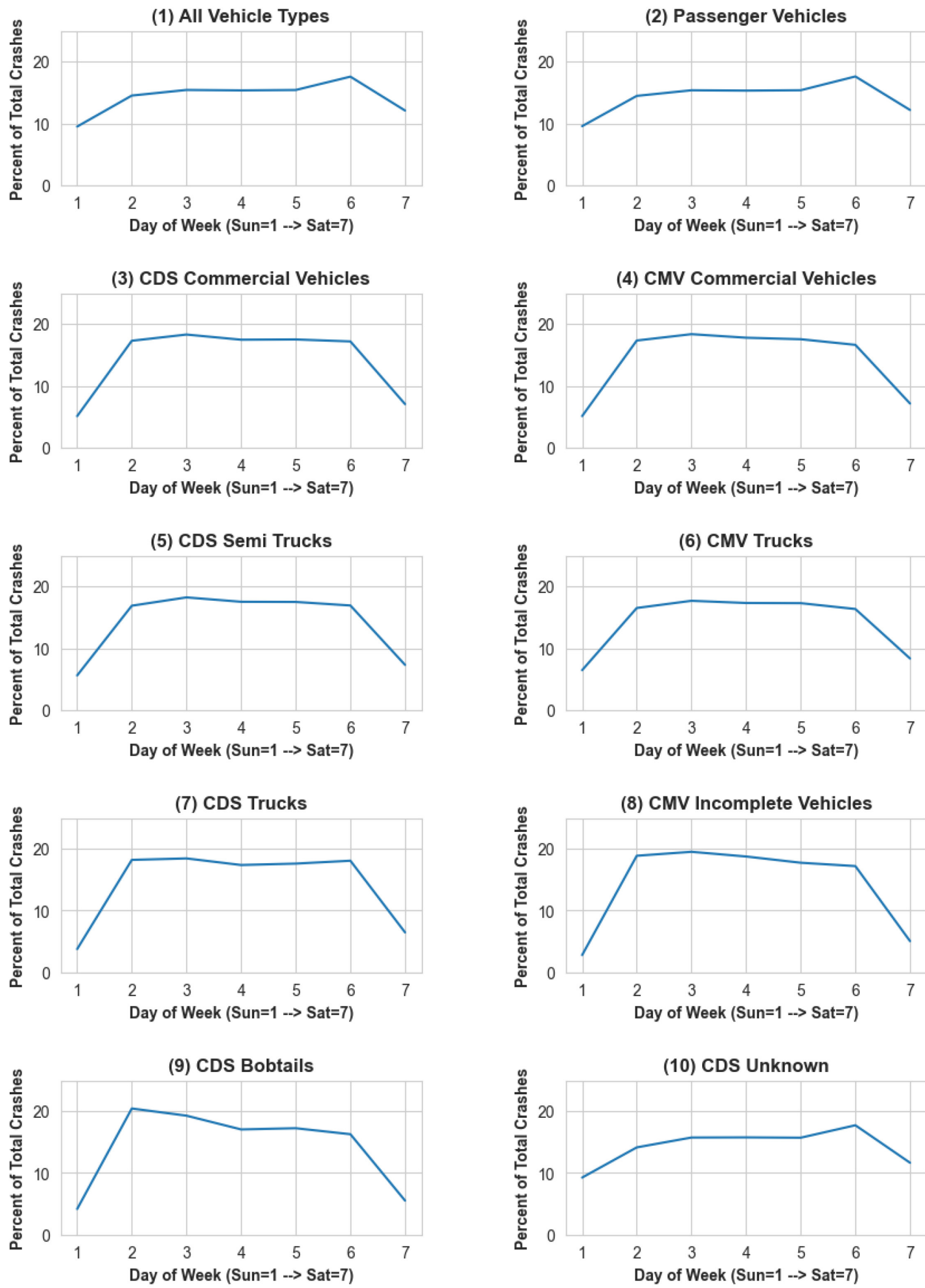

Figure 5.10 Crash percentage by day of the week for vehicle type

5.3.2.5 Hour

The trends by hour show the same trends as discussed in section 5.3.1.5. These trends seem to solidify the nature of the relationships between the CDS and CMV vehicle types that are discussed in section 5.3.2.3.

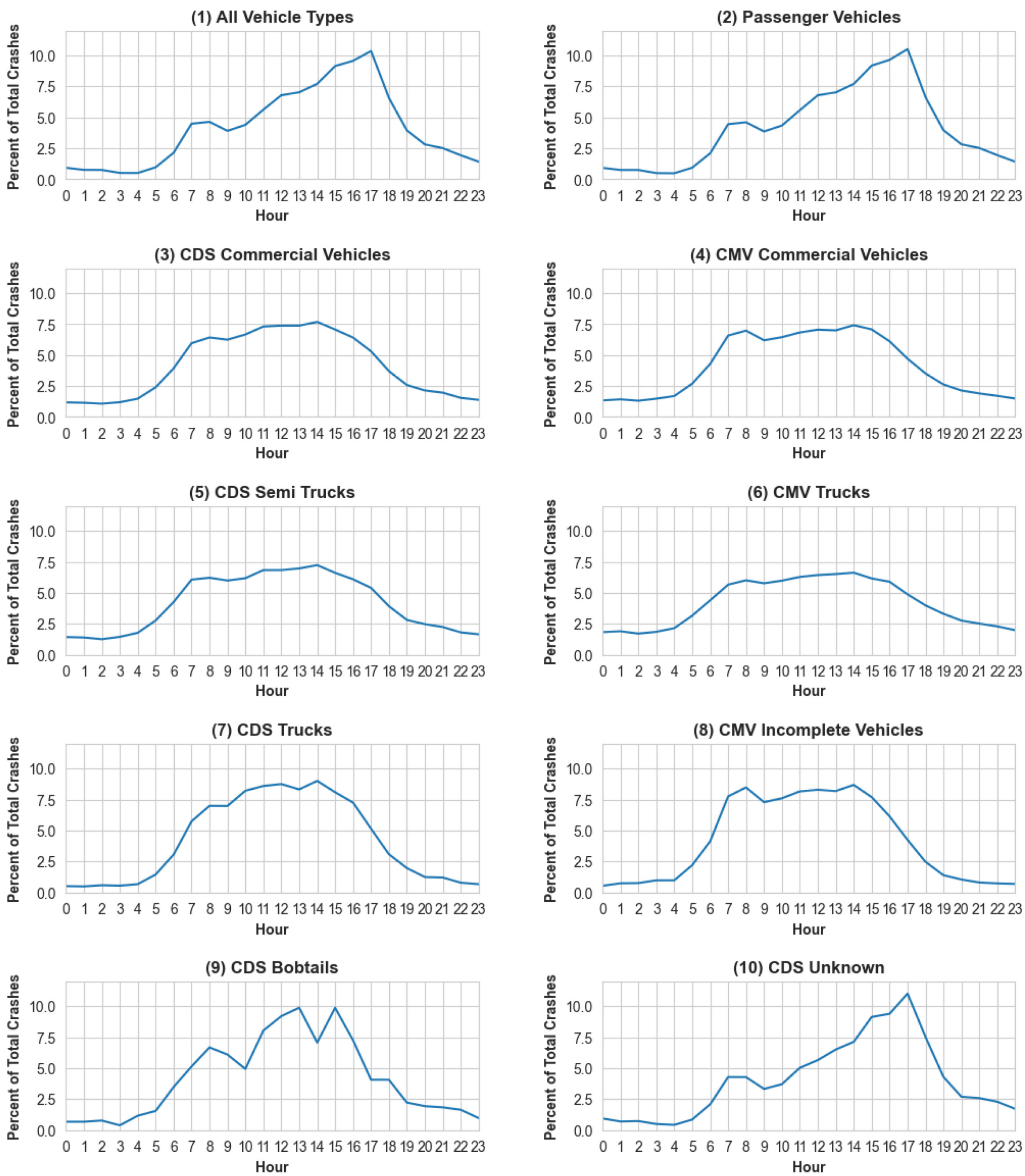

Figure 5.11 Crash percentage by hour for vehicle type

5.3.2.6 Crash Location

The trends of crash locations broken down by vehicle type are seen in Figure 5.12. Large commercial vehicles crash at a much higher rate on rural state and interstate highways and freeways than other vehicle types. The maps show that semi-trucks make up most of these large commercial vehicles while CDS Truck crashes are much more concentrated in and directly around urban areas. CDS Unknown type is also very much concentrated in urban areas. This is largely unexplainable but may have to do with unusual, job specific, commercial vehicles being concentrated in urban areas.

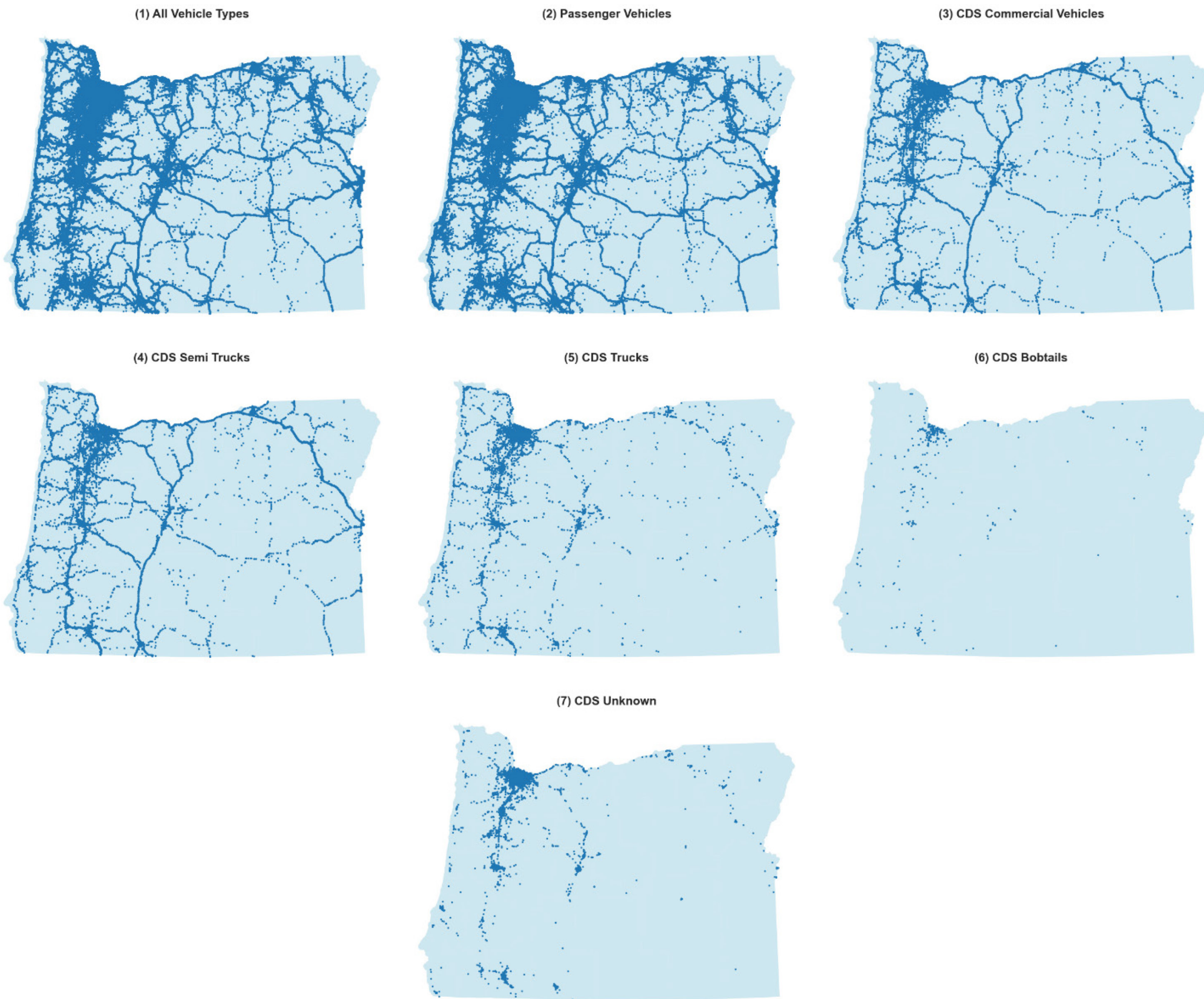

Figure 5.12 Crash locations for vehicle type

Once again it is noted that the CMV datasets could not be included in this location analysis because the CMV data had no location information.

5.3.2.7 Crashes by Road Type

Crash trends by road type largely echo the ideas discussed in the previous section. As seen, Semi Trucks experience about half their crashes in rural areas, whereas CDS Trucks experience a large majority of their crashes in urban areas. The trends for CDS Unknown do not match the trends discussed in the previous section, showing that Unknown body types experience a significant portion of their crashes in rural areas. This discrepancy can most likely be attributed to Unknowns experiencing crashes in rural areas near urban areas.

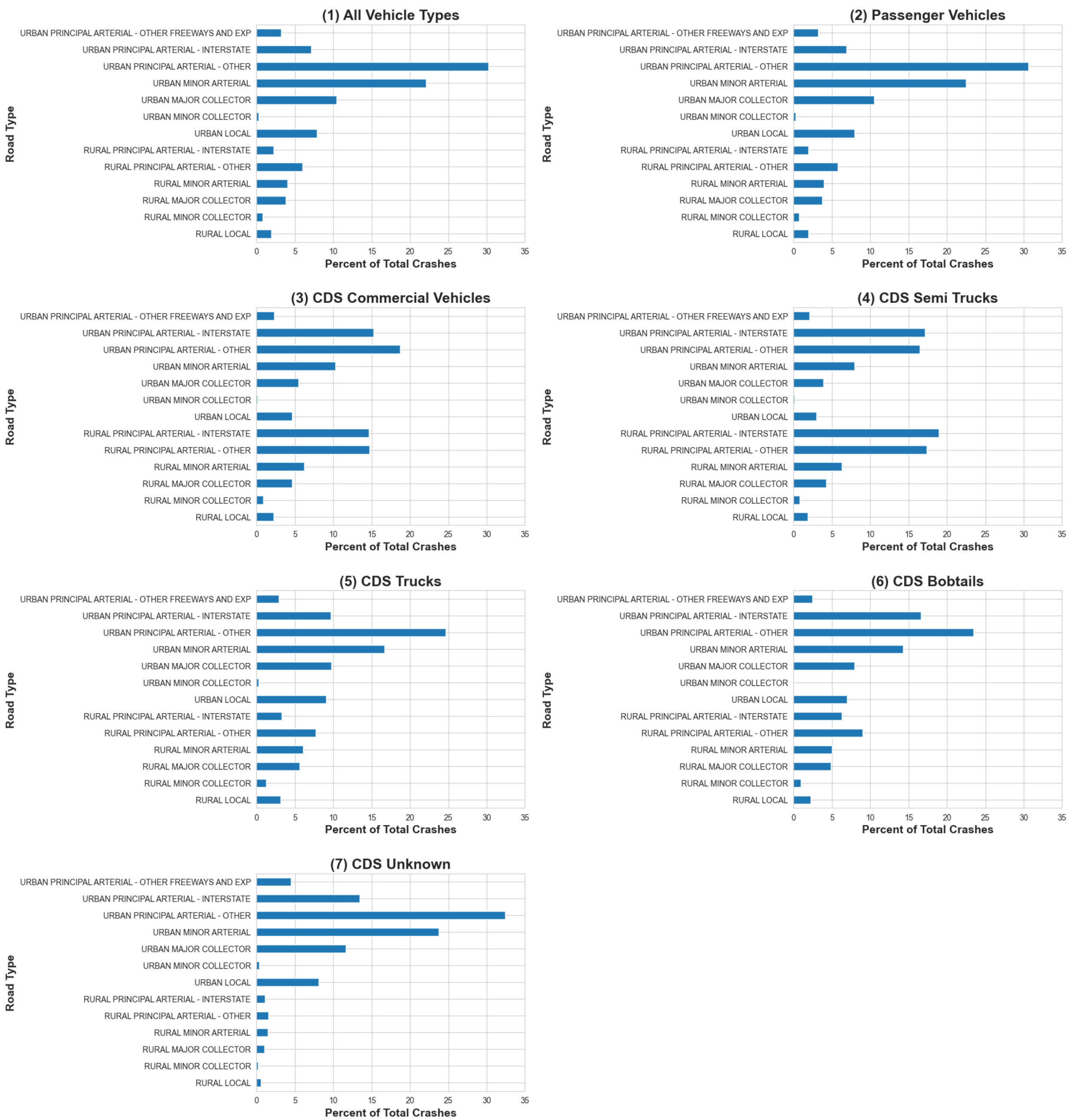

Figure 5.13 Crash percentage by road type for vehicle type

One note on all trends by vehicle type is that while CDS Bobtails mostly resembles CDS Semi Trucks, there is significantly less data on this vehicle type than the others making it less reliable. Also, the CDS Unknown category trends have resembled commercial vehicle trends for some time delineations, and resembled passenger vehicle trends for other time delineations. This most likely shows that the vehicles in the CDS labeled as unknown type are made up of a combination of commercial and private vehicles or that the crash reporter was not able to make a decisive judgement about the vehicle.

5.3.3 Trends For Delivery vehicles only

This subsection presents the results for UPS and FedEx commercial vehicles (delivery vehicles).

5.3.3.1 Temporal Trends

The temporal trends of delivery vehicles, as seen in Figure 5.14, are much as would be expected. Most crashes involving delivery vehicles happen during working hours, 8 A.M. to 6 P.M., Monday through Friday, with more crashes in the afternoon than morning. There are a few crashes that take place on Saturdays and none on Sundays, and there are no crashes between the hours of 7 P.M. and 6 A.M. Also unsurprisingly, delivery vehicle crashes rise significantly in the month of December, likely due to people shopping online for holiday gifts, significantly increasing the number of deliveries that need to be made and, in December, weather conditions may be also adverse. As discussed in Sections 5.1.4, the delivery vehicles analyzed in this study are UPS and FedEx vehicles only. Even so, it can be expected that other delivery vehicles would trend very near what is shown here as all delivery companies hold very similar schedules.

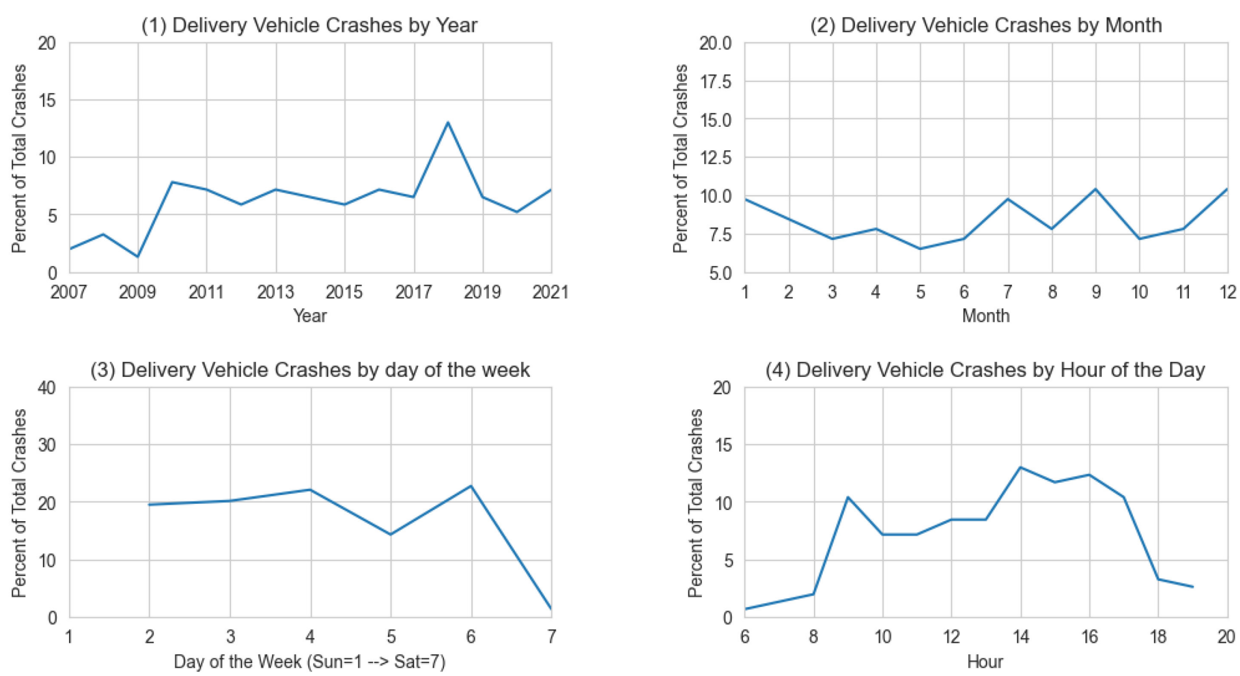

Figure 5.14 Delivery vehicle temporal crash trends

The delivery vehicle crash trends by year (Figure 5.14) do not seem to follow the overall trends discussed before. The line of best fit would show an upward trend, likely showing that delivery vehicle crashes are rising more quickly than all crashes. The two dips in the yearly trend line are 2009 and 2020, both of which included economic recession and COVID for the latter. It is not clear why crashes peaked in the year 2018.

5.3.3.2 Road Type

The breakdown of delivery vehicle crashes by road type shown in Figure 4.14 indicates that the majority of delivery vehicle crashes occur on urban roads, specifically the Arterials with Major Collectors being the third most likely to see a delivery vehicle crash. Also, it is important to note that Interstates do not see many delivery vehicle crashes, in stark contrast to commercial vehicles in general. Again, this intuitively makes sense as the delivery vehicles must stick to roads that have residences and businesses on them to make their deliveries.

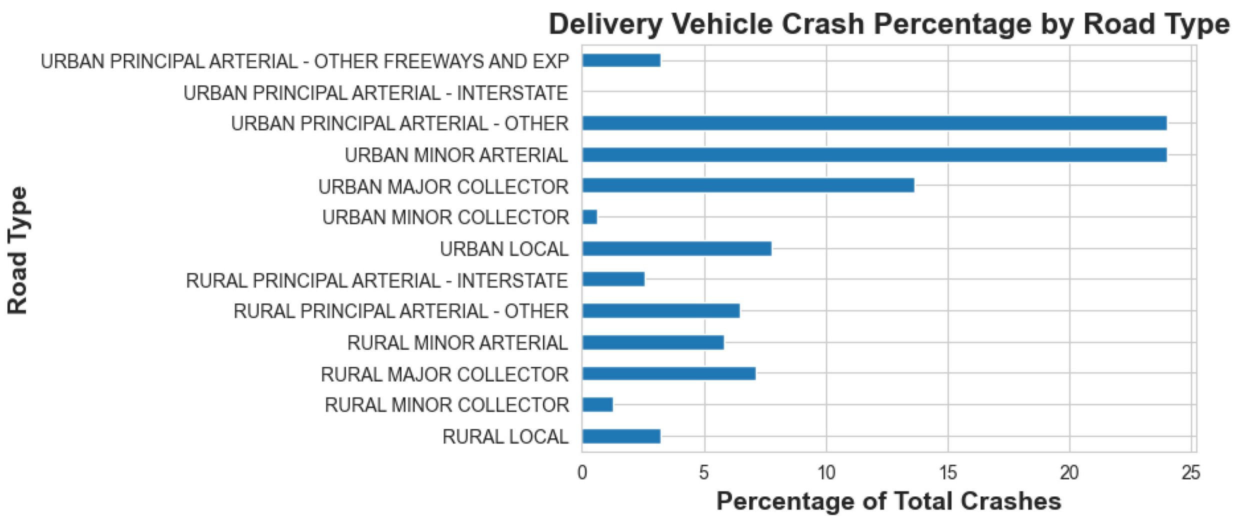

Figure 5.15 Delivery vehicle crash percentage by road type

5.3.4 Summary

Trends by different time periods were presented and do not seem to show conclusive results or stark differences among commercial vehicle types.

5.4 SPATIAL CRASH TRENDS

To analyze spatial crash trends the data was analyzed at the County level and also by place type.

5.4.1 Crash Trends by County

This section describes delivery vehicle, commercial vehicle, and all vehicle crashes by county in Oregon and in the Portland Metro area.

The statewide trends of vehicle crashes by county show the same urban to rural trends as previously found, that delivery vehicles experience crashes in the most populated areas. The additional information gathered from the county maps is that a vast majority of all crashes are happening in the Willamette Valley and the Rogue Valley. This makes sense as this is where the bulk of Oregon's population is located. The map of commercial vehicle crashes by county shown in Figure 5.17 shows that many commercial vehicle crashes tend to happen along the Interstate corridors of I-5 and I-84. Multnomah County is overwhelmingly the county with the most crashes in Oregon. This is unsurprising, as it is the county with the highest population and the most commercial activity. It also hosts the Port of Portland which drives a significant amount of commercial traffic in Oregon.

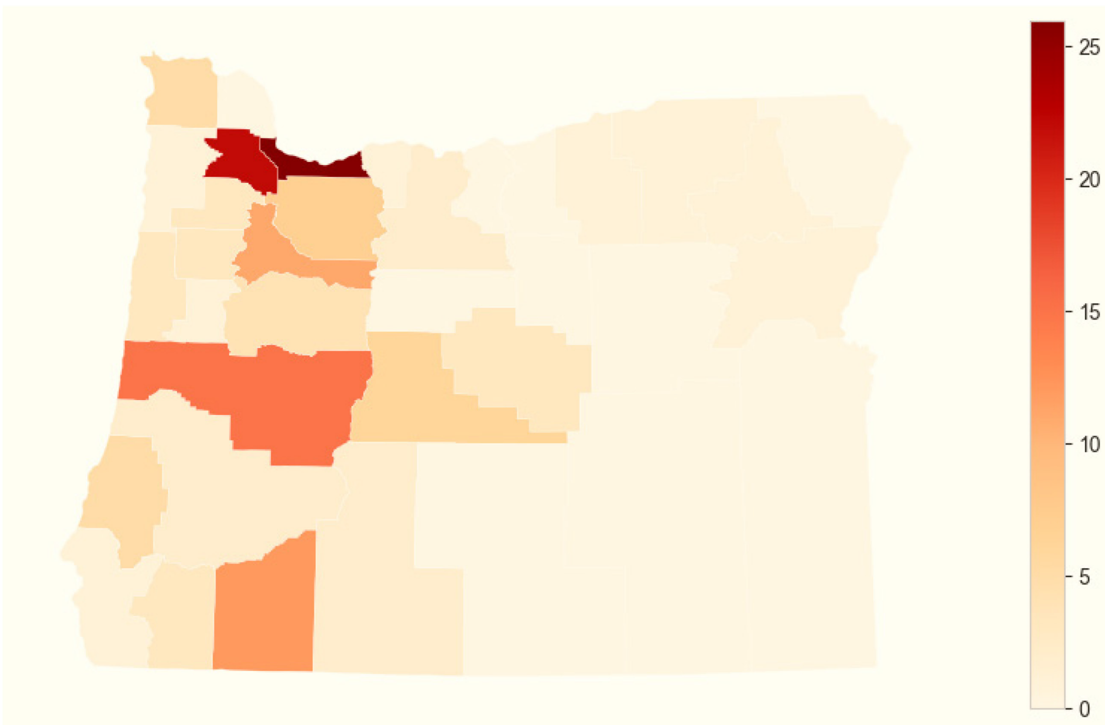

Figure 5.16 Delivery vehicle crashes per county in Oregon

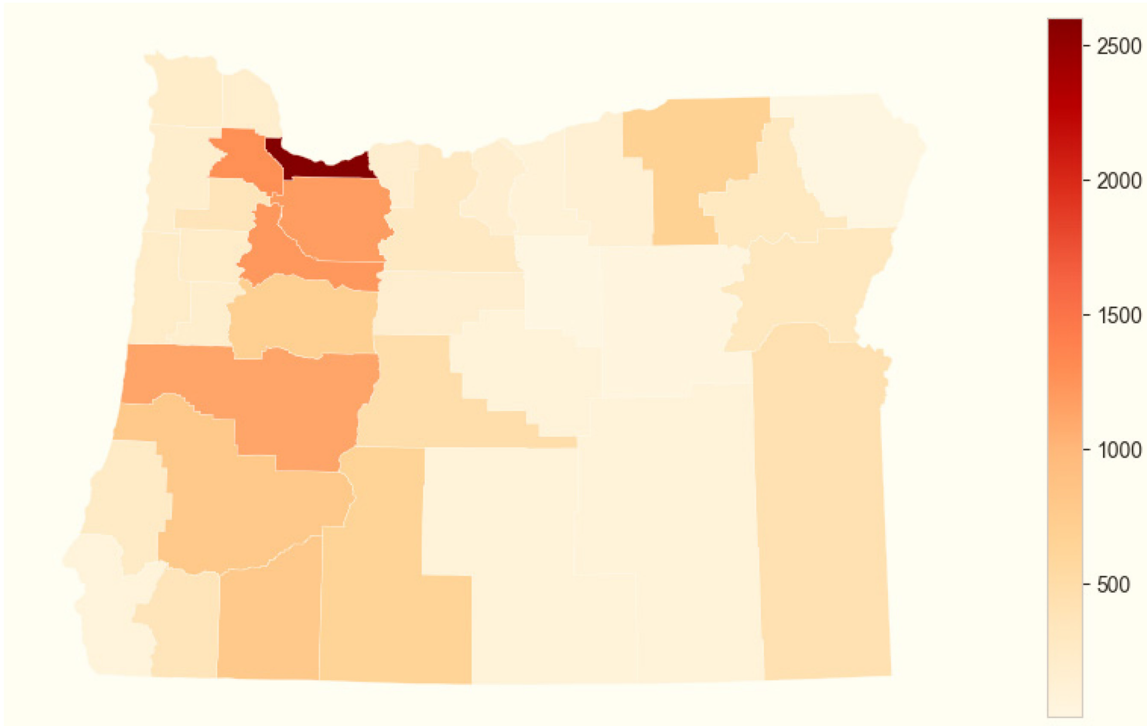

Figure 5.17 Commercial vehicle crashes per county in Oregon

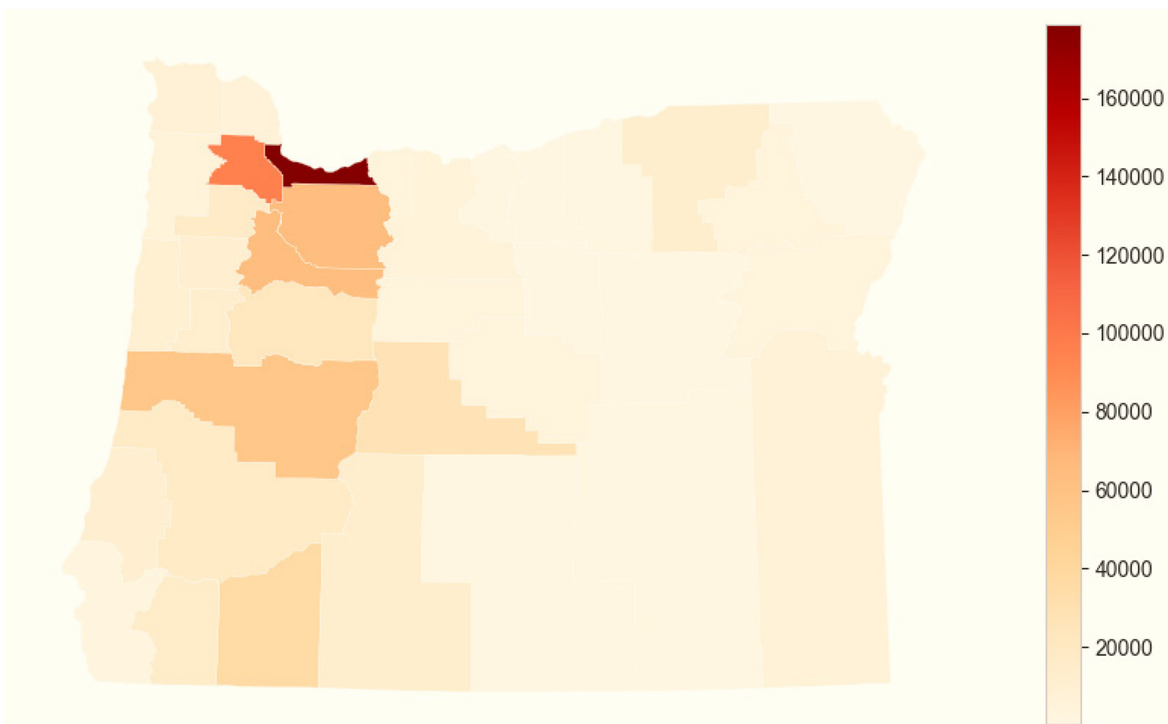

Figure 5.18 All vehicle crashes per county in Oregon

5.4.2 Counties with the Most Crashes

Tables Table 5.26, Table 5.27, and Table 5.28 show the top ten counties with the most delivery vehicle, commercial vehicle, and all vehicle crashes and the per capita rate respectively. The per capita figures are provided using scientific notation to see the order of magnitude between rates across tables.

Table 5.26 Counties with the most delivery vehicle crashes

County	Crashes	Percent	Population	Per Capita ($x\ 10^{-5}$)
Multnomah	26	18.3%	815,428	0.319
Washington	22	15.5%	600,372	0.366
Lane	15	10.6%	382,971	0.392
Jackson	12	8.5%	223,259	0.537
Marion	11	7.7%	345,920	0.318
Clackamas	7	4.9%	421,401	0.166
Deschutes	6	4.2%	198,253	0.303
Clatsop	5	3.5%	41,072	1.217
Coos	5	3.5%	64,929	0.770
Linn	4	2.8%	128,610	0.311

The number of delivery vehicle crashes is too low to find consistent trends per capita, especially in counties with both low number of crashes and low population like Clatsop. The number of per capita crashes is very low in Clackamas.

Table 5.27 Counties with the most commercial vehicle crashes

County	Crashes	Percent	Population	Per Capita ($x\ 10^{-2}$)
Multnomah	2,603	16.1%	815,428	0.319
Washington	1,275	7.9%	600,372	0.212
Marion	1,219	7.5%	345,920	0.352
Clackamas	1,192	7.4%	421,401	0.283
Lane	1,132	7.0%	382,971	0.296
Douglas	795	4.9%	111,201	0.715
Jackson	787	4.9%	223,259	0.353
Linn	696	4.3%	128,610	0.541
Umatilla	674	4.2%	80,075	0.842
Klamath	642	4.0%	69,413	0.925

The number of commercial vehicle crashes is too low to find consistent trends per capita.

Table 5.28 Counties with the most vehicle crashes

County	Crashes	Percent	Population	Per Capita
Multnomah	178,760	24.6%	815,428	0.219
Washington	95,760	13.2%	600,372	0.160
Clackamas	64,456	8.9%	421,401	0.153
Marion	64,005	8.8%	345,920	0.185
Lane	55,994	7.7%	382,971	0.146
Jackson	36,395	5.0%	223,259	0.163
Deschutes	26,880	3.7%	198,253	0.136
Linn	22,468	3.1%	128,610	0.175
Douglas	17,460	2.4%	111,201	0.157
Yamhill	16,476	2.3%	107,722	0.153

5.4.3 Crash Trends by Place Type

Some records that did not have valid spatial data had to be dropped and the number of delivery vehicle records dropped from 154 to 142 and the number of commercial vehicles dropped from 21,504 to 16,186.

The results of delivery vehicle crashes by Place Type are summarized below in Table 5.29 alongside commercial vehicle crashes and all vehicle crashes. All MPO Place Types lie within a Metropolitan Planning Organization Zone and TOD refers to a Transit Oriented Development Area.

The ratio, used in Tables Table 5.29, Table 5.30, and Table 5.31, was calculated to directly compare the ratios of the number of crashes across a Place Type to the number of Block Groups represented by that Place Type. The formula is shown below in Equation 5-1.

$$\boldsymbol{ratio_{ij}} = \left(\frac{\frac{\boldsymbol{Number\ of\ Crashes_{ij}}}{\boldsymbol{Number\ of\ Block\ Groups_{i}}}}{\boldsymbol{Total\ Crashes_{j}}} \right) * \mathbf{10,000} \tag{5-1}$$

- i: Index for the block group type
- j: Index for the dataset (Delivery Vehicles, Commercial Vehicles, or All Vehicles)
- *Number of Crashes*: The summation of all crashes of a dataset across all block group type i in dataset j.
- *Number of Block Groups*: The number of all the block groups of the block group type i.
- *Total Crashes*: The summation of all crashes in dataset j.

The ratio of number of crashes by Place Type to number of block groups by Place Type was normalized by dividing by the total number of crashes in that dataset and finally multiplied by 10,000 so the final numbers were mostly between one and ten. A high ratio shows that the associated Place Type category experiences higher than normal levels of crashes in comparison to the other Place Type categories. The ratio for all Place Types combined together is 3.80, which can be used as a baseline comparison for each ratio of the Place Type categories per Vehicle Category.

Table 5.29 Delivery vehicle crashes in place types

Place Type	Number of Block Groups	Delivery Vehicles		
		Crashes	Percentage Crashes	Ratio
Rural	337	24	16.9%	5.02
Isolated City	248	12	8.5%	3.41
Rural Near Major Center	288	14	9.9%	3.42
City Near Major Center	240	8	5.6%	2.35
MPO Low Density	117	5	3.5%	3.01
MPO Residential	823	34	23.9%	2.91
MPO Mixed Use	371	18	12.7%	3.42
MPO Employment	111	20	14.1%	12.69
MPO TOD	99	7	4.9%	4.98
All	2,634	142	100.0%	3.80

Table 5.30 Commercial vehicle crashes in place types

Place Type	Number of Block Groups	Commercial Vehicles		
		Crashes	Percentage Crashes	Ratio
Rural	337	5,122	31.6%	9.39
Isolated City	248	944	5.8%	2.35
Rural Near Major Center	288	2,663	16.6%	5.71
City Near Major Center	240	865	5.3%	2.22
MPO Low Density	117	789	4.9%	4.17
MPO Residential	823	2,018	12.5%	1.52
MPO Mixed Use	371	1,366	8.4%	2.28
MPO Employment	111	1,587	9.8%	8.83
MPO TOD	99	832	5.1%	5.19
All	2,634	16,186	100.0%	3.80

Table 5.31 All vehicle crashes in place types

Place Type	Number of Block Groups	All Vehicles		
		Crashes	Percentage Crashes	Ratio
Rural	337	84,652	11.6%	3.45
Isolated City	248	40,737	5.6%	2.26
Rural Near Major Center	288	77,760	10.7%	3.71
City Near Major Center	240	49,089	6.7%	2.81
MPO Low Density	117	27,561	3.8%	3.24
MPO Residential	823	183,162	25.2%	3.06
MPO Mixed Use	371	129,480	17.8%	4.80
MPO Employment	111	74,708	10.3%	9.25
MPO TOD	99	60,576	8.3%	8.41
All	2,634	727,725	100.0%	3.80

The ratios show some interesting trends for Delivery Vehicles when compared to the other data sets. First, Delivery Vehicles show a much lower ratio in rural areas than Commercial Vehicles even though they are a subset of that group. This is likely because deliveries are going to be proportional to population, not area, and therefore are more likely to take place in urban areas where there is a higher population.

Delivery Vehicles ratio peaks in the MPO Employment Place Type. While it is not surprising to see a high ratio for this Place Type, it is surprising to see the Delivery Vehicles ratio be significantly higher than both Commercial Vehicles and All Vehicles ratios. This may suggest that either delivery vehicles have a significant portion of their delivery routes and lots of deliveries in these areas, that these areas simply present riskier circumstances for delivery vehicles, or both. Last, it is very surprising to see that the Delivery Vehicle ratio is lower than both the Commercial Vehicles and All Vehicles ratios for the MPO TOD Place Type. As these Transit-Oriented Districts generally have lots of housing and commercial businesses, one would assume that these areas would receive lots of deliveries. However, this statistic may speak to effective traffic and transportation design in these TOD areas in keeping safety as the top priority. One note on this analysis is that since there is such a small sample size for Delivery Vehicles, the ratios for Delivery Vehicles are prone to larger margins of error.

The results of the crashes by place type tabulation, showed that delivery vehicles tended to have similar Ratios as all vehicles except for Transit Oriented Development Areas. It is not immediately apparent why delivery vehicles experience a lower ratio of their crashes in these areas, as a high number of deliveries would still be expected in these zones. Delivery vehicles did, however, have the highest Ratio in Employment areas, much higher than commercial vehicles and all vehicles. This was a little surprising as these commercialized and industrialized zones typically have traffic systems specifically designed for larger commercial vehicles.

5.5 SUMMARY AND CONCLUSIONS

This section presented and analyzed crash trends to understand the evolution and patterns of freight-related safety crashes in Oregon. The trend analysis included yearly trends as well as seasonal, weekly, and hourly crash trends by commercial vehicle type and also spatial trends by county and by land use type.

The combination of data sources is time consuming and results in data losses though allows the observation of new trends. We found that while many data records are lost through the filtering and joining processes, there is still enough data to determine spatial and temporal trends for commercial vehicles by type or weight but not enough for delivery vehicles involving FedEx and UPS vehicles due to the low number of observations. However, it can be concluded that delivery vehicle crashes tend to be in high employment areas and delivery vehicle crashes are more likely to occur on arterials and major collectors, as opposed to on interstates where many commercial vehicle crashes occur.

The key recommendation to better monitor medium truck crashes is to modify the way data is currently collected by adding: a) more truck categories that separate medium from heavy duty trucks in the CDS data, b) including more geographic granularity, i.e. latitude and longitude, in the CMV data, and c) an additional ID or recording system that can facilitate the matching of CMV and CDS commercial vehicle data.

It was possible to break down commercial vehicle crash data by vehicle weight and type. However, estimating crash rates by vehicle mile was not feasible because section 4 could not provide vehicle utilization data by weight, type, or company as presented in this report. Furthermore, we were unable to find any Amazon-vehicles in the crash data despite Amazon being one of the top three carriers in the DEQ survey. This discrepancy is likely due to Amazon's subcontracting practices, which limit the monitoring of their safety performance. Thus, there was no way to link the DEQ data with the crash data utilized in this section. Future research efforts should focus on developing alternative matching algorithms and analyzing trends post-2021. With a longer time series and more crash data, it may be possible to discern clearer trends.

6.0 SUMMARY AND RECOMMENDATIONS

The sections provide the project summary and corresponding recommendation

6.1 PROJECT SUMMARY

The project focused on analyzing medium-duty vehicle operations and safety within Oregon, driven by increasing e-commerce and changes in logistics that resulted in a significant rise in the usage of these vehicles. The main objectives were to understand the trends in medium-duty truck usage, assess the associated safety risks, and provide recommendations for policy improvements.

The data and data gap section introduced the data sources and processes used to link various datasets for the study. It provided a comprehensive overview of medium-duty vehicle operations and the characteristics of crashes involving these vehicles in Oregon. The data comprised a statewide survey by the Oregon Department of Environmental Quality (DEQ) and crash data from the Oregon Department of Transportation (ODOT) Crash Data System (CDS) and the Oregon Commercial Motor Vehicle (CMV) crash database. These datasets were meticulously integrated to filter and analyze commercial vehicle crash data by vehicle class, company, and location. Additionally, the Oregon DOT Place Types were used to examine the relationship between land use and commercial vehicle crashes. This analysis identified patterns and factors contributing to crashes, offering insights into the underlying causes and potential areas for intervention. The findings revealed that crashes involving medium-duty trucks were influenced by a range of factors, including driver demographics, vehicle types, road conditions, and environmental factors. This foundational analysis was crucial for understanding the scope and nature of the safety issues associated with medium-duty trucks and laid the groundwork for more targeted safety interventions and policy recommendations.

The comprehensive analysis of medium-duty vehicle operations in Oregon, using the DEQ survey data, examined the operations of medium-duty vehicles, providing detailed breakdowns of vehicle counts by weight class, annual mileage, fleet sector, county of origin, and body type. This analysis offered critical insights into the distribution and operational patterns of medium-duty vehicles, helping to understand their impact on the state's transportation system. The data gathered in this section served as a basis for assessing the current state of medium-duty truck operations and identifying trends and patterns. The findings indicated a diverse range of uses and operational patterns for medium-duty trucks, highlighting the importance of tailored policy measures that address the specific needs and challenges of different sectors. This section underscored the need for policies that promote the adoption of safer and more efficient vehicles, as well as infrastructure improvements to support the growing volume of medium-duty truck traffic.

The safety analysis section delved into crash data, examining vehicle types, crash counts, and trends over time and across different geographic areas. It identified significant trends in crash severity and frequency, particularly for delivery vehicles. The analysis also explored the spatial distribution of crashes, revealing areas with higher incidences and helping to pinpoint regions where safety interventions may be needed. This detailed examination of crash data provided a clear picture of the safety landscape for medium-duty trucks and highlighted critical areas for improvement. The findings emphasized the need for targeted safety campaigns, stricter regulations, and enhanced monitoring to reduce crash rates and improve overall safety. By identifying the most common types of crashes and the conditions under which they occurred, this analysis offered valuable insights that could inform the development of more effective safety measures.

In conclusion, the comprehensive analysis provided in this project offered valuable insights into the operations and safety of medium-duty vehicles in Oregon. It highlighted the need for targeted policy interventions and continuous monitoring to enhance safety and optimize transportation infrastructure. The findings and recommendations served as a crucial foundation for policymakers to address the growing challenges posed by the increasing usage of medium-duty trucks. By implementing the recommended measures, Oregon could improve the safety and efficiency of its transportation system, ensuring that the benefits of increased medium-duty truck usage were realized without compromising road safety.

6.2 RECOMMENDATIONS

In meeting with objective 3 of this study, the following sections represent recommendations based on the data collection and analysis, analysis of medium-duty vehicle operations, and safety analysis.

6.2.1 Data Collection and Descriptive Analysis

Given the difficulty in obtaining comprehensive data on medium-duty vehicles, enhancing data collection efforts is crucial for gaining a thorough understanding of their operations. Integrating additional data sources, such as telematics and GPS data, can provide more detailed insights into vehicle movements and behaviors. Regularly updating and refining data linkage processes will ensure the accuracy and completeness of the datasets used in safety analyses. This continuous improvement will enhance the reliability of safety assessments. Utilizing descriptive analysis findings to develop targeted safety interventions can help reduce crash occurrences. By identifying specific factors contributing to accidents, tailored interventions can be implemented to address these issues effectively. Tailored interventions might include enhanced data collection, targeted safety campaigns, infrastructure improvements, regulatory enhancements, technological interventions, and collaboration with industry stakeholders.

6.2.2 Comprehensive Analysis of Medium-Duty Vehicle Operations

Understanding the impacts of medium-duty vehicle operations is essential for developing effective policies and infrastructure plans. Detailed analysis of operational patterns, including vehicle counts by weight class, annual mileage, fleet sector, and geographic distribution, provides critical insights into how these vehicles affect the transportation system. Utilizing this data can help optimize infrastructure planning and maintenance, ensuring that road networks can accommodate the increasing volume of medium-duty truck traffic.

By identifying trends and patterns in medium-duty vehicle usage, the State (policymakers) can make informed decisions about resource allocation and infrastructure improvements. This approach will enhance the efficiency and safety of the transportation system, ensuring that it can support the growing demands of medium-duty truck operations without compromising road safety. Developing policies based on comprehensive data analysis will help address specific challenges posed by medium-duty vehicles, leading to a more resilient and well-managed transportation network.

6.2.3 Safety Analysis

To improve the monitoring and safety of medium-duty trucks, several key recommendations are proposed. Firstly, implementing targeted safety campaigns in regions with high crash incidences can effectively address specific local issues and reduce crash rates. These campaigns should focus on the unique challenges faced by each region, providing tailored solutions to improve safety. Additionally, investing in advanced crash data analytics tools will enhance the accuracy and timeliness of safety assessments, enabling more proactive safety management.

Developing and enforcing stricter regulations for delivery vehicle operations is also essential. This includes mandatory safety inspections and compliance with best practices in vehicle maintenance and driver behavior to ensure that delivery vehicles operate safely on the roads. Enhancing collaboration between state agencies, local governments, and private sector stakeholders is crucial for developing comprehensive safety strategies tailored to the unique challenges of medium-duty truck operations. This collaborative approach will ensure that all relevant parties work together to improve road safety.

Furthermore, improving data collection methods is necessary for gaining a deeper understanding of medium-duty truck operations. This involves modifying the current data collection system by adding more truck categories that separate medium from heavy-duty trucks in the Crash Data System (CDS), including more geographic granularity in the Commercial Motor Vehicle (CMV) data, and establishing an additional ID or recording system to facilitate the matching of CMV and CDS commercial vehicle data.

In conclusion, these recommendations aim to enhance the safety and efficiency of medium-duty truck operations in Oregon. By implementing targeted safety campaigns, investing in advanced data analytics, enforcing stricter regulations, fostering collaboration, and improving data collection methods, policymakers can create a safer and more efficient transportation system that accommodates the growing use of medium-duty trucks while ensuring the safety of all road users.

6.3 SUMMARY

In summary, to enhance medium-duty truck safety and performance, ODOT should develop a comprehensive monitoring methodology that ensures ongoing tracking and analysis. This methodology would involve integrating advanced data collection tools such as telematics and GPS systems to gather detailed information on vehicle movements, driver behaviors, and operational patterns. By establishing a robust data linkage process, ODOT can regularly update and refine datasets, ensuring their accuracy and completeness. This continuous improvement will enhance the reliability of safety assessments. Additionally, the methodology should include the implementation of targeted safety campaigns based on descriptive analysis findings, infrastructure improvements in high-risk areas, and the adoption of advanced safety technologies such as collision avoidance systems. Collaboration with industry stakeholders will also be essential for sharing best practices and developing effective safety strategies. By systematically monitoring and analyzing medium-duty truck operations, ODOT can identify emerging trends and issues, allowing for timely interventions that improve safety and efficiency on Oregon's roads.

6.4 EXTERNAL PROJECT CHALLENGES

The research team faced numerous challenges in completing this project, primarily due to the onset of the COVID-19 pandemic. The pandemic led to significant difficulties in obtaining necessary data as state-level policies restricted access and operations, causing delays and gaps in data collection. Additionally, the project experienced instability in management, with changes in Project Management from ODOT’s side complicating coordination and continuity. Further exacerbating the situation, a Co-Principal Investigator (PI) left to take another position outside the state, necessitating a transition to new leadership midway through the project. These factors collectively created a challenging environment for the research team, requiring adaptability and resilience to maintain progress and achieve project objectives.

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APPENDIX A

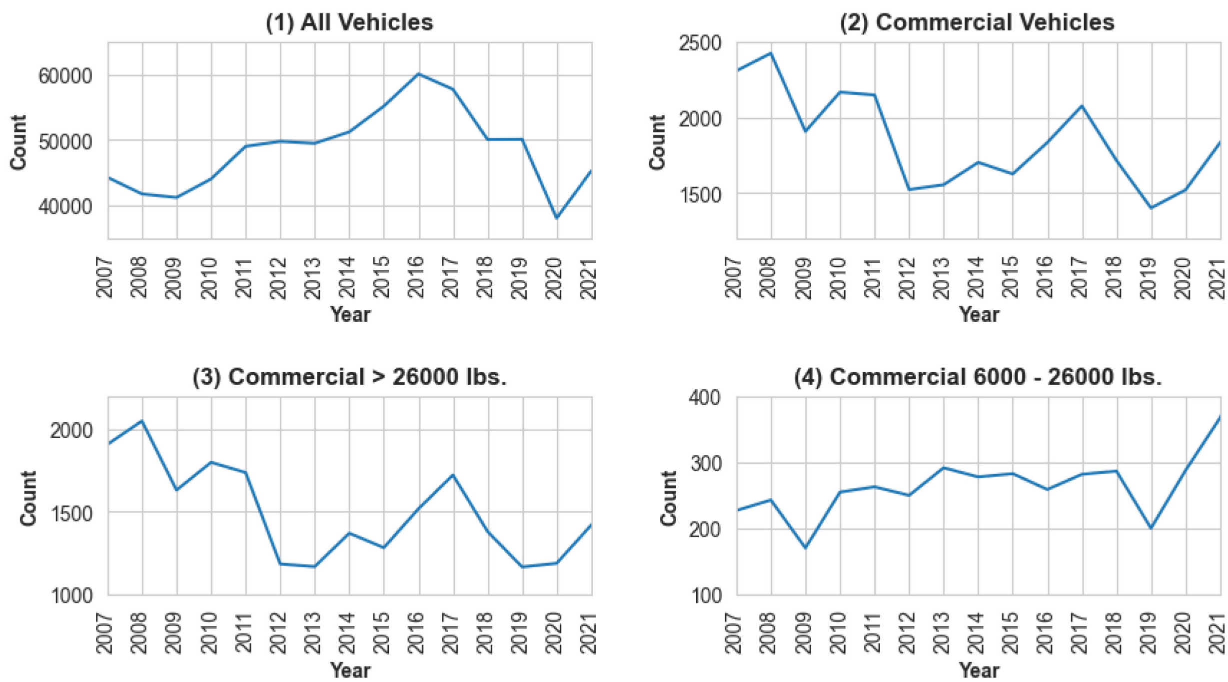

Figure A.1. Yearly trends of crash counts by vehicle weight.

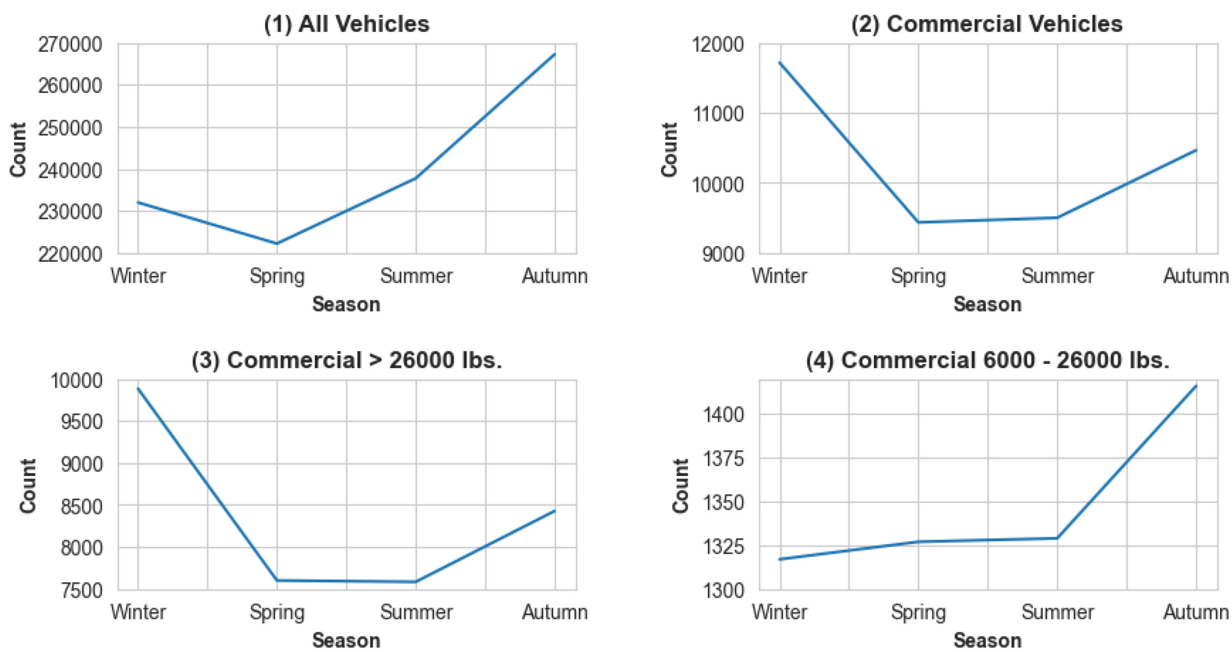

Figure A.2. Seasonal trends of crash counts by vehicle weight.

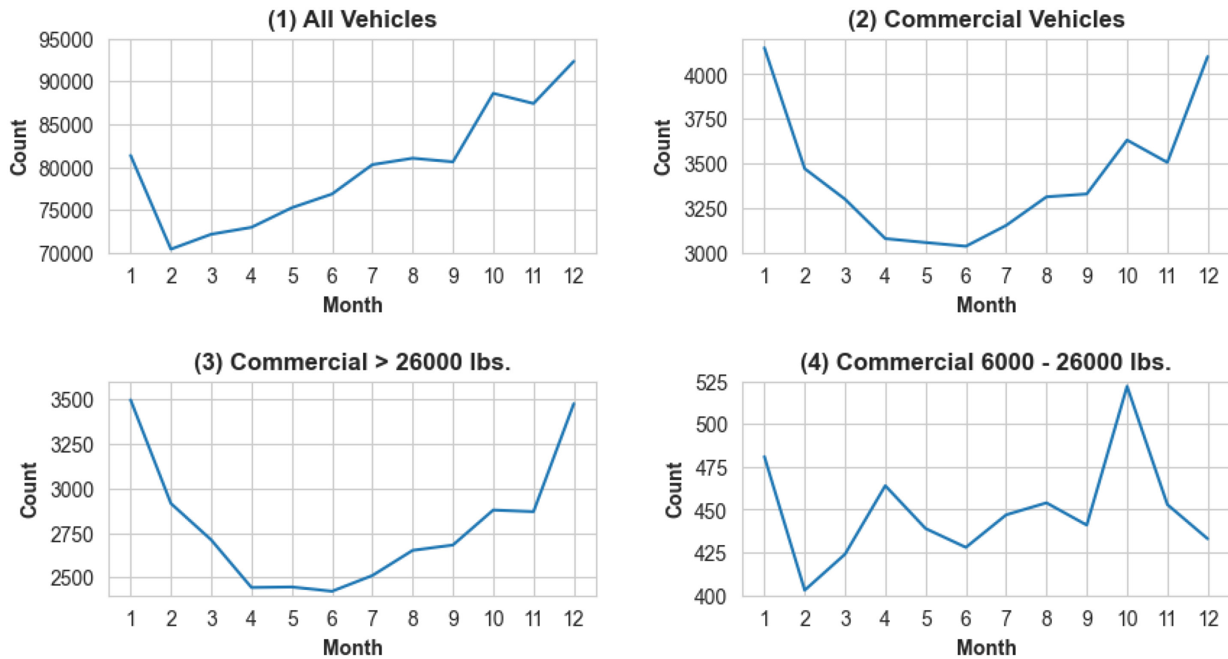

Figure A.3. Monthly trends of crash counts by vehicle weight.

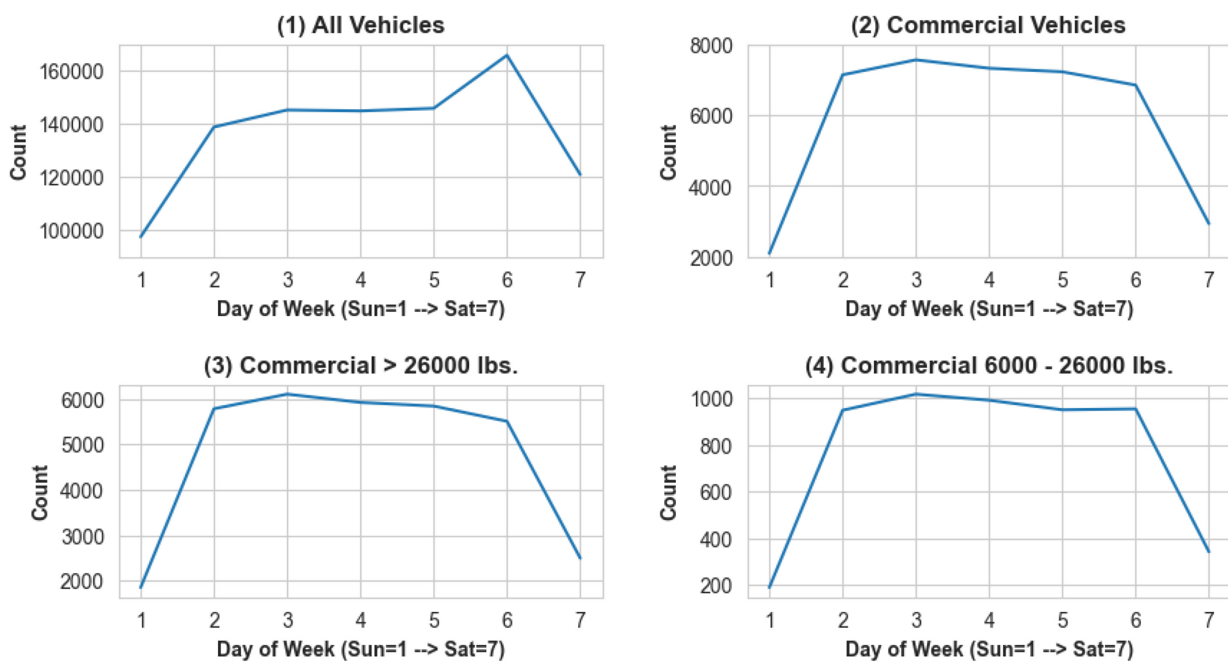

Figure A.4. Day of the week trends of crash counts by vehicle weight.

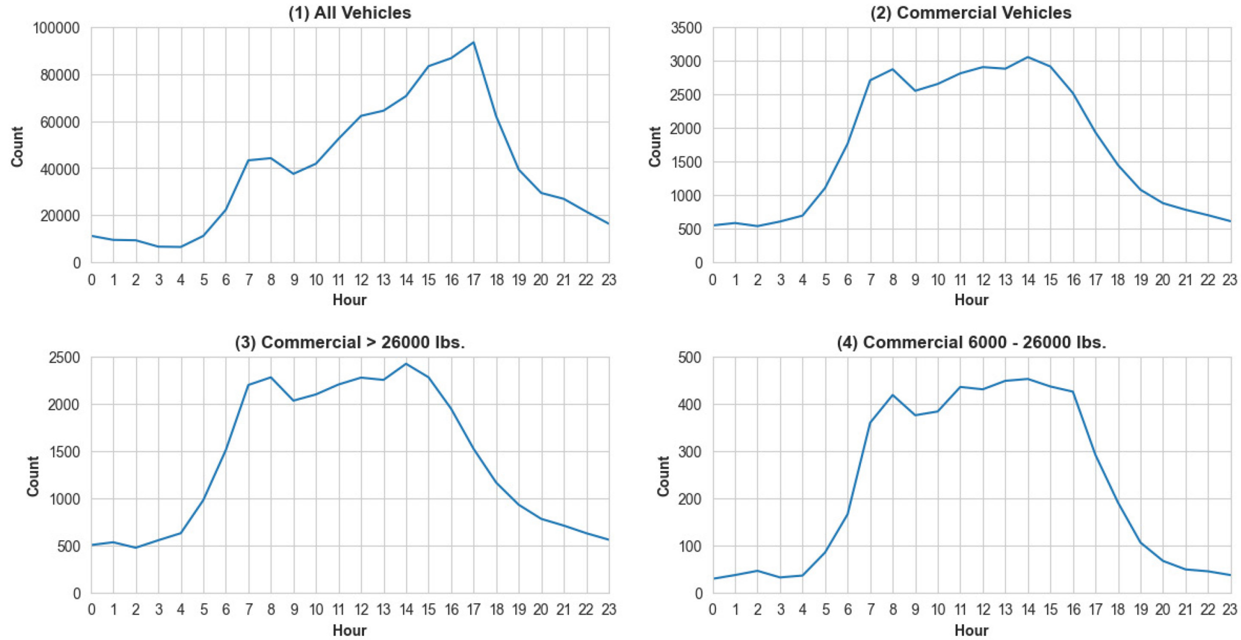

Figure A.5. Hourly trends of crash counts by vehicle weight.

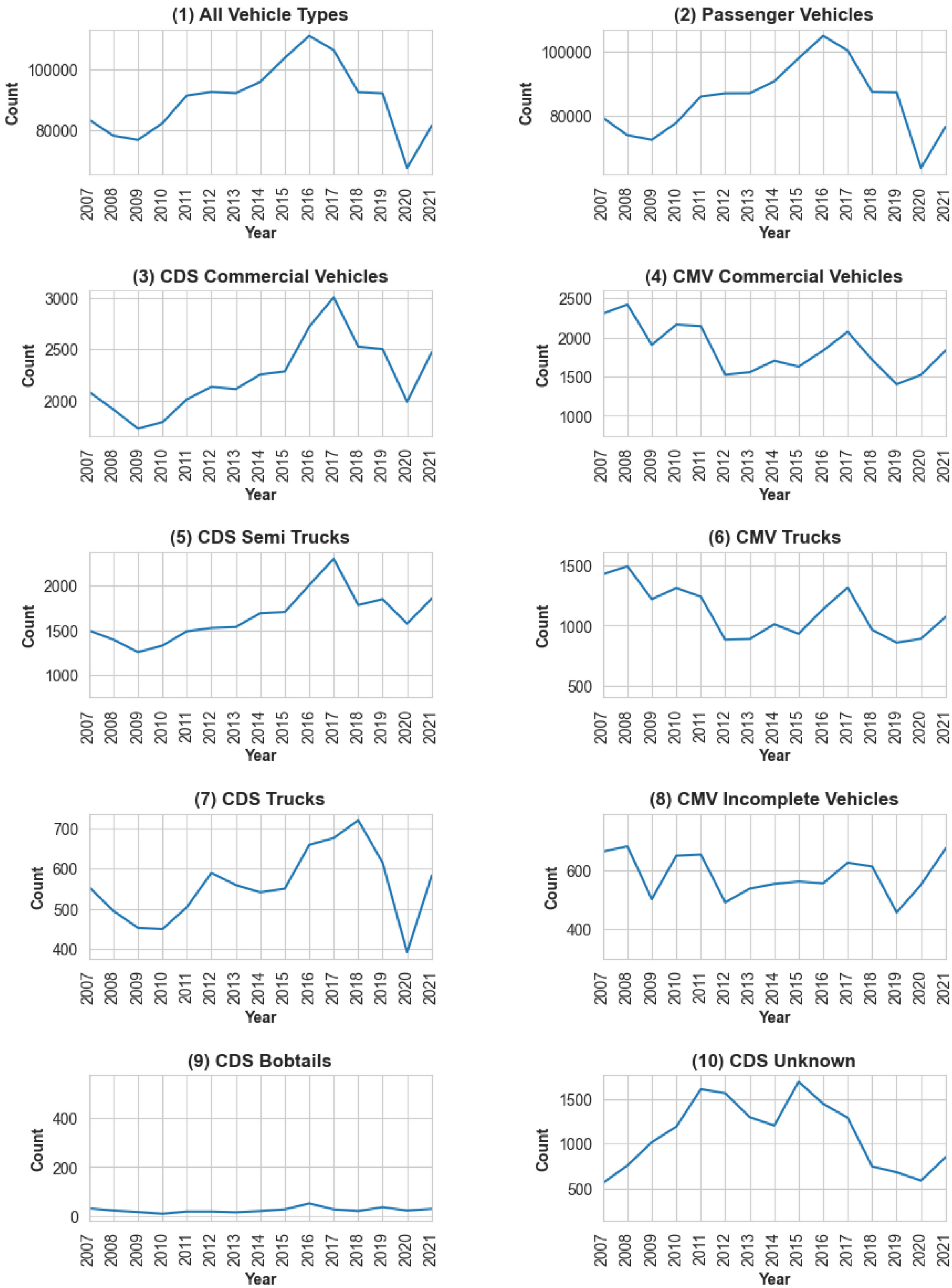

Figure A.6. Yearly trends of crash counts by vehicle type.

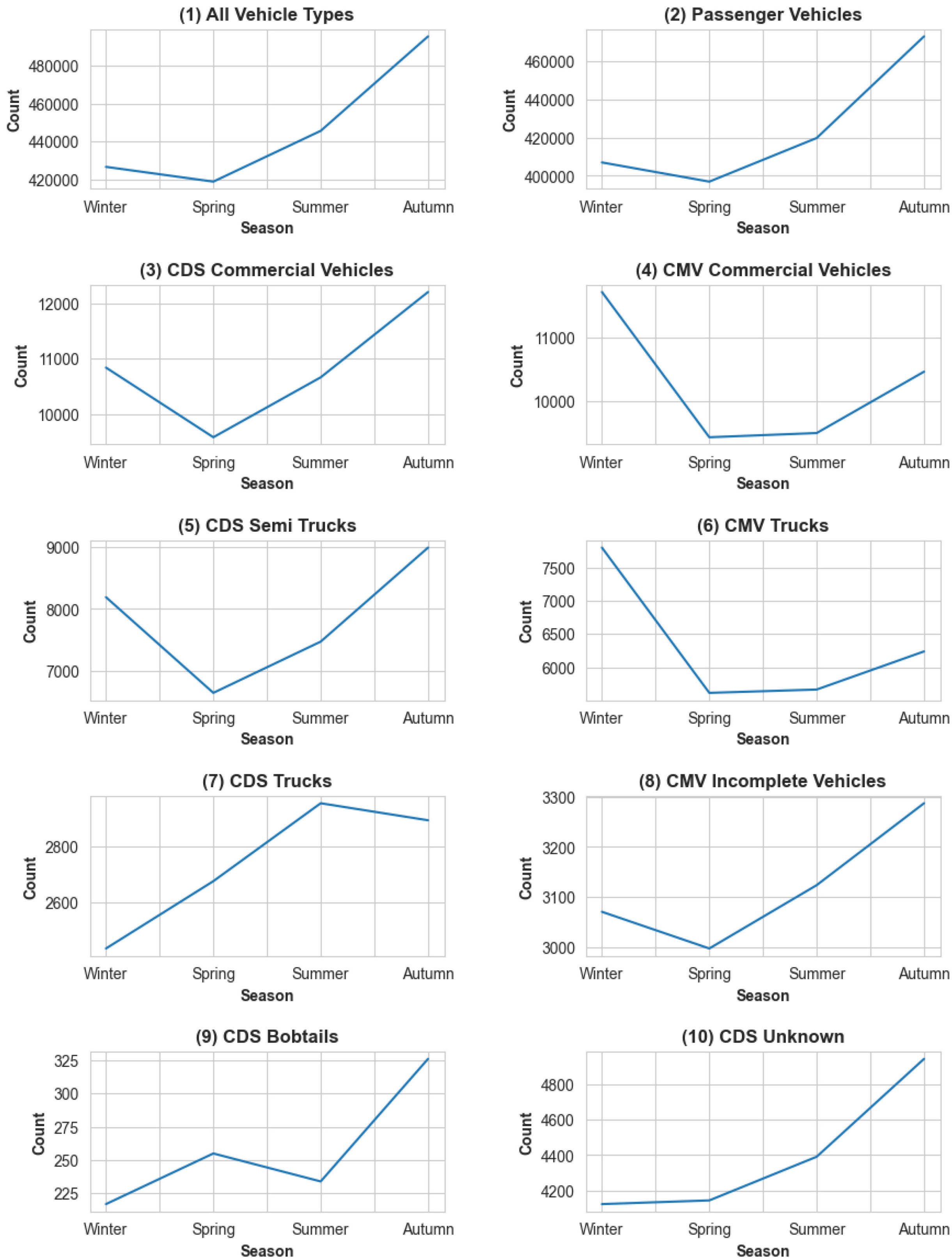

Figure A.7. Seasonal trends of crash counts by vehicle type.

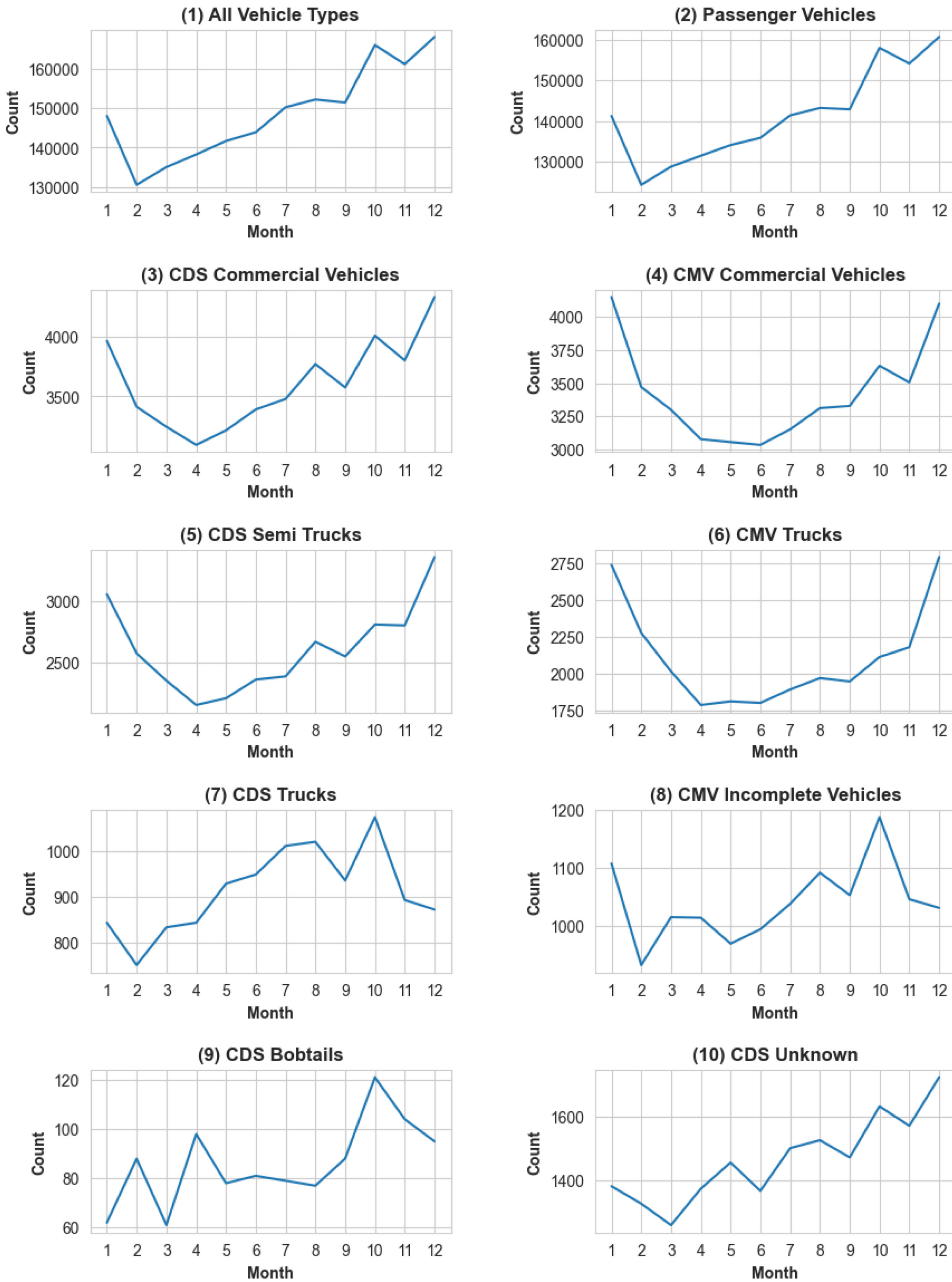

Figure A.8. Monthly trends of crash counts by vehicle type.

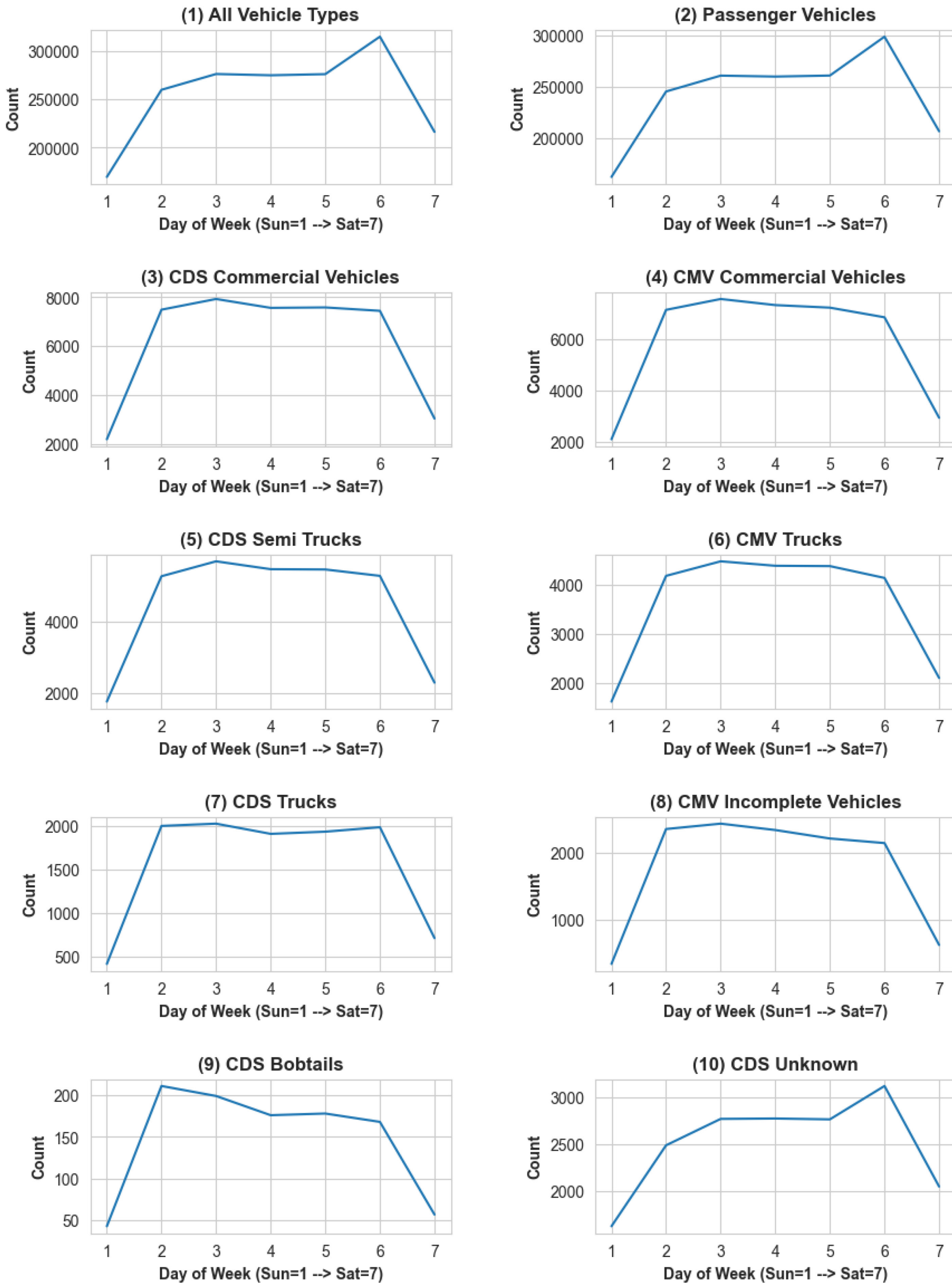

Figure A.9. Day of the week trends of crash counts by vehicle type.

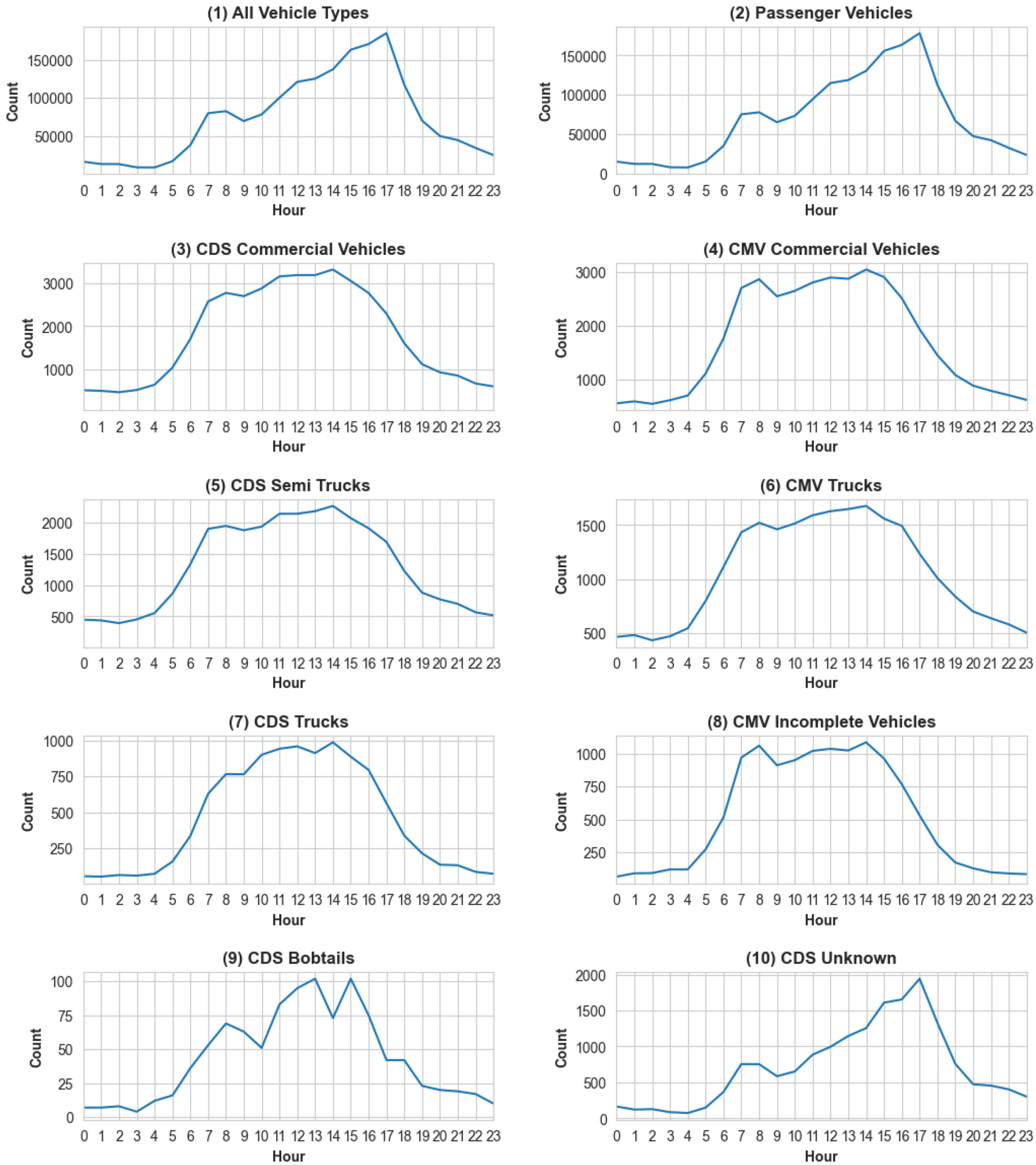

Figure A.10. Hourly trends of crash counts by vehicle type.

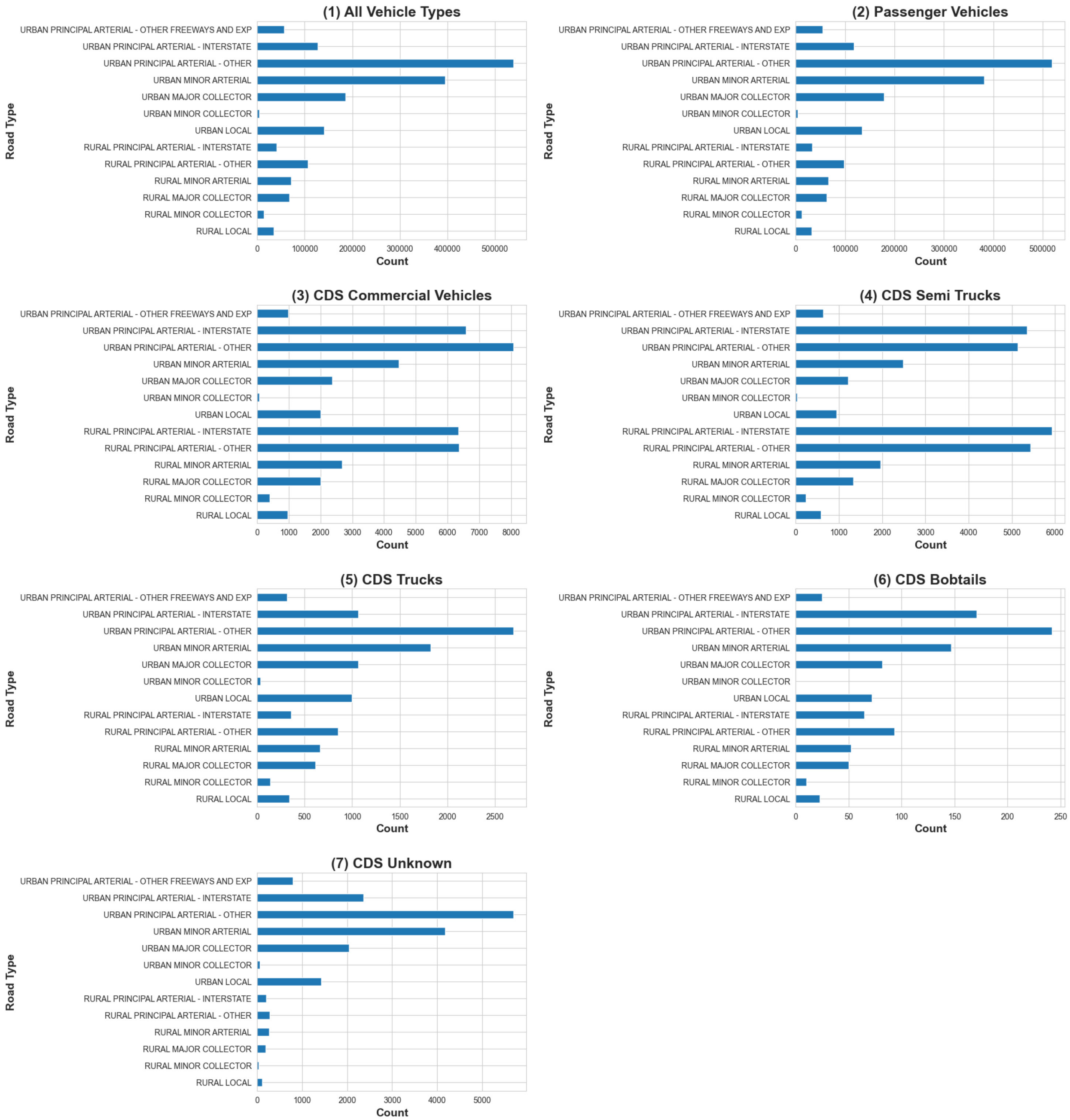

Figure A.11. Road type trends of crash counts by vehicle type.

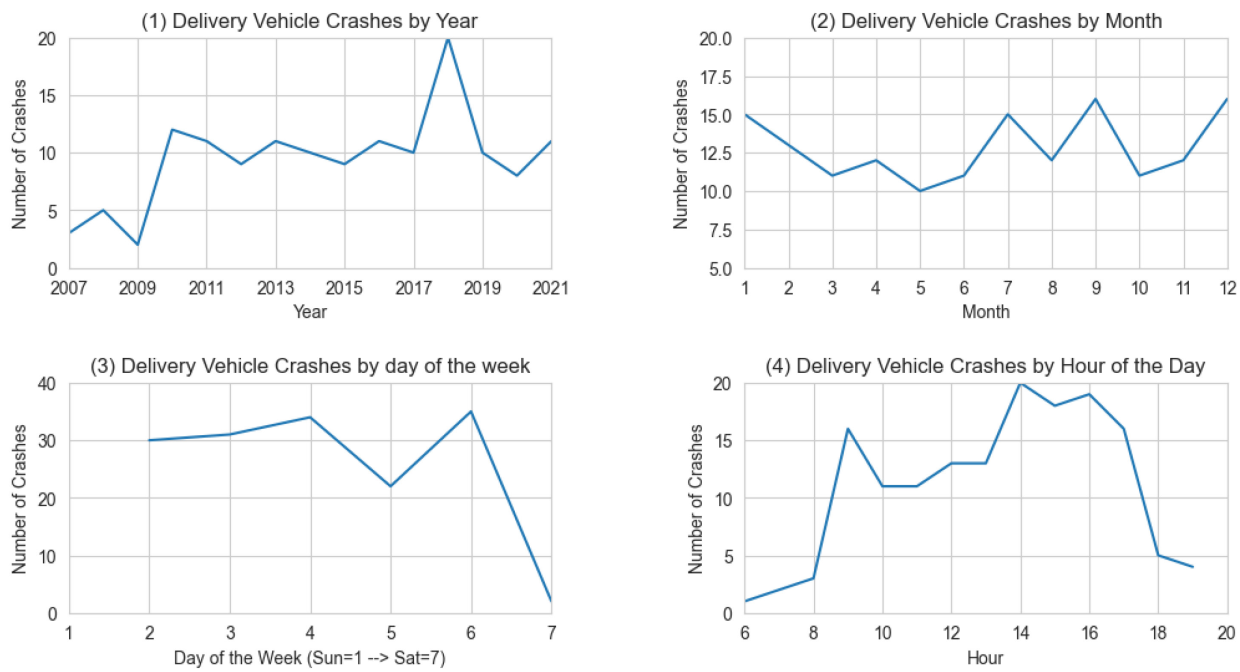

Figure A.12. Temporal trends of delivery vehicles by crash count.

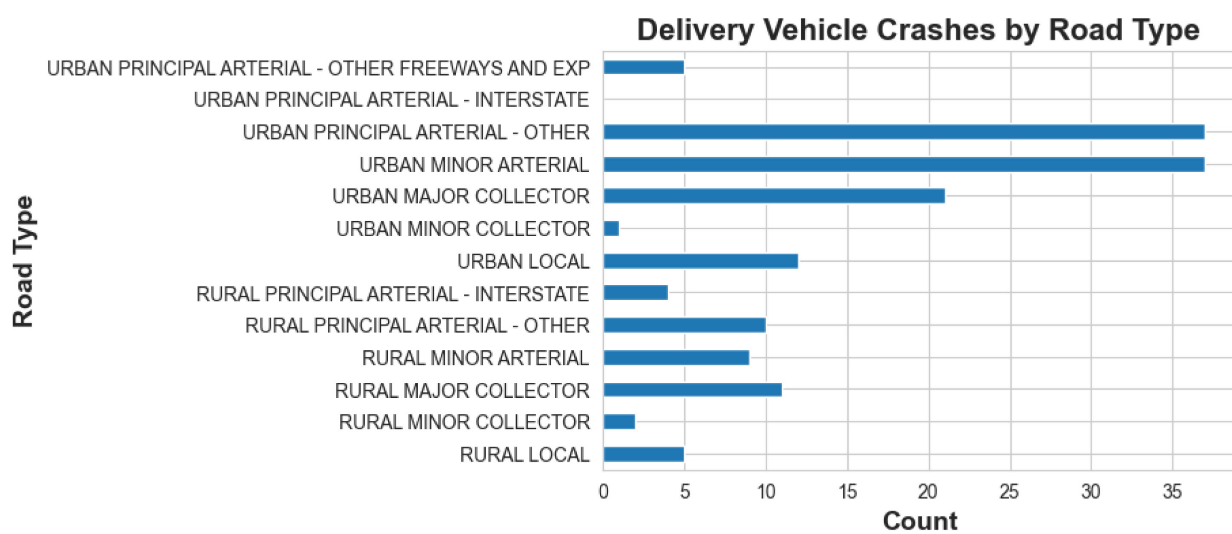

Figure A.13. Crash counts of delivery vehicles by road type.