TOWARDS AN UNDERSTANDING OF FINANCIAL INFLUENCES ON HEAVY VEHICLE SAFETY OUTCOMES

Wonmongo Lacina Soro
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Centre for Accident Research and Road Safety- Queensland
School of Psychology and Counselling
Faculty of Health
Queensland University of Technology
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Abstract

Heavy vehicles disproportionately contribute to road trauma. According to the Australian Bureau of Statistics, these vehicles account for less than 3% of the national vehicle fleet per year and almost 17% of the annual road fatalities. The national freight task is projected to triple over the next three decades, with heavy vehicles carrying more than 95% of the domestic goods. The importance of the freight sector to the national economy combined with the projected increase in the freight task imply increased heavy vehicle travel and significant challenges for road safety decision makers if adequate preventive actions are not taken.

Research has demonstrated that the financial pressure associated with the high level of competition among carriers contributes to poor safety performance. Competition creates an economic pressure which motivates heavy vehicle companies to underbid, reduce safety investments, outsource the driving task and pressure drivers to work faster and longer than legally required. Consequently, speeding and fatigue are the main proximal contributing factors to at-fault heavy vehicle-involved fatal crashes. Nevertheless, regulating speeding, fatigue and its likely contributing factors such as drug use, having inadequate sleep patterns or breaching hours-of-service regulations may not sufficiently and adequately deal with road safety issues because these regulations assume that safety is solely the responsibility of the drivers. The likelihood that drivers speed or drive while fatigued appears to be affected by the practices of heavy vehicle companies in terms of safety investment (e.g. technology adoption, vehicle maintenance, driver training), outsourcing of the driving task and driver payment methods. Hence, research suggested that the actual reasons for the poor safety performance of heavy vehicle drivers could be understood by examining the financial structure of the whole heavy vehicle industry, the

different pressures that may contribute to the poor performance and the economic rewards linked to the industry.

However, there is little empirical research examining the direct influence of the financial performance of heavy vehicle companies on safety outcomes. Importantly, to date, there has been no comprehensive assessment of financial influences (direct and indirect) on safety performance in the heavy vehicle industry. The current research program was undertaken in response to this gap, with the main aim to develop a better understanding of financial influences on heavy vehicle safety outcomes within the Australian context. Specifically, the research program first examined the safety impact of driver employment type and payment methods and their relationships with knowledge of the Chain of Responsibility (CoR) legislation which was designed to improve safety in the Australian heavy vehicle industry. Then, it examined the association between financial performance and factors, including employment type and payment methods, that are likely to influence the safety performance of heavy vehicle companies.

Six research questions were formulated:

RQ1. Are heavy vehicle driver employment type and payment methods associated with crash involvement?

RQ2. Are heavy vehicle driver employment type and payment methods related to driver use of cruise control?

RQ3. Do heavy vehicle driver payment methods mediate the relationship between driver employment type and fatigue-related behaviours?

RQ4. What is the relationship between heavy vehicle company awareness of CoR legislation and the driver employment types and payment methods?

RQ5. Is there a bidirectional link between company financial performance and HV crash involvement?

RQ6. Is HV company financial performance associated with other factors influencing crash involvement?

A conceptual framework was developed based on the existing research and the research gaps. It hypothesises that financial performance is related to company awareness of CoR legislation and both influence the driver employment types and payment methods. It proposes that payment methods influence safety performance based on driver employment type, and employment type and payment methods directly and indirectly influence crash involvement. Lastly, it posits a bidirectional association between financial performance and safety performance, and that financial performance is related to other factors influencing crash involvement, including driver employment type and payment methods. Based on the conceptual framework, three quantitative studies were designed to examine the research aims and questions.

Study 1 used existing case-control data on 1038 Australian long-distance heavy vehicle drivers collected by a telephone survey (cases) and face-to-face interviews (controls) in the states of New South Wales and Western Australia between November 2008 and November 2011. Cases were drivers involved in police-attended crashes during the study period and controls were drivers who self-reported to have not been involved in police-attended crashes in the previous 12 months. Three sub-studies examined the direct (Study 1a and c) and indirect (Study 1b) associations of driver employment type and payment methods with driver safety performance. Heavy vehicle drivers in Australia can be employee drivers, defined as company-employed drivers; owner drivers, defined as self-employed persons supporting the full costs of their activities; or subcontractor drivers, defined as drivers hired by companies or owner drivers for specific projects or periods. Regarding payment methods, drivers can be paid by the hour, day, or week (time-based rates) which may be supplemented by overtime pay for any extra hours or days worked when drivers are paid a fixed salary for working a specified number of hours per day or days per week. Alternatively, drivers can be paid based on the amount of work performed (piecework or performance-based payment), for instance, by the number of trips completed between a given origin and destination or the distance driven in kilometres.

Study 1a examining RQ1 showed that heavy vehicle driver employment type and payment methods directly influence crash involvement. Owner drivers have lower odds of crash involvement than employee drivers and drivers who are paid distance-based rates have higher odds of crash involvement than those paid trip or time-based rates. Then, Study 1b and Study 1c, examining RQ2 and RQ3 respectively, showed that driver employment type and payment methods might also indirectly influence crash involvement through either speed-regulation using cruise control (Study 1b) or fatigue-related behaviours such as stimulant intake, rest breaks and drowsy driving (Study 1c). Study 1b showed that while distance-based payments may encourage the use of cruise control compared to trip-based payments; they could moderate owner driver use of the device. Study 1c showed that payment method is a mediator between employment type and fatigue-related behaviours, with performance-based payments associated with the poorest performance for owner drivers.

The findings from Study 1 implied that driver employment type and payment methods may have safety implications. Time-based rates are associated with a better safety performance than distance-based rates, and outsourced drivers (owner drivers) are safer than employee drivers. Thus, Study 2 explored RQ4 examining the relationship between heavy vehicle company awareness of CoR legislation and the driver employment types and payment methods. It used existing data on 400 Australian heavy vehicle companies collected by a telephone survey in April and May 2012. It showed that a better understanding of fatigue management schemes is associated with higher odds of outsourcing the driving task and paying time-based rates to drivers. Fatigue management schemes are aimed to ensure a safer subcontracting system by requiring all the actors in the transport logistics and supply chain, including drivers, to comply with fatigue management regulations.

However, safety performance may still be poor if truck operators are not financially healthy enough to operate new equipment or adequately maintain the existing equipment; and poor safety performance may in turn adversely affect financial performance. Study 3 examined RQ5 and RQ6 using primary self-reported data on 69 Australian heavy vehicle companies collected by a telephone survey between February and October 2019. It demonstrated a bidirectional relationship between financial performance and safety performance. Moreover, financial performance is related to other factors influencing crash involvement; with companies that reported good financial performance tending to implement safety-promoting policies. They tend to be very familiar with CoR legislation and pay drivers on time basis irrespective of the distance. Good financial performers also report using employee drivers for long-distance trips, using drivers with good skills, buying new vehicles or using vehicles that are more likely to be equipped with technology, carrying livestock, refrigerated or dangerous goods, and paying performance-based rates to drivers irrespective of the distance.

There are a number of practical implications of these findings. Firstly, distance-based rates are associated with the poorest safety performance. Secondly, financial knowledge appears to be an essential factor in enhancing safety performance in the heavy vehicle industry. Thus, heavy vehicle company managers should consider taking similar training to avoid financial instability that may reduce the amount of resources devoted to safety investments. Thirdly, a better understanding of fatigue management schemes is associated with paying time-based rates suggesting that education could increase the knowledge of freight stakeholders about their respective duties formulated in the different legislations. Fourthly, company financial performance could be considered as a safety performance indicator and included in the CoR legislation. Overall, the findings of the research could inform future policy and practice by guiding both researchers and safety regulators.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

ATA	Australian Trucking Association
BITRE	Bureau of Infrastructure, Transport and Regional Economics
CA	Correspondence analysis
CC	Cruise control
CI	Confidence interval
CoR	Chain of Responsibility
ET	Employment type
FM	Fatigue management scheme
FP	Financial performance
HOS	Hours-of-service
HV	Heavy vehicle
ICC	Interstate Commerce Commission
LRT	Likelihood ratio test
MCA	Motor Carrier Act
MLR	Multinomial Logistic Regression
NHVR	National Heavy Vehicle Regulator
NRTC	National Road Transport Commission
NTARC	National Truck Accident Research Centre
NTC	National Transport Commission
OLS	Ordinary least squares
OR	Odds ratio
OSA	Obstructive Sleep Apnoea
RSR	Road Safety Remuneration
RSRO	Road Safety Remuneration Order

RSRT	Road Safety Remuneration Tribunal
SP	Safety performance
tkm	Tonne-kilometre (the transport of one tonne of goods over one kilometre)

List of Publications

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Statement of Original Authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Signature: QUT Verified Signature

Date: 28 September 2020

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Chapter 1: Introduction

The current research program aims to provide a better understanding of financial influences on safety performance in the heavy vehicle (HV) industry. This chapter provides the rationale of the research; describes the operational environment of HVs and highlights research gaps. Then, it discusses the significance of the research, states the research aim, defines research questions and outlines the scope of the research. Lastly, it defines the key research terms and summarises the chapter.

1.1 RESEARCH BACKGROUND

Following the declaration of the period 2011-2020 by the United Nations as the Decade of Action for Road Safety, world decision makers committed to halving the number of road fatalities and injuries by 2020 (World Health Organization, 2018). Notably, work-related transport safety was not identified as a priority area. Nevertheless, the number of road fatalities worldwide has increased from 1.25 million in 2013 (World Health Organisation, 2015) to 1.35 million in 2016 with almost 50 million injuries (World Health Organization, 2018). While low- and middle-income countries bear the largest burden of the world road crashes (World Health Organization, 2018), the number of fatalities and injuries is still significant in some of the high-income countries such as Australia.

Since the 1970s, Australia has significantly improved its road safety outcomes, reducing the annual fatality rate by more than 85% from 28.93 fatalities per billion passenger kilometres travelled in 1975 to 3.91 fatalities per billion passenger kilometres travelled in 2018 (BITRE, 2018, 2019d). Nevertheless, despite the continuing efforts and policies undertaken by the different road safety organisations, there is still a gap between the achievements and the objectives. The

National Road Safety Strategy for the decade 2011-2020 targeted a reduction by at least 30% in the annual numbers of fatalities and severe injuries by the end of 2020 (Australian Transport Council, 2011), although it can be argued that it would be more appropriate to use rates rather than raw numbers. Statistics from BITRE (BITRE, 2019d) show a reduction in the annual fatality rate from 4.85 fatalities per billion passenger kilometres travelled in 2011 to 3.91 fatalities per billion passenger kilometres travelled in 2018, corresponding to a decrease of only 11% in the number of fatalities. The number of serious injuries has been trending up since 2001, increasing from 114.43 injuries per billion passenger kilometres travelled to 135.24 injuries per billion passenger kilometres travelled in 2018 (BITRE, 2019d). At this pace, the predicted reduction of at least 30% in both the numbers of road fatalities and injuries is unlikely to be achieved by the end of 2020.

The National Road Safety Strategy recognised that HVs disproportionately contribute to road injuries and fatalities compared to their proportion in the national vehicle fleet. Heavy vehicles account for less than 3% of this fleet per year with rigid HVs, representing 77.6% of the total HVs (Australian Bureau of Statistics, 2019). While the total number of fatalities involving all HVs decreased by almost 14%, between June 2009 and June 2019, Figure 1.1 shows that the number of fatalities involving rigid HVs increased by 3.3% (BITRE, 2019b).

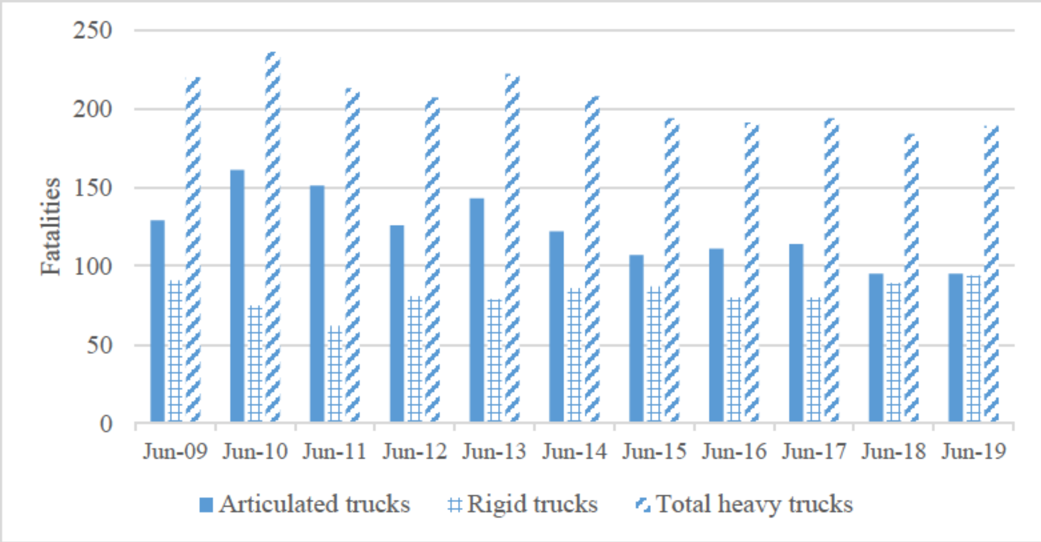


Figure 1.1 Heavy vehicle-related fatalities in Australia

Despite the decrease in HV-related fatalities, they accounted on average for 16.5% of the road fatalities per year (BITRE, 2019c) between December 2008 and December 2017. Moreover, almost 80% of the fatalities were not occupants of the heavy vehicle, as shown in Figure 1.2. Light vehicle occupants were the most affected, with 60% of the fatalities on average per year, followed by third-party road users with 20% of the fatalities on average per year. Third-party road users include pedestrians and motor and pedal cyclists.

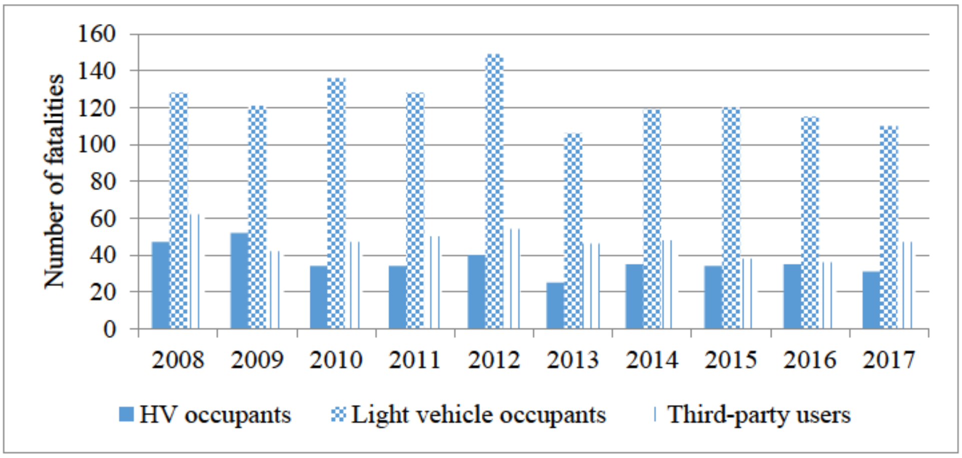


Figure 1.2 Australian heavy vehicle-related fatalities per road users

In addition to causing fatalities and injuries, HV-related crashes can be more costly and destructive in terms of property damage compared to crashes involving only light vehicles (Mayhew, Robertson, & Brown, 2015). Heavy vehicle crashes may result in damaging the cargo and in contamination of the environment when hazardous materials are spilt on roads. Crashed vehicles can block roads and result in lengthy delays for all traffic. These delays may also hamper the supply chain and result in higher operating costs for companies (Britto, Corsi, & Grimm, 2010).

1.1.1 The economic importance of heavy vehicles

The road freight sector plays a major role by connecting all the sectors of the economy. Since the year 2009-2010, the road freight sector has been generating an annual added value greater than 17 billion dollars. Thus, in terms of added value to the national economy, this sector has been among the twenty-three highest contributing sectors of the economy and the greatest contributing sector of the transport industry in the year 2019. The added value of the road sector is predicted to increase to 21.1 billion dollars by 2023-2024 (IBISWorld, 2019). Moreover, the interstate freight task, measured in tonne-kilometres (tkm) defined as the number of tonnes of goods transported over one kilometre, is projected to more than double between 2008 and 2030, increasing from 70.4 billion tkm to 159.1 billion tkm. Over the same period, the freight task within capital cities is projected to increase from 40.2 billion tkm to 66.6 billion tkm, while freight task in the rest of the country is expected to rise from 80.7 billion tkm to 116.1 billion tkm (BITRE, 2010). Altogether, the national road freight task is projected to increase by almost 56% between 2018 and 2040 (BITRE, 2019a) with more than 95% of the goods being carried in HVs by 2050 (Australian Logistics Council, 2014). The importance of the freight sector to the national economy combined with the increased projections in freight task imply increased traffic for HVs and constitute significant challenges for road safety decision makers if adequate preventive actions are not taken.

1.2 OPERATING CONTEXT OF AUSTRALIAN HEAVY VEHICLES

There are minimal barriers to entry into the HV industry in Australia. The possession of a registered truck and the appropriate driving licence is sufficient to operate in the Australian freight transport sector (Beesley, 2016; Jones, 2015; Walker, 2012). Operating a HV is not subject to business licensing as is the case in countries such as Canada, the UK and the United States (Boylaud & Nicoletti, 2001; Mooren & Grzebieta, 2010; NTC, 2015). This relatively easy entrance has resulted in a large number of HV operators and intense competition between carriers. Thus, some HV companies use third-party drivers to improve profit margins (NTC, 2008; Quinlan, Johnstone, & Mayhew, 2006).

1.2.1 Institutional responsibilities for heavy vehicle safety in Australia

In Australia, the Federal Government has responsibility for vehicle standards and importation requirements and the individual states are responsible for most regulations and enforcement relating to vehicle registration and use. For example, the Australian Design Rule 65/00 requires that all HVs weighing 12 or more tonnes gross vehicle mass manufactured on or after January 1991 be fitted with speed limiters set to a maximum of 100 km/h. Enforcement of this requirement is the responsibility of state governments. The speed limit for particular sections of roads or types of vehicles is also a state responsibility. Thus, South Australia and the Northern Territory set a speed limit of 90 km/h for road trains (NTC, 2016).

Given that many HVs operate across state boundaries, several organisations have been established to work towards uniform approaches among the states. The National Transport Commission (NTC), formerly known as National Road Transport Commission (NRTC), is the leading organisation in the reforms of the national land transport to support the Australian governments to enhance safety, productivity, environmental performance and regulatory efficiency. The NTC established the National Heavy Vehicle Regulator (NHVR) in 2013 to develop regulations about all vehicles weighing more than 4.5 tonnes. The NHVR designs HV national laws and reforms to establish a national framework for assisting and regulating the use of HVs in order to promote public safety, monitor the effect of HVs on the environment, road network and public facilities; stimulate the productivity and efficiency of HVs in the road transport of commodities and passengers (NTC, 2019).

Some non-governmental organisations also contribute to HV safety. National Truck Insurance (NTI), Australia's largest truck insurer, produces biennial reports on crashes involving trucks insured by the company through its research centre, the National Truck Accident Research Centre (NTARC). These reports classify the crashes based on several factors such as the cause (e.g. speeding, fatigue, mechanical failure) and the estimated financial losses of the crash (e.g. major crashes cause financial damages greater than $50,000) (NTARC, 2017). The Australian Trucking Association (ATA) aims to provide a safer working environment for the trucking industry (ATA, 2016). NTI cooperated with the ATA to establish the TruckSafe voluntary industry accreditation scheme (NTARC, 2019). TruckSafe requires operators to provide documentation showing that they have safe workplaces, and well-maintained vehicles driven by healthy and trained drivers (ATA, 2019).

1.3 COMPANY FACTORS INFLUENCING SAFETY

Outsourcing the driving task provides several advantages to the outsourcing companies. It increases flexibility by creating and expanding services to meet customer demand without hiring new drivers (Mayhew & Quinlan, 1997). Outsourcing is beneficial to carriers servicing large geographical areas where there are several supply chains to be serviced because they often use drivers other than their own employees to alleviate the complexities associated with managing drivers throughout the supply chain (Cantor, 2016). Outsourcing can provide access to specialised technology that the company ordinarily does not possess (Belcourt, 2006; Cantor, 2016).

Nevertheless, the use of third-party drivers may jeopardise the business of the outsourcing companies (Mayhew & Quinlan, 1997). The subcontracted drivers are often paid based on the amount of work performed, and due to competition for work, they may underbid, which, combined with performance pay, may divert attention from safety and encourage risky driving behaviours (Hensher & Battellino, 1990; Hensher, Battellino, Gee, & Daniels, 1991; NTC, 2008). Moreover, the presence of many subcontractors may create a more segmented and complex work environment that is not easy to manage, and the outsourcing companies may not consider the consequences of their decisions on safety outcomes (Cantor, 2016). Thus, the cargo may be carried in a supply chain composed of several subcontracting parties. At each level of this chain, the involved party takes part of the profit margins and passes on the tight contract to the next level. At the end of the chain is the least powerful party composed of drivers who undergo the adverse effects of the profit dilution in the supply chain (Quinlan, 2001), motivating them to speed, work extended hours and become vulnerable to fatigue, crash risk and other occupational health safety issues such as injuries, diseases, and mental health (Johnstone, Nossar, & Rawling, 2015; Quinlan & Wright, 2008; Williamson & Friswell, 2013).

Safety efforts in the HV industry have mostly focused on regulating speeding (Haworth & Rowden, 2006; NTARC, 2015; Quinlan & Wright, 2008), fatigue and its likely contributing factors, such as excessive driving, drug use and having inadequate sleep patterns (Safe Work Australia, 2014; Williamson, Friswell, & Sadural, 2001).

However, in the early 1990s, research suggested that strategies to control speed and fatigue-related behaviours cannot sufficiently and adequately deal with road safety issues because they assume that safety is solely the responsibility of the drivers (Hensher & Battellino, 1990; Hensher, et al., 1991). However, drivers are themselves frequently influenced by their employees and customers. In response, the National Transport Commission (NTC) introduced the Chain of Responsibility (CoR) legislation in the transport logistics and supply chain. Under the CoR legislation, all parties in the transport logistics and supply chain, not just the driver, have a responsibility to prevent driver fatigue and ensure that the driver complies with the hours-of-service (HOS) regulations, speed, vehicle mass and dimensions limits (NTC, 2007b, 2012a; The Chain of Responsibility Taskforce, 2014). There is credible evidence that the CoR legislation has improved road safety in the HV industry (BITRE, 2019c; NTC, 2019). Nevertheless, speed and fatigue remain the most significant contributing factors to HV-related fatal crashes (Jones, 2015; Mooren, 2016; Stern et al., 2018), each being, for instance, the main reason for more than 20% of the National Truck Insurance insured truck major crashes. Major crashes are crashes that cause damages evaluated to more than $50,000 (NTARC, 2017).

It appears that HV companies may reduce safety investment (e.g. technology adoption, vehicle maintenance, driver training) and adopt payment policies that implicitly pressure drivers to work faster (Caskey & Ozel, 2017). The logic, as described by Baker (1985) in Chow (1989, p. 220) is as follows:

> The only way for a marginal carrier to stay in business ... is to cut costs and there are few places to cut costs in motor freight operations. Fuel prices are market set, and fuel usage is, in large part, a function of new technology and maintenance, either of which costs money. The only alternative is to run older equipment, pay less in wages, work drivers longer, and/or skimp on maintenance.

Attempts to reduce the adverse effects of financial pressure and those of its associated drawbacks on the HV industry are likely to have limited impacts so long as the subcontracting system which is believed to be the impetus for performance-based payments is not considered (Mayhew & Quinlan, 1997). Thus, Hensher and Battellino (1990) and Hensher, et al. (1991) suggested that the actual reasons for HV driver unsafe behaviours and fatigue could be understood by examining the HV industry as a whole through its financial structure, the different pressures that may contribute to the undesired road safety outcomes and the economic rewards linked to the whole industry. To date, there has not been such a comprehensive evaluation of the financial influences on road safety outcomes in the HV industry.

In sum, the financial structure of HV companies affects their safety investments and practices in terms of driver employment type and payment methods. Due to financial pressure, companies tend to reduce safety investments, subcontract the driving task and motivate drivers to work longer and faster through performance-based payments. Thus, conceptually as shown in Figure 1.3, this research program examines the associations of the driver employment type and payment methods with safety performance. Then, it examines the associations of financial performance with driver employment type and payment methods, safety investments and safety performance.

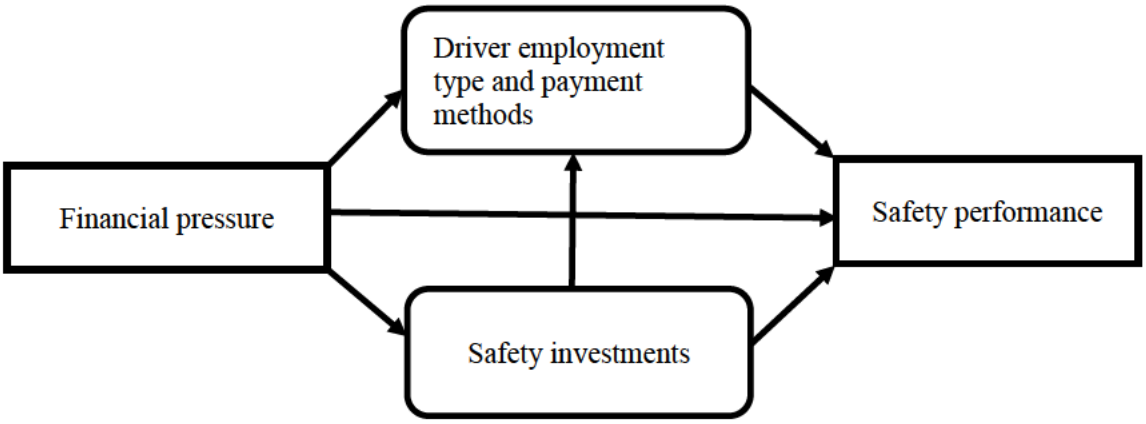


Figure 1.3 Conceptual scheme of financial influences on safety performance

1.4 RESEARCH GAPS

Further description of the research gaps is provided in Chapter 2. This section reports a summary of these gaps. Few empirical studies exist examining the financial influences of HV companies on safety outcomes. These studies were conducted using US data and provided mixed findings. They all looked at the direct financial influences on safety outcomes, ignoring the financial influences on some of the critical intervening factors that could influence safety outcomes. Moreover, none of the previous studies assessed the bidirectional relationship between financial status and safety outcomes. Britto, et al. (2010) hypothesised that poor safety performance could negatively affect company business by damaging its reputation; resulting in the company losing customers and failing to attract new business partners and skilled drivers.

To summarise, it appears that a comprehensive and consistent understanding of the financial influences of HV companies on road safety outcomes is lacking.

1.5 SIGNIFICANCE OF THE RESEARCH

The road freight transport industry significantly contributes to the Australian economy. Nevertheless, HVs, which are predicted to conduct most of the freight task, disproportionately account for road fatalities. This poor safety performance is likely to worsen with increasing freight task. The HV industry is under financial pressure and this appears to be threatening safety performance. Gaining a better understanding of the relationship between financial pressure and HV safety performance could inform future policy and practice by providing guidance to both researchers and safety regulators who implement and monitor policies aimed to improve HV safety.

1.6 RESEARCH AIM AND QUESTIONS

The aim of this research is to develop a better understanding of the mechanisms through which financial pressure influences road safety outcomes within the Australian heavy vehicle industry. Specifically, the research firstly examines the safety impact of driver employment type and payment methods and their relationships with the CoR legislation designed to improve safety in the HV industry. Then, it examines the association between the financial performance of companies and factors, including driver employment type and payment methods that are likely to influence the safety performance of these companies.

The research questions designed to achieve these objectives are provided below. The literature review showed that performance-based payments are associated with poor safety performance. However, little research has examined the effects of the possible underlying reason (employment type) on safety, and the findings are mixed. Moreover, this research did not include payment methods. Research questions 1, 2 and 3 (RQ1, RQ2 and RQ3) examine either the direct or the indirect association of HV driver employment type and payment methods with safety outcomes such as crash involvement, speeding and fatigue.

RQ1. Are HV driver employment type and payment methods associated with crash involvement?

RQ2. Are HV driver employment type and payment methods related to driver use of cruise control (a speed regulation device)?

RQ3. Do HV driver payment methods mediate the relationship between driver employment type and fatigue-related behaviours?

The subcontracting of the driving task and driver payments methods are major factors that influence driver safety performance in the HV industry. The CoR legislation was introduced to mitigate the adverse effects of the subcontracting of the driving task and driver payment methods in the HV industry. Nevertheless, examinations of the association of the CoR legislation with employment type and payment methods are missing. Research Question 4 (RQ4) focuses on this gap.

RQ4. What is the relationship between HV company awareness of CoR legislation and the driver employment types and payment methods?

The literature review showed that driver employment type, payment methods, market segment, vehicle condition (age, maintenance, technology adoption and its usage) and awareness of the CoR legislation are factors that could significantly affect road safety outcomes. The financial health could affect road safety outcomes either directly or indirectly through these factors. Research Questions 5 and 6 (RQ5 and RQ6) are related to these direct and indirect relationships, and the causal association between financial performance and safety performance.

RQ5. Is there a bidirectional link between company financial performance and HV crash involvement?

RQ6. Is HV company financial performance associated with other factors influencing crash involvement?

1.7 SCOPE OF THE RESEARCH

This program of research examines company financial influences on heavy vehicle safety performance. The studies undertaken are limited to Australia, although international literature was reviewed. While the term heavy vehicle applies to buses and trucks weighing more than 4.5 tonnes gross vehicle mass, the current research program excludes buses. It includes both intra-state and interstate and short and long-distance operations (although Study 1 is restricted to trucks of more than 12 tonnes gross vehicle mass on trips of more than 200 kms). While safety incidents for heavy vehicle drivers include falls and other occupational injuries, the focus of this research was on road crashes on public roads. Safety performance is measured in terms of police-attended crash involvement and the perceptions of company representatives about the safety performance of companies. Likewise, financial performance is measured by the perception of company financial health. Objective measures of financial performance were not collected. Objective measures of financial performance may not be available because of, for instance, poor reporting by companies or their unwillingness to disclose sensitive information (Vij & Bedi, 2016). Subjective measures have the advantage of providing information on overall performance, rather than individual objective measures (Santos & Brito, 2012). Importantly, research has reported high degrees of positive association between the subjective measurements of a performance indicator and its objective measurements (Wall et al., 2004).

1.8 KEY RESEARCH TERMS

This section defines several important terms to the understanding of the research.

1.8.1 Heavy vehicle

In this research, HVs refer to trucks weighing more than 4.5 tonnes gross vehicle mass used to carry freight as specified by the National Heavy Vehicle Regulator in Australia. The first two studies of the research program respectively are restricted to drivers and companies operating trucks of at least 12 tonnes while the third study includes companies operating trucks weighing more than 4.5 tonnes. Fatigue management legislation applies only to trucks weighing 12 tonnes or more (Jones, 2015) because they are the most likely to be operated for long-distance trips (>200 km from the base). Fatigue management legislation, as discussed in the literature review chapter, is aimed to ensure that all parties in the transport logistic and supply chain, not just the driver, have responsibility to ensure that no drives while fatigued (NTC, 2012b).

1.8.2 Road safety outcomes

According to Koornstra, Lynam, and Nilsson (2002), road safety outcomes can be measured in terms of social costs, final outcomes or intermediate outcomes.

1.8.2.1 Social costs

The social costs are the monetary value of the final outcomes (defined in the next section). They include the total costs that the crashes impose on the whole society and give an overview of the consequences of road crashes on the economy and human well-being (Wijnen & Stipdonk, 2016). Social costs and final outcomes are the most critical outcomes in road safety (Nafukho, Hinton, & Graham, 2007).

1.8.2.2 Final outcomes

The final outcomes are composed of the number of crashes and their associated injured and killed. They are considered final outcomes because they are the results of the risk conditions called intermediate outcomes (defined in the next section) (European Transport Safety Council, 2001). Final outcomes are the most conventional indicators used to measure road safety outcomes (Eksler, 2010; Morsink, Oppe, Reurings, & Wegman, 2007; Suhana & Hussain, 2013). The number of crashes is the most useful indicator to assess road safety performance. As data on this variable is managed by the police, there are generally fewer political disputes over the results compared to the results from other indicators (Han, 2016). However, information about the injured, particularly in less severe crashes, is often missing due to incompleteness, underreporting or data management deficiencies (Eksler, 2010). Due to these deficiencies, only the number of fatal crashes and associated fatalities are often collected (Wilmots, Hermans, Brijs, & Wets, 2010).

Nevertheless, while social costs and final outcomes can help identify the best road safety performers, they do not highlight the reasons nor give information about the actions that should be undertaken to enhance safety performance (Al-Haji, 2007). For instance, the number of crashes does not reveal anything about their influencing factors. Thus, it does not give any information about the countermeasures to improve road safety (Assum & Sørensen, 2010; Hermans, Brus, & Wets, 2008; Hermans, Van den Bossche, & Wets, 2009; Holló, Eksler, & Zukowska, 2010; Karanikas, 2016; Kukić, Lipovac, Pešić, & Rosić, 2016; Wegman et al., 2008).

1.8.2.3 Intermediate outcomes

The intermediate outcomes characterise the risk conditions that result in the final outcomes and provide precise clues to policymakers about the type of actions needed to efficiently develop the road safety system of an organisation (Hermans, et al., 2008; Wegman, et al., 2008). The most frequently used indicators to measure road safety performance are related to safety behaviours such as speed levels, drink driving, and seat belt and helmet usage rates. These indicators are often supplemented by some quality indicators related to road networks, vehicle fleets or emergency services. They all offer a more straightforward way to manage the effects of policy and allow an early design of targeted countermeasures. They also enable a deeper understanding of the causes of safety issues than is possible by considering only the number of crashes (Arsénio et al., 2009; European Transport Safety Council, 2001).

1.8.3 Financial performance

Financial performance is a measurement of how well a company can use its own resources to generate further income (Knight & Bertoneche, 2000). The examination of the financial performance of a company helps identify the factors that favour or hinder its growth (Hatem, 2014). The indicators used to assess this performance can be grouped into four categories: profitability ratios, leverage ratios, efficiency ratios and liquidity ratios (Chow, 1989; Knight & Bertoneche, 2000).

The profitability ratios are the most used and refer to a company ability to generate higher revenues than the expenses to ensure its shareholders that it can face management-related potential risks (Knight & Bertoneche, 2000). The leverage (also called financial) ratios are the next most used indicators and designate the company long-term capacity to finance debts. The efficiency indicators are used to explore how well the capital is utilised in a company. They primarily focus on the extent of the business created by the capital rather than on the benefit directly. Then, liquidity ratios show a company capacity to face short-term debt obligations. Table 1.1, adapted from Knight and Bertoneche (2000), summarises the different financial indicators, including their mathematical formula and their relationship with financial performance.

There is no conclusive evidence of which measurement performs better than others and research on the degree to which any of them outweighs the others is still limited (Venanzi, 2011). In the road safety area, cash flow-based measurements are considered as an appropriate basis for assessing financial performance because they take into account investment necessities, corporate tax and depreciation issues in a rational way (Beard, 1992; Miller & Saldanha, 2016; Rodríguez, Rocha, & Belzer, 2004).

Table 1.1 Summary of financial health outcomes

Category	Indicator	Formula	Relationship with financial performance
Profitability	Profit margin	$\frac{Net\ income}{Revenue}$	Positive
	Gross margin	$\frac{Profit\ margin}{Revenue}$	Positive
	Return on assets	$\frac{EBIAT^{*}}{Total\ assets}$	Positive
	Return on investment	$\frac{Net\ income}{Total\ assets}$	Positive
	Cash flow return on assets	$\frac{Cash\ flow}{Total\ assets}$	Positive
	Return on equity	$\frac{Net\ income}{Total\ equity}$	Positive
Leverage	Debt ratio	$\frac{Debt}{Total\ assets}$	Negative
	Debt equity	$\frac{Debt}{Equity}$	Negative
	Leverage	$\frac{Total\ assets}{Equity}$	Positive
	Interest coverage	$\frac{EBIT^{**}}{Interest\ paid}$	Positive

Efficiency	Asset turnover	$\frac{Revenue}{Total\ assets}$	Positive
	Days sales in receivables	$\frac{Trade\ receivables}{Sales}$	Negative
	Inventory days	$\frac{Inventories}{Average\ cost\ of\ sales\ per\ day}$	Negative
Liquidity	Current ratio	$\frac{Current\ assests}{Current\ liabilities}$	Positive
	Quick ratio	$\frac{Quick\ assets}{Current\ liabilities}$	Positive
	Payable days	$\frac{Trade\ liabilities}{Average\ purchases\ per\ day}$	Negative

*EBIAT: Earnings before interest after tax; **EBIT: Earnings before interest and tax

Source: Adapted from Knight and Bertoneche (2000)

1.8.4 Heavy vehicle driver employment type

According to the National Transport Commission (NTC, 2012b), heavy vehicle drivers in Australia are generally classified as employee drivers, owner drivers and subcontractors. Employee drivers, as the name indicates, are employed by companies, which provide vehicles and support the costs related to their operations. Owner drivers are self-employed businesspersons who possess their own vehicles, fully support the costs of their equipment and fuel and carry freight on a contractual basis either with companies or directly with clients. Subcontractor drivers do not possess any HVs and are hired by HV companies or owner drivers for specific tasks or periods. In practice, some drivers may move between the different employment categories, changing their employment types accordingly, and companies may simultaneously engage drivers from all employment categories.

1.8.5 Heavy vehicle driver payment methods

Heavy vehicle drivers can be paid per unit of time (hour, day or week) worked which may be supplemented by an overtime pay for any extra hours or days worked when drivers are paid a fixed salary for working a specified number of hours per day or days per week. Alternatively, drivers can be paid based on the amount of work performed (piecework or performance-based payment), for instance, by the number of trips completed between a given origin and destination, the distance driven in kilometres, the load carried or a percentage of the income earned (Mooren et al., 2014). Time-based payments, unlike performance-based payments, are likely to also cover non-driving tasks.

1.8.6 Chain of Responsibility

The CoR legislation is a regulatory framework applied to vehicle's mass, load, dimension, speeding, fatigue and vehicle accreditation of operations involving vehicles weighing more than 4.5 tonnes, except fatigue regulations, which concern vehicles of 12 tonnes and more (Jones, 2015). This legislation was introduced by the National Transport Commission in 1997 in the Australian transport logistics and supply chain (NTC, 2015). It has progressively been improved to minimise and manage the adverse effects of intense competition on the HV industry. It stipulates that

> …all who have control, whether direct or indirect, over a transport operation bear responsibility for conduct which affects compliance should be made accountable for failure to discharge that responsibility (Carslake, Cureton, & Potter, 2012, p6).

The application of the CoR legislation is not limited to the federal regulations. The participating jurisdictions have derogated from the national rules, making local variations in the application of the legislation (NTC, 2019), as discussed in Chapter 2.

1.9 THESIS OUTLINE

The remaining document is structured as follows.

Chapter 2 is devoted to the literature review. It provides a discussion of the factors affecting HV crashes. Then, it describes research connecting financial performance, driver employment type and payment methods to safety outcomes. Finally, it proposes a conceptual framework for the whole research, identifies research gaps, states the aims and restates research questions.

Chapter 3 describes the methodologies of each study and reports the ethical considerations.

Chapter 4 documents Study 1 which addresses the first three research questions regarding the direct and indirect connection of driver employment type and payment methods with safety outcomes. It is divided into three sub-studies. Study 1a evaluates the direct association of driver employment type and payment methods with crash involvement (RQ1). Study 1b assesses if driver employment type and payment methods could indirectly influence crash involvement through the use of a speed regulation technology—cruise control (RQ2). Study 1c explores whether payment methods could be mediators between driver employment type and fatigue-related behaviours (RQ3).

Chapter 5 documents Study 2 which focuses on RQ4, which relates the CoR legislation to driver employment type and payment methods.

Chapter 6 documents Study 3 which answers RQ5 and RQ6 that connect financial performance either directly or indirectly to safety outcomes and the bidirectional link between financial performance and safety outcomes.

Chapter 7 discusses the findings of the research, highlights the limitations, strengths and suggests some directions for future research.

Chapter 8 presents the conclusions.

1.10 CHAPTER SUMMARY

This chapter contextualised the research. It showed that, despite the impressive progress Australia has made to improve road safety, there is still a significant gap between the achievements and the objectives. Heavy vehicles are significant factors that widen this gap because of their disproportionate representation in the number of fatalities. Research suggested that a comprehensive and consistent examination of the financial influences of HV companies on safety performance could help improve safety in the HV industry. This chapter introduced the context, aim, research questions and significance of the research and presented the different studies that were designed to answer the research questions. The next chapter presents the literature review.

Chapter 2: Literature review

2.1 INTRODUCTION

Heavy vehicles are major contributors to road trauma (Mooren, et al., 2014). Crashes involving heavy trucks are likely to result in more fatalities and severe injuries to third-party road users than those involving light vehicles (Litchfield, 2017) and disrupt the functioning of both the supply chain and traffic (Cantor, Corsi, & Grimm, 2009). These larger damaging effects motivate research into the factors contributing to HV crashes.

Research about truck crash contributing factors has mostly focused on driver-related factors. This approach has been criticised on the grounds that it considers that drivers are solely responsible for the poor safety performance. Truck companies' practices such as safety investments, subcontracting of the driving task and driver payment methods may be important factors that favour poor driver performance. This chapter presents HV crash contributing factors and examines the association of the above-mentioned company practices with these factors before presenting the coping solutions (legislative approach) to improve HV safety. The chapter ends with a formulation of the conceptual research framework, a highlight of the research gaps, a formulation of research questions and objectives, and a summary of the chapter.

2.2 FACTORS CONTRIBUTING TO HEAVY VEHICLE CRASHES

The factors that contribute to truck crashes are generally classified as driver, vehicle and environment-related (Cantor, Corsi, Grimm, & Özpolat, 2010) as shown in Figure 2.1. The driver is characterised by different traits which can be health and mental conditions; and states which can be sleep patterns, fatigue and mood. The environmental factors comprise roadway features, the weather and other road users while vehicle factors are the vehicle configuration, its mechanical state and its safety equipment (Cantor, et al., 2010; Knipling, 2011a; Panel on Research Methodologies and Statistical Approaches to Understanding Driver Fatigue Factors in Motor Carrier Safety and Driver Health, 2016).

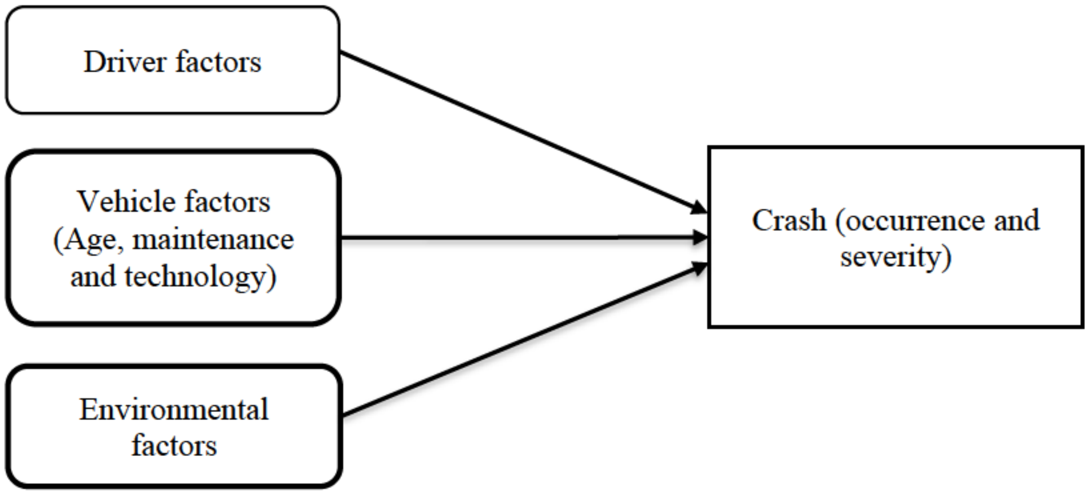


Figure 2.1 Classification of the key causes of heavy vehicle crashes
(Source: Cantor, et al., 2010)

The driver-related factors, in sum, include speeding, fatigue and its contributing factors, and driver mental, physical, and sociodemographic characteristics. The set of factors related to the vehicle includes vehicle type, vehicle defects and the quality of the vehicle equipment (which may be related to the age of the vehicle and its maintenance) while environmental factors are related to elements such as the road, weather conditions and the other road users. In addition to influencing crash likelihood, some of these factors such as speeding (Choi, Oh, & Kim, 2014; Dong, Dong, Huang, Hu, & Nambisan, 2017; Hao et al., 2016), fatigue (Hao, et al., 2016), road pavement (Cerwick, Gkritza, Shaheed, & Hans, 2014; Hao, et al., 2016), bad weather (Cerwick, et al., 2014; Dong, et al., 2017; Dong, Richards, Huang, & Jiang, 2015; Hao, et al., 2016), driver age (Cerwick, et al., 2014; Dong, et al., 2017), road lighting (Dong, et al., 2017), and road geometric design (Chu, 2012) also affect crash severity. The crash severity refers to the outcome of the crash in terms of injury level, such as no injury, minor injury, major injury or fatal injury.

As described in the introductory chapter, HV companies under financial pressure are likely to operate old equipment and adopt payment policies that encourage drivers to work longer and faster. Thus, understanding the associations of driver fatigue, speeding and vehicle condition with HV crash involvement is of paramount importance for the research program. A description of the relationship between these three factors and crash risk is presented below.

2.2.1 Driver fatigue

Fatigue is a serious issue in the HV industry because it greatly contributes to road crashes in the sector. Despite the difficulty in identifying whether fatigue contributed to individual crashes, fatigue is acknowledged as an important contributor to HV crashes (Attewell, Lock, Dobbie, & Walker, 2001; Connor, Whitlock, Norton, & Jackson, 2001; Haworth, Triggs, & Grey, 1988; Lal & Craig, 2001; NRTC, 2001; Phillips, 2014; Williamson et al., 2011). Fatigue manifests itself by a reduced alertness, inadequate judgment, drowsy driving, falling asleep at the wheel, poor memory, mood change, poor speed and lane control, and less engagement with the driving environment that ultimately increases crash risk (Haworth & Rowden, 2006; NTC, 2007b; Saltzman & Belzer, 2007). The Fatigue Expert Group of the National Road Transport Commission (NRTC), the Australian Transport Safety Bureau and the New Zealand Land Transport Safety Authority (NRTC, 2001) designed a framework, as shown in Figure 2.2, to summarise the work- and driver-related factors that contribute to truck driver fatigue. Initiatives to mitigate driver fatigue and manage the different elements that can improve the HV industry safety have been designed in the

Chain of Responsibility Legislation (CoR) legislation which is described later in this research.

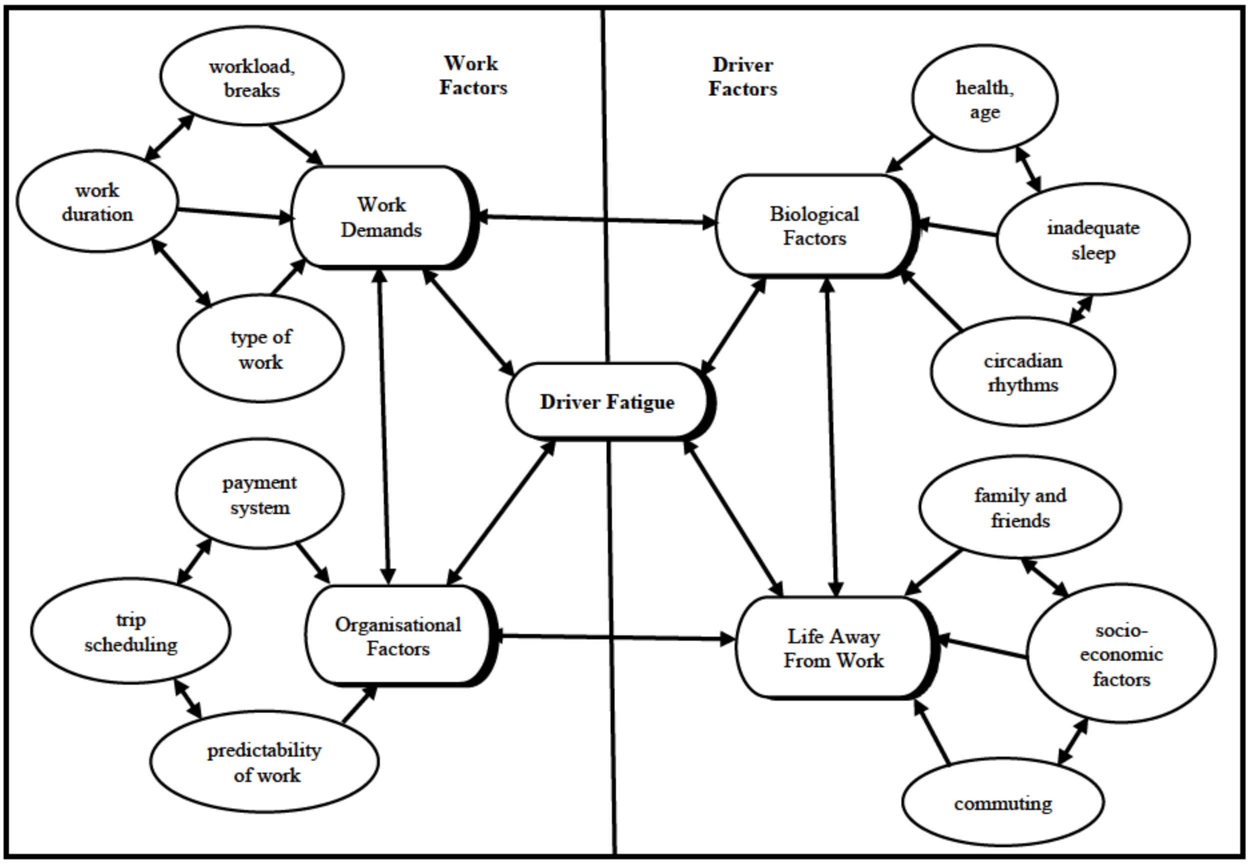


Figure 2.2 Factors affecting heavy vehicle driver fatigue
(Source: NRTC, 2001)

The Fatigue Expert Group highlighted three reasons why fatigue is an important road safety issue for HV transport operators. Firstly, crashes involving HVs are frequently more severe than those that do not involve HVs. In multiple vehicle crashes, the risk of injuries and fatalities is higher for the non-HV occupants. Secondly, long-distance HV driving job is more associated with driving under the effects of stimulants, speeding and other undesired road safety behaviours than other driving jobs. Thus, fatigue contributes to many HV at-fault crashes. Lastly, fatigue can affect HV driver health because it has long-term adverse effects on the human body.

Figure 2.2 shows that fatigue is the result of an interaction between driver- and work-related factors. For instance, the payment systems such as distance-based payments are associated with uncertainty in driver earning and may encourage stimulant intake, driving extended hours without rest breaks and the self-imposition of tight schedules (Crum, Morrow, Olsgard, & Roke, 2001; Morrow & Crum, 2004; Sallinen & Hublin, 2015). A major cause of truck driver fatigue is the unbalanced working schedules. Extended driving time generally directly or indirectly results in circadian rhythm effects, sleep deficiency, and time-on-task fatigue, and thus in cumulative fatigue (Amundsen & Sagberg, 2003; Hege et al., 2015; Stevenson et al., 2014). Due to the irregularity and tightness in work schedules, drivers often do not have time to enjoy healthy diets and practise sport (Boeijinga, Hoeken, & Sanders, 2016). This may increase the risk of physical and mental exhaustion and can result in poor health (Boeijinga, et al., 2016; Boyce, 2016), which also impairs driving performance (NTC, 2007b). If the non-driving tasks such as loading and unloading and the associated time are not paid, drivers may be tempted to drive longer hours, and this is likely to increase the likelihood of fatigue (Williamson & Friswell, 2013). Distance-based payments, in addition to encouraging fatigued driving, also encourage speeding.

2.2.2 Speeding

Speeding commonly refers to travelling faster than the posted speed limit or driving at a speed that is not suitable for the conditions (Willis & Gangell, 2012). At higher speeds, the time to react to events is shorter and reduces the manoeuvrability. Thus, speeding increases crash occurrence and its severity (Aarts & Van Schagen, 2006; Watson, Watson, Siskind, & Fleiter, 2009). Mooren, et al. (2014) estimated that the full compliance of Australian HV drivers with speed limits would be associated with a 29% reduction in HV crashes.

Speeding is one of the major contributing factors to crashes in the Australian HV industry (Friswell, Irvine, & Williamson, 2003; Mooren, et al., 2014). It was coded as responsible for 14.8% of major crashes in 2017 that were analysed in the National Truck Insurance Major Accident Investigation report (NTARC, 2019). A survey of some Australian HV drivers showed that they tended to view speeding as reasonably safe. Those paid distance-based rates were more likely to drive faster because the distance was viewed as a source of income. Those who considered speeding as dangerous tended to drive more safely (Edwards, Davey, & Armstrong, 2016).

2.2.3 Vehicle defects

Vehicle failures influence crash occurrence and severity. The likelihood of failures is related to the age and maintenance level of the vehicle fleet. Timely maintenance increases the lifespan of vehicles and reduces the risk of failure. It also helps to identify the defects before they turn into a safety hazard (Chow, 1989). Though there is still a need for further investigation on the effects of vehicle inspection (Mooren, et al., 2014) and vehicle mechanical conditions on crash risk in the trucking industry (Blower, Green, & Matteson, 2010), it has been widely reported that inadequately maintained vehicles are related to a higher crash risk (Al-Bulushi et al., 2015; Assemi & Hickman, 2016; Corsi, Fanara, & Jarrell, 1988; Knipling, 2011b). In an examination of the link between the mechanical conditions of large trucks and crash risk in the United States, drivers who had had one or more vehicle condition violations had crash likelihoods that were 1.7 times higher than those who had not committed any violation (Blower, et al., 2010). In a similar study, also using US large truck data, Teoh, Carter, Smith, and McCartt (2017) found vehicle defect violations to be related to high crash risk.

Fatigue, speeding and vehicle condition are critical issues in HV safety analysis, and further research is required to reduce their safety damages (Marcus & Rosekind, 2017). The financial pressure that HV companies undergo is hypothesised to be one of the critical factors that increase the likelihood of speeding, fatigued driving and vehicle defects, and thus result in poor safety performance. This poor safety performance may, in turn, undermine the financial situation of companies leading to a causal relationship between financial performance and safety performance.

2.3 CAUSAL CONNECTIONS BETWEEN FINANCIAL PERFORMANCE AND SAFETY PERFORMANCE

Financially distressed HV companies may be encouraged to reduce the amount of investment devoted to the equipment maintenance or inspection and other safety aspects such as driver training and payments or to undertake actions that are not favourable to safety (Chow, 1989). Similarly, a poor safety performance can undermine the reputation of a company, hinder its production process, create economic and opportunity costs, and may result in poor financial performance (Argilés-Bosch, Martí, Monllau, Garcia-Blandón, & Urgell, 2014; Zyglidopoulos, 2001). Thus, financial performance can influence safety performance, which in turn can influence financial performance.

2.3.1 Effects of financial performance on safety performance

Research about the influence of financial issues on safety performance in the trucking industry began in the United States in the 1980s. Before 1980, the Interstate Commerce Commission (ICC) regulated interstate freight transport in the United States (Corsi & Fanara, 1988; Corsi, et al., 1988). The ICC subjected the transport of each type of freight from one specific origin to another specific destination to the deliverance of a certificate. The ICC also controlled pricing and routes enabling the carriers operating nationwide to make benefits regardless of cost structures (Boyer, 1993; Francia, Porter, & Sobngwi, 2011). Nevertheless, in the early 1980s, there were numerous large retailers and grocery wholesalers who needed goods to be carried from factories to other destinations all over the country. Just-in-time deliveries became common and enabled manufacturers and retailers to decrease inventory costs and enhance their financial performance. A high number of interstate carriers were accordingly needed to carry goods. Thus, ICC regulations were criticised on the grounds that they led to inefficiency in the freight transport industry (Francia, et al., 2011). In response, Congress passed the Motor Carrier Act of 1980 (MCA) to deregulate the interstate freight carrying activity by removing the restrictions and, accordingly, ease the entrance of new interstate operators. The MCA changed the operating environment of the trucking industry across the country. In the five years following the MCA, the number of ICC-authorised carriers more than doubled (Corsi & Fanara, 1988; Scheraga, Haslem, & Corsi, 1994; Silverman, Nickerson, & Freeman, 1997). This resulted in increased competition among carriers leading companies to underbid, reduce safety investments and pressure drivers to work faster (Boyer, 1993; Chow, 1989; Corsi & Fanara, 1988).

The literature about financial influences on safety performance addresses two main topics: the relationship between financial performance and safety performance and the relationship between driver payment and safety performance (Mooren, Williamson, & Grzebieta, 2015).

This section focuses on studies connecting financial performance to safety performance in the trucking industry. A comprehensive search was conducted to identify peer-reviewed journal articles and grey literature dealing with this connection.

Studies considered in the review were papers written in English connecting any measurement of financial performance (profitability ratio, efficiency ratio, leverage ratio or liquidity ratio) to any safety outcome (social costs, intermediate or final). A search was conducted on four electronic databases (Google Scholar, Science Direct, Transport Research International Documentation, and Proquest) using the following terms (financial* or profitability*) and (safety* or crash* or accident*) and (truck* or heavy vehicle* motor carrier*). A total of 11 studies met the inclusion criteria. A summary of these studies, all conducted using US data, including the authors; the financial and safety performance variables; the sample; the model and the outcomes is presented in chronological order in Table 2.1. Some studies were conducted within a cross-sectional framework while others were conducted using longitudinal data.

2.3.1.1 Cross-sectional studies

Corsi (2004) assessed the link between financial performance and safety performance using bivariate correlations and did not find any relationship between financial performance and safety performance. However, this analysis was not performed within a multivariate context. Bivariate correlations do not allow the inclusion of confounding factors that can capture the complexity of the link between the compared factors (Britto, et al., 2010). Corsi, et al. (1988), in a before-and-after deregulation (of the US trucking industry) analysis, ran separate linear regressions using two non-overlapping cross-sectional data sets. In addition to financial performance, the regression included six other management policy variables. The findings showed that financial performance was not significantly associated with crash rates in the pre-deregulation period while it was significantly associated with lower crash rates in the post-deregulation period. Thus, the authors recommended that financial performance should be considered in truck safety analyses.

The profitability of past periods may influence the safety level of the current period. While Corsi, et al. (1988) did not test this assertion, Bruning (1989) included two lags for financial performance measured by the operator's profitability. The profitability, its lags and other explanatory variables related to the driver, the equipment and the weather were regressed, in a log-linear regression, on a crash rate.

Altogether, six equations were estimated based on the commodity types and the operator size. The estimates suggested that contemporaneous profitability was significantly negatively associated with crash rates for the whole sample and the subsamples of general freight, specialised freight and large size operators. The two lagged profits (profit of 1980 and profit of 1982) also had a significantly negative association with crash rates for the whole sample and the subsamples of general freight and specialised freight carriers. In contrast, only the second lag showed a similar result for large size carriers. Hunter and Mangum (1995) also used crash rates as the dependent variable. In addition to the variables representing financial performance, other explanatory variables related to employment characteristics, such as union membership and owner drivers were considered in the analysis. The estimates for each type of employment type provided findings that differed based on the financial performance measurements and employment type.

Table 2.1 Summary of the studies exploring the link between trucking operators' financial and safety performance

Author(s)	Sample	Key variables SP: Safety performance FP: Financial performance	Model	Findings
Corsi, et al. (1988)	Two non-overlapping US cross-sectional data sets for: 988 HV companies in 1977 770 HV companies in 1984	*SP:* Total crashes per vehicle mile *FP:* Operating ratio (operating expenses/operating revenue)	Ordinary least squares (OLS) regressions	On average, there was no significant increase in crash rates No relationship between FP and SP before deregulation A better FP associated with lower crash rates after deregulation
Bruning (1989)	Cross-sectional data for 468 US HV companies on: Profitability for 1980, 1982 and 1984 SP and other variables for 1984	*SP:* Total crashes per mile driven *FP:* Profitability (return on transport investment)	Log-linear regressions	Contemporaneous profitability was associated with lower crash rates for the whole sample and the subsamples of general freight, specialised freight and large size companies The two lagged profits were associated with lower crash rates for the above-mentioned groups except for large size carriers, whose first lag though negative was not significant
Chow (1989)	Data set for 81 US HV operators which went bankrupt between 1983 and 1986	*SP:* Insurance and safety expenses per vehicle mile; maintenance costs per vehicle mile *FP:* A score index for financial distress	OLS regressions	Financially distressed companies spent less on insurance and safety per mile
Beard (1992)	Longitudinal data set for 146 US HV operators on FP from 1982 to1985 Cross-sectional data for same companies on SP and other variables for 1986	*SP:* Binary variable equals 1 if truck is placed out-of-service and 0 otherwise *FP:* Cash flow	Probit regressions	A better FP associated with a lower likelihood of placing vehicles out-of-service
Hunter and Mangum (1995)	Two US non-overlapping cross-sectional data sets for:	*SP:* Number of fatal and injury crashes per million miles	OLS regressions	For union operators, only the net debt to equity ratio significantly predicted crashes; this ratio was as expected associated with lower

	117 HV companies in 1976 and their 1975 FP information 235 HV companies in 1986 and their 1985 FP information	*FP:* Income per mile; net debt to equity ratio; operating ratio		crash rates in 1985-1986 For non-union operators, only the revenue per mile significantly predicted crashes; it was as expected associated with lower crash rates in 1985-1986 For owner operators, the operating ratio as expected was associated with lower crash rates for the two data sets while the revenue per mile was associated with lower crash rates for the 1985-1986 data only
Corsi (2004)	Cross-sectional data for 700 US HV companies in 2004 and their 2003 FP information	*SP:* Driver safety assessment score index; vehicle safety assessment score index; safety management score index *FP:* Operating ratio, return on assets	Bivariate correlations	None of the FP measurements significantly predicted the SP
Rodríguez, et al. (2004)	Cross-sectional data for 60 US HV companies in 1998	*SP:* Number of crashes *FP:* Operating ratio, labour cost per income, cash flow ratio	Negative binomial regression	None of the FP variables predicted crash counts across the whole sample Cash flow ratio and the labour cost per income were associated with fewer crashes for small operators only
Naveh and Marcus (2007)	Longitudinal US data from 1992 to 1996 for: 40 ISO 9002:1994 certified HV companies 20 non-certified HV companies	*SP:* Numbers of crashes, injuries and fatalities; driver safety assessment score index; vehicle safety assessment score index; safety management assessment score index *FP:* Return on assets (net revenue/total assets)	Hierarchical linear models	Unsafe on-road behaviours decreased after the certification Certified companies were involved in fewer unsafe behaviours compared to the non-certified A better FP associated with fewer unsafe on-road behaviours
Britto, et al. (2010)	Cross-sectional data for 657 US HV companies in 2003 and their 2002 FP information	*SP:* Number of crashes; driver safety assessment score index; vehicle safety assessment score index	Negative binomial and OLS regressions	A better FP associated with an improved SP

		FP: Net profit margin (net income/total operating income)		
Pritchard (2010)	2,100 US HV companies between 1998 and 2004	*SP:* Total number of crashes, number of fatal crashes per truck *FP:* Return on equity, debt to equity ratio, insurance premium and claims paid	OLS and Poisson regressions	A better FP associated with lower fatal crashes
Miller and Saldanha (2016)	Longitudinal data set for 20 US HV operators on SP from 2010 to 2013 and on FP from 2009 to 2012	SP: Unsafe driving score index, HOS compliance score index, vehicle maintenance score index FP: Gross revenue	Mixed-effects panel regressions	A better FP associated with fewer unsafe behaviours

Rodríguez, et al. (2004) used the number of crashes for safety performance while financial performance was measured by the operating ratio, the labour cost per income and the cash flow ratio and the other explanatory variables were related to factors such as driver payment and company size. The labour cost per income referred to the fraction of the net income devoted to the employees' salaries while the cash flow ratio was the cash flow from the activities over the current obligations. It measures the ability of the company to face its current commitments. The cash flow is more dependable than liquidity measures because it incorporates the changes in both the revenue and the balance sheet while removing the effects of accounting conventions. The findings showed that none of the financial measurements was significantly associated with safety performance. When splitting companies based on the size, the estimates reported a decrease of 0.3% and 0.4% following an increase of 10% in the cash flow and the labour cost per income respectively for small-size companies. The small size of the sample was highlighted as a limitation of the study.

Thus, Britto, et al. (2010) used a larger data set and measured financial performance by the net profit margin while safety performance was represented by three elements: the number of crashes, and the driver and vehicle safety assessment scores; a lower score implying a better safety performance (see Britto, et al, 2010, for the construction process of these scores). In addition to the net profit margin, the additional explanatory variables were related to the company equipment, distance driven per prime mover, driver wage and the ownership of the operating material. The findings showed that financial performance is significantly associated with enhanced safety performance. Naveh and Marcus (2007) used almost the same safety performance variables with Britto, et al. (2010) in their study of the effects of ISO certification on driving performance and measured financial performance by the return on assets. The results showed a positive relationship between financial and safety performance. Pritchard (2010) found similar results when measuring safety performance by the number of fatal crashes.

Most of the studies reviewed crash rates or the number of crashes to represent safety performance. These metrics do not reveal the true safety performance of a truck company because its drivers or trucks may not have been at-fault, and conclusions based on these studies may be misleading. Thus, in the absence of information about at-fault crashes, Chow (1989) used some safety-related expenditure metrics which, according to the author, represent companies' efforts to prevent crashes. This study analysed the association between financial distress and company safety investments for HV companies carrying general freight. The findings confirmed that financial distressed companies tended to devote fewer resources to vehicle maintenance and other safety activities and were more likely to engage in risky operations. In contrast, financially healthy companies devoted more resources to safety investments and had good safety records.

The use of crash rates or number and incomes (or profitability) as proxies for safety performance and financial performance, respectively, is problematic. Crash rates often rely on poor self-reported data from operators, and crashes can be random events beyond the control of companies. Incomes and profitability can be greatly distorted by taxes. Moreover, using the contemporaneous measurements or a single year measurement may not be a reasonable representation of the financial performance of a company (Beard, 1992; Chow, 1989). To address these issues, Beard (1992) used cash flow as the measurement of financial performance and a dummy dependent variable for trucks placed out-of-service during the 1986-widespread roadside safety inspection undertaken in the US State of Tennessee. Cash flows were considered an appropriate basis for assessing companies' financial status in risky industries because they account for investment necessities and rationally incorporate tax and depreciation issues. The findings showed that financially powerful companies were less likely to be poorly rated in roadside inspections because of the good state of their vehicles.

2.3.1.2 Longitudinal studies

The weak and inconclusive findings from previous studies may be due to the use of cross-sectional measurements of both financial and safety performance. Cross-sectional metrics ignore the dynamics within and between variables. The consideration of these dynamics in analyses is critical in providing a holistic view of the link between financial and safety performance. In a longitudinal approach, Miller and Saldanha (2016) quantified safety performance using three variables: a score for unsafe driving which refers to the hazardous and careless manoeuvre of the vehicle; a score for HOS compliance which is denoted by driver noncompliance with HOS rules; and a score for vehicle maintenance identified as the failure to keep the vehicle in a good state or avoid load shifting. These three metrics, according to the authors, are strongly correlated to crash rates. However, unlike crash rates, inputs such as breaches of HOS regulations, that are used to compute the three metrics are more directly under the company's control than crashes. The gross revenue (income before any deductions), lagged by one year, represented financial performance. This type of revenue has been reported in numerous annual reports in the trucking industry. The estimates from a mixed-effects model in a longitudinal framework supported that financial performance is significantly related to improved safety performance.

As can be seen from Table 2.1, studies about the effect of financial performance on safety performance are inconclusive. Half of the studies used data collected just after the deregulation of the US trucking industry and their findings may no longer hold if freight carriers have found strategies to cope with the economic shocks of the deregulation (Miller & Saldanha, 2016). Most of the studies which supported the theoretical prediction were based on models with limited explanatory power. The set of explanatory variables used in each study explained less than 8% (Corsi, et al., 1988), 15% (Bruning, 1989), 31% (Hunter & Mangum, 1995) and 20% (Britto, et al., 2010) of the dependent variable representing safety performance. These low explanations of the dependent variables raise the necessity for further examination of the question.

All the studies reviewed used objective measures of financial performance and safety performance. However, objective metrics may not always be available because of, for instance, poor reporting by companies or their reluctance to share sensitive data (Vij & Bedi, 2016). An alternative approach is to collect subjective metrics asking companies how well they have been performing. The use of subjective metrics has been popular in evaluating organisational performance (Singh, Darwish, & Potočnik, 2016). They have the advantage of providing information on overall performance, rather than individual objective metrics (Santos & Brito, 2012; Wall, et al., 2004). Importantly, research has reported high degrees of positive correlation between the subjective measurements of a performance indicator and its objective measurements (Dawes, 1999; Singh, et al., 2016; Vij & Bedi, 2016; Wall, et al., 2004).

The relationships between financial performance and crash involvement and occupational injuries were also examined in other sectors such as aviation, railroad, and mining. In the airline industry, Sinha (2007) did not find any causality between profitability and the number of crashes and fatalities in US aviation between 1947 and 1998. Golbe (1986) examined the link between contemporaneous profitability and the number of crashes in US aviation between 1963 and 1996 and between 1967 and 1970. The findings showed the absence of a significant relationship between profitability and safety performance. Rose (1990) improved upon Golbe (1986) by considering the lagged profitability with data between 1955 and 1974 and found that profitability is conducive to safety. Noronha and Singal (2004) focused on US major airline companies and found that good financial performers were less likely to experience mishaps between January 1983 and December 1998.

Nevertheless, previous research was limited because it mostly used data from the period before deregulation (the US airline industry was deregulated in 1978) which was not subject to higher competition. Raghavan and Rhoades (2005) accordingly re-examined the link between profitability and crash rates using data between 1955 and 2002 for US major airline carriers. The results showed a nonlinear relationship between profitability and safety performance. Madsen (2013) and Xu (2015) also reported a nonlinear relationship between profitability and the number of crashes. Madsen (2013) examined a sample of 133 US aviation companies between 1990 and 2007. Xu (2015) used data for 110 airline companies from 26 countries from 1990 to 2009. Madsen (2013) reported that the nonlinear relationship was due to a positive relationship (i.e. higher profitability was associated with higher safety performance) for companies operating below their profitability target and a negative relationship (i.e. higher profitability was associated with lower safety performance) for companies operating above this target.

In the railroad industry, Golbe (1983) reported a positive link between profitability and safety performance in the US railroad sector between 1963 and 1967. Asfaw, Mark, and Pana-Cryan (2013) found an inverse relationship between profitability and occupational injuries (i.e. higher profitability is associated with fewer occupational injuries) in U.S. underground coal mines between 1992 and 2008.

2.3.2 Effects of safety performance on financial performance

It would be rational for HV companies to considerably invest in safety to reduce crash risks, but some of them often fail to do so (Hopkins, 1999). They may see safety investment as a cost that has adverse repercussions on their competitiveness (Fernández-Muñiz, Montes-Peón, & Vázquez-Ordás, 2009). However, an unsafe environment undermines workers' morale and may result in their resignation from the company. Crashes can cause delays or failures in deliveries which may damage their credibility with partners such as customers. The drawbacks of poor safety performance include, but are not limited to, higher insurance claims and high lawsuit costs, damage to the company's reputation and poor quality service which increases the risk of losing customers and deterring qualified workers from entering the company (Cantor, 2008; Mahachandra & Sutalaksana, 2015; Rodríguez, et al., 2004; Zyglidopoulos, 2001).

An analysis of 455 Spanish trucking companies revealed that the safety management system, defined as the set of policies and mechanisms that companies implement to monitor the potential risks that can affect employee health and safety, positively affects companies' competitiveness, safety performance and (to a lesser extent) economic-financial performance (Fernández-Muñiz, et al., 2009). However, the study did not include information about the specific link between crash rates and financial performance.

This preliminary analysis presented in what follows constitutes a showcase to hypothesise that investments in safety can improve company profit in the long-term (Carslake, et al., 2012). McColl's Transport, Australia's largest specialised carrier of milk, food and bulk chemicals has been operating since 1952 (National Road Safety Partnership Program, 2013). The company underwent a tumultuous period which resulted in its sale in 2005 to a private equity company. The turmoil continued during the two years after the sale with the company's safety and financial situation significantly deteriorating. In 2009, the administrative board acknowledged that safety within the company needed to be overhauled for the company to recover and safety became the focus of the new managing team. The company invested in safety technologies, such as GPS, to monitor vehicles in real-time. It no longer pressured drivers to meet unrealistic delivery schedules. It built a yard closed to key customers to enable drivers to rest while the cargo was being loaded or unloaded. It also provided drivers with specific training based on the type of loads such as milk tankers and chemical tankers and raised wages to the top 25% of the industry to attract and/or retain experienced and skilled personnel. The company ensured internal compliance with CoR regulations and considered educating its external partners to comply with these regulations. It was then able to charge customers a premium because they were aware of the company strong compliance with safety regulations. This safety investment resulted in substantial savings to insurance premiums and contributed to the improvement of the company's overall financial performance.

Drivers' remuneration policy is also a component of safety investments that may influence directly or indirectly driver safety performance. The indirect influence refers to the relationship between driver pay and factors such as driver turnover and vehicle defects that may influence safety performance.

2.4 DIRECT LINKS BETWEEN DRIVER PAY AND SAFETY PERFORMANCE

The outsourcing of the driving task is a major factor influencing carriers' payment policies (Mayhew & Quinlan, 1997). This section examines crash involvement based on driver employment type before examining the relationship between driver payment policies and safety performance in the coming sections.

2.4.1 Driver employment type and crash involvement

Theoretical predictions assert that owner drivers are prone to drive more safely than employee drivers because risky behaviours will put their capital at risk (Nickerson & Silverman, 2003). Conversely, owner drivers are under financial pressure to cover both the fixed and variable costs of their activities (Cantor, Celebi, Corsi, & Grimm, 2013; National Truck Insurance, 2016) and may therefore be tempted to engage in hazardous practices. These contradictory theoretical predictions have triggered empirical examinations of crash involvement for the different driver employment types. A summary of these studies is provided in Table 2.2. Among those studies that examined the relationship between the proportion of owner drivers and the company's crash involvement, Corsi, et al. (1988) and Britto, et al. (2010) found a positive relationship, while Dammen (2005) and Cantor (2014) found a negative relationship and Bruning (1989) did not find any significant association. Another study which focused on the safety of employee drivers (Cantor, 2016) concluded that employee drivers had poorer safety performance. Those studies which compared the safety of owner and employee drivers within the same company reported mixed results, with some finding that owner drivers are safer than employee drivers (Hunter & Mangum, 1995) while others found the reverse (Cantor, et al., 2013; Monaco & Redmon, 2012). In Australia, Mayhew and Quinlan (2006) reported mixed safety outcomes from comparisons between employee and owner drivers.

Table 2.2 Previous studies relating heavy vehicle driver employment type and crash involvement

Author(s)	Key variables SP: Safety performance ET: Employment type	Sample	Findings
Corsi, et al. (1988)	*SP:* Number of crashes per vehicle mile *ET*: Owner driver proxied by the percentage of miles rented	Two-non overlapping US cross-sectional data sets for 998 heavy vehicle (HV) companies in 1977 and 770 HV companies in 1984	Use of owner drivers associated with higher crash rates
Bruning (1989)	*SP:* Number of crashes per mile driven *ET*: Owner driver proxied by the ratio of rented power units to the total number of power units	Cross-sectional data for 468 US HV companies on profitability for 1980, 1982 and 1984, and crash rates, employment type and other variables for 1984	No significant relationship between using owner drivers and crash rates
Hunter and Mangum (1995)	*SP:* Number of fatal and injury crashes per million miles *ET*: Owner operated companies, union companies, non-union companies	Two US non-overlapping cross-sectional data sets for 117 HV companies in 1976 and their 1975 financial information, and 235 HV companies in 1986 and their 1985 financial information	Owner operated companies have higher crash rates than non-union companies for the 1975-1976 data No relationship exists for the 1985-1986 data
Monaco and Williams (2000)	*SP:* Dummy variable for crash involvement, moving violation, logbook violation over the past 12 months *ET*: Binary indicator taking 1 for owner drivers and 0 for employee drivers	1997 cross-sectional survey data from 573 US HV drivers	No difference in terms of crash involvement and logbook violations Owner drivers have more moving violations than employee drivers
Dammen (2005)	*SP:* Crash rate, injury rate *ET*: Owner driver proxied by the ratio of the rented distance to the total distance	516 US HV companies in 1996	Use of owner drivers associated with lower crash and injury rates
Mayhew and Quinlan (2006)	*SP:* Number of crashes, hours of work *ET*: Self-report of whether the driver is an employee or owner-driver	2000 survey data from 300 long-haul HV drivers in New South Wales, Australia	Mixed results for major crashes Owner drivers had lowest crash counts over the past 12 months and the highest over the past 5 years Owner drivers drive longer hours than

			employee drivers
Britto, et al. (2010)	*SP:* Number of crashes, driver safety assessment; vehicle safety assessment *ET*: Percentage of the owned fleet	Cross-sectional data for 657 US HV companies in 2003 and their 2002 net profit margins	Fleet ownership increases the number of crashes, but improves vehicle safety and does not affect driver safety
Monaco and Redmon (2012)	*SP:* Number of crashes, injuries, and fatalities *ET*: Owner driver proxied by companies having one truck and one driver, and for multiple truck companies by the percentage of the fleet that is trip or term leased	2009 data on 295,814 US HV companies	Companies using owner drivers have fewer crashes, injuries and fatalities than those using employee drivers Mixed results for serious and fatal crashes
Cantor, et al. (2013)	*SP:* Number of crashes, driver and vehicle out-of-service violation rates *ET*: Dummy variable equals 1 for employee drivers and 0 for owner drivers	599,758 US HV drivers having had at least three roadside inspections over 2008-2011	Owner drivers less involved in crashes but have higher driver- and vehicle out-of-service violation rates than employee drivers
Cantor (2014)	*SP:* Number of crashes, driver and vehicle out-of-service violation rates *ET*: Owner driver proxied by the percentage of the owned fleet	1,380,764 US HV companies	Fleet ownership decreases the number of crashes but increases driver- and vehicle out-of-service violation rates
Cantor (2016)	*SP:* Number of crashes, proportions of driver and vehicle out-of-service rates *ET*: Employee drivers proxied by the ratio of owned tractors to the total number of owned and leased tractors	108,780 US HV Companies	Using employee drivers associated with poor safety performance

Similar to the theoretical predictions, empirical studies show mixed results about the relationship between HV driver employment type and crash involvement. Moreover, they were mostly conducted at the company level, and none of them included payment methods among the explanatory variables.

2.4.2 Driver payment methods

There are two main kinds of payment methods for HV drivers (Mooren, et al., 2015). Time-based payment consists of companies remunerating drivers based on the amount of time worked or with a salary that is related to all tasks that the driver does comprising driving activity, the time devoted to the loading and unloading of the vehicle, and the time spent in queues or in waiting for loading and unloading. The alternative method ties the payment to the amount of work performed. This method is known under different names, such as performance-based payment, productivity-based payment, piece rate payment, result-based payment and output-based payment. It generally does not include payment for all the non-driving tasks that the time-based payments consider.

Some payments can be based on the combination of these two methods. For example, an hourly rate may be combined with bonuses linked to the company's profit, or a base pay plus a performance-based rate, where the base pay can be a fixed amount or flat rate up to a certain amount.

In addition to payment by salaries and piece rates, employers can also shape the safety behaviours of their drivers, mainly employee drivers, with financial incentives (safety or early delivery bonuses) or penalties for late deliveries (Mattson, Torbiörn, & Hellgren, 2014), incentives or non-wage benefits (Dale-Olsen, 2006; Helppie & Macis, 2009; Werner, Kuiate, Noland, & Francia, 2016), and other non-monetary rewards, such as gold stars or medals (De Gieter & Hofmans, 2015; Gupta, Jenkins Jr, & Delery, 1996). Concerning financial incentives, Indian drivers receiving financial incentives for early or on-time deliveries had 1.5 times higher odds of drowsy driving compared to the other drivers (Mahajan, Velaga, Kumar, Choudhary, & Choudhary, 2019). Regarding gold stars, Dale-Olsen (2006) and Helppie and Macis (2009) concluded that they can be appropriate to motivate drivers but cannot replace monetary payments and should preferably be awarded in association with financial rewards. Incentives and other benefits, found mostly in the

United States, include but are not limited to health care plans, retirement plans, sick and vacation leave, free accommodation, and the opportunity to buy stocks at less than the market value (Dale-Olsen, 2006; Helppie & Macis, 2009). The driver compensation system is composed of the payment methods and the benefits that have been just described (Belzer, Rodriguez, & Sedo, 2002). Compensation according to Milkovich, Newman, and Gerhart, 2014, p13) refers to “all forms of financial returns and tangible services and benefits employees receive as part of an employment relationship”. The compensation system for truck drivers is summarised in Figure 2.3.

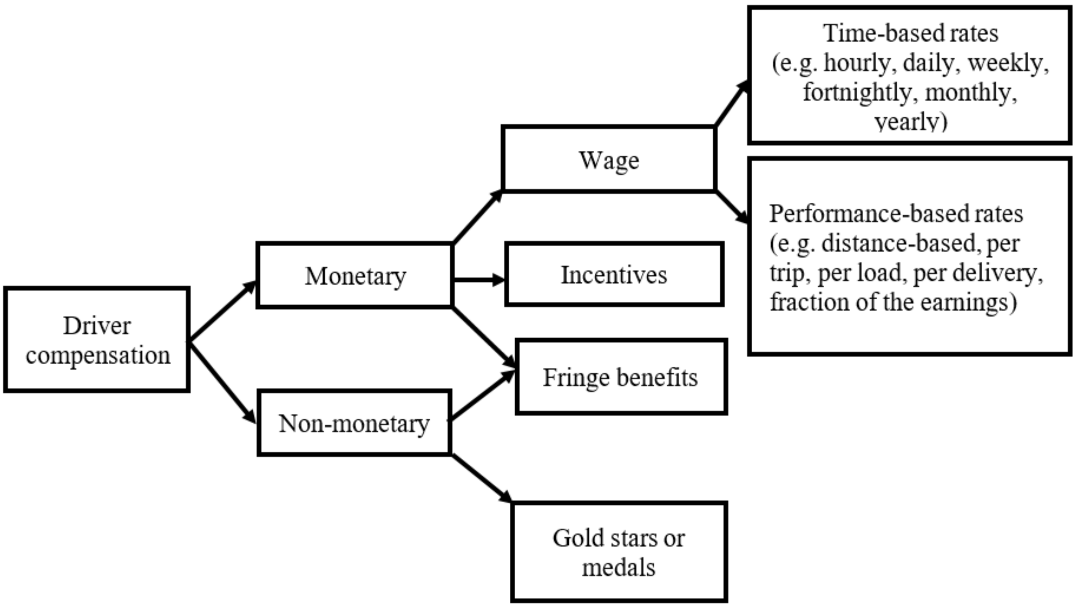


Figure 2.3 Truck vehicle driver compensation

2.4.3 Effects of driver compensation on safety performance

Studies considered in this section were English-written papers connecting any form of driver compensation to any safety outcome (social costs, intermediate, or final outcome). A search was conducted on four electronic databases (Google Scholar, Science Direct, Transport Research International Documentation, and Proquest) using the following terms: (motor carrier* or truck* or heavy vehicle*) and (payment* or remuneration* or compensation* or incentive* or benefit*) and (safety* or crash* accident* or sleepiness* or fatigue* or drug* or stimulant* or speed*).

There was no time restriction regarding the year papers were published. A total of 29 studies met the inclusion criteria. Table 2.3 provides a summary of these studies, which were mostly conducted in Australia and the United States, including the authors, the safety performance and compensation variables, the sample, the model, and the outcomes, in chronological order.

Hensher and Battellino (1990) were among the first authors to examine the impact of economic rewards on truck driver safety performance. The safety performance consisted of the drivers' average speed, fatigue and their compliance with HOS limits. Data collected from 46 long-distance truck drivers at a major loading/unloading truck stop in Sydney showed that speeding, fatigue and HOS violations were a result of the declining remuneration rates. In the same vein, some Californian truck drivers breached speed and work time regulations to compensate for the reduction in their salaries due to deregulation (Kraas, 1993). These patterns were also found in a survey of 402 Australian long-distance truck drivers. Due to low and performance-based economic rewards, they tended to speed, use stimulants and self-imposed schedules (Golob & Hensher, 1994). Hensher and Battellino (1990) concluded that any compensation different from a fixed salary would likely result in risky behaviours from truck drivers in the quest for higher earnings.

Table 2.3 Summary of studies examining the link between truck driver compensation and safety performance

Author(s)	Sample	Key variables SP: Safety performance CP: Compensation	Model	Findings
Hensher and Battellino (1990)	Cross-sectional survey data for 46 Australian long-distance truck drivers	*SP:* Average trip speed *CP*: A percentage of trip earnings	OLS regression	Drivers receiving a portion of trip earnings drove in average 15 km/h faster than others Drug users speed 20 km/h faster than non-drug users
Hensher, et al. (1991)	Cross-sectional survey for 820 Australian long-distance truck drivers	*SP:* Likelihood of speeding, using drugs, or self-imposing arrival time *CP*: Various time-and performance-based payments	Probit regressions	Performance-based rates were associated with self-imposition of tight schedules, speeding and stimulant intake
Kraas (1993)	Data for US truck drivers between 1976 and 1987	*SP:* At-fault crashes per 1million vehicle-miles *CP:* Real wage rate	OLS regressions	A high wage was associated with lower crash rates after the deregulation, but not before
Golob and Hensher (1994)	Cross-sectional survey data for 402 Australian truck drivers	*SP:* Average speed, drug use, self-imposed arrival time *CP:* Trip rate	Structural equations	Trip rates and low pay rates were associated with self-imposition of tight schedules, speeding and stimulant intake
Monaco and Williams (2000)	Cross-sectional survey data for 573 US truck drivers	*SP:* Dummies for crash occurrence, moving violation and logbook violation *CP:* Dummies for distance-based and hourly pay rates	Probit regressions	Higher pay rates were associated with lower crash involvement and logbook violations
Williamson, et al. (2001)	Cross-sectional survey data for 1007 Australian long-haul truck drivers	*SP:* Fatigue *CP:* Various time-and performance-based payments	Bivariate correlations	Performance-based rates were associated with higher levels of fatigue than time-based rates

Belzer, et al. (2002)	Cross-sectional data for 102 US HV companies	*SP:* Number of crashes *CP:* Base per mile rate, pay raise, paid time off, unpaid non-driving time, safety bonus, production bonus, health insurance, life insurance	Negative binomial regression	Paid time off and production bonus were not statistically significant influences on number of crashes A 10% increase in the remaining compensation variables was associated with a reduction of crashes by between 0.5% and 5.2%.
	11,540 US truck drivers observed between September 1995 and March 1998 over 13- month period before a pay raise and over another 13-month period after the pay raise	*SP:* Dummy variable for crash occurrence *CP:* Base pay rate, pay raise from period 1 to period 2	Cox proportional hazards regression	The pay raise and a 10% increase in the base pay rate were associated with a reduction of crash involvement by 6% and 34%, respectively
	247 US truck drivers	*SP:* Dummy variable for crash occurrence *CP:* Per mile pay rate, number of paid days, safety bonus, late penalty, on-time bonus	Probit regression	A 10% increase in the per-mile rate and the number of paid days were associated with a reduction of crash involvement by 21% and 7%, respectively None of the bonuses was significant
Rodríguez, Rocha, Khattak, and Belzer (2003)	11,540 US truck drivers observed between September 1995 and March 1998 over 13- month period before a pay raise and over another 13-month period after the pay raise	*SP:* Number of crashes *CP:* Base pay rate, pay raise from period 1 to period 2	Zero-inflated Poisson and logit regressions	On average, An increase of 1 cent in the base pay was associated with a decrease of 2.22% in the number of crashes A 1% increase in the pay raise was associated with a reduction of 0.23% in the number of crashes
Corsi (2004)	Cross-sectional data for 700 US HV operators in 2004 and their 2003 compensation information	*SP:* Driver safety assessment score; vehicle safety assessment score; safety management score *CP:* Wage	Bivariate correlations	Higher wages were associated with better safety performance
Rodríguez, et al. (2004)	Cross-sectional data for 60 US HV companies in 1998	*SP:* Number of crashes *CP:* Per mile pay rate, drivers, pay raise, unpaid driving time, vacation and sick pay,	Negative binomial regression	The unpaid driving time was associated with poor safety performance while the health plan was associated with better safety performance

		safety bonus, health plan, life insurance		
Rodriguez, Targa, and Belzer (2006)	2,368 US truck drivers observed between September 1995 and February 1998 over 13-month period before a pay raise and over another 13-month period after the raise	*SP:* Number of crashes *CP:* Base pay rate, pay raise from period 1 to period 2	Semi-parametric hazard regressions	An increase of 1 cent in the base pay was associated with a reduction of 8.8% in driver turnover A 1% increase in the pay raise was associated with a reduction of 1.33% in the number of crashes Driver turnover was not a significant associated of the number of crashes
Williamson, Cooley, Hayes, and O'Neill (2006) and Williamson (2007)	Two Australian 7-year apart cross-sectional surveys of 970 and 1007 truck drivers	*SP:* Drug use *CP*: Various time-and performance-based payments	Logistic regression	Performance-based and lower pay rates were associated with high levels of drug use
Nafukho, et al. (2007)	14,340 US truck drivers	*SP:* Number of crashes *CP:* Wage, paid time off, safety bonus	Stepwise regression	Wage and paid time off though significant and positive were weakly related to decreased number of crashes
Britto, et al. (2010)	Cross-sectional data for 657 US HV companies in 2003 and their 2002 payment information	*SP:* Number of crashes; driver safety assessment score; vehicle safety assessment score *CP:* Average driver wage	Negative binomial and OLS regressions	Higher wages were associated with improved safety performance
Pritchard (2010)	Data for 2,100 US HV companies between 1998 and 2004	*SP:* Total number of crashes, number of fatal crashes per truck *CP:* Wage	OLS and Poisson regressions	Higher wages were associated with lower fatal crash rates
Williamson and Friswell (2013)	Cross-sectional survey data for 475 Australian long-distance truck drivers	*SP:* Likelihood of fatigue *CP:* Time-based rate, trip-based rate, a dummy for payment related to loading/unloading time	Logistic regression	Trip-based payments and no pay for waiting were associated with longer driving times and more fatigue

Mooren, et al. (2014)	Cross-sectional survey data of 50 Australian HV companies	*SP:* Insurance claim rate *CP:* Various time-based and performance-based payments	Statistical comparison	Low claimers (good safety performers) mostly paid their drivers on time basis, such as per hour, per week and salaries, and paid for all work done High claimers mostly paid their drivers based on performance, such as per trip and per load
Thompson and Stevenson (2014)	Cross-sectional survey data for 346 Australian long-haul truck drivers	*SP*: distance driven, driving time, sleep duration, work time *CP:* Distance-based rate, trip-based rate, hourly/weekly rates	Multivariate analysis of covariance	Distance-based rates were associated with poor safety performance than trip rates which in turn were associated with poor safety performance than hourly/weekly rates
Faulkiner (2015)	11,457 US truck drivers observed between September 1995 and February 1998 over 13-month period before a pay raise and over another 13-month period after the pay raise	*SP:* Number of crashes per million vehicle miles *CP*: Base pay, pay raise	Cox proportional hazards regression	The pay raise was associated with a decrease of 41% in crash rates and almost 46% in crash costs
Edwards, et al. (2016)	A set of drivers from 3 Australian HV companies	*SP:* Speeding *CP:* Hourly rate, distance- or load-based rate	Qualitative analysis	Distance- or load-based rates were associated with an increased likelihood to speed
Werner, et al. (2016)	1,835 US long-haul truck-load dry vans companies between 1989 and 1997	*SP:* Insurance cost per mile *CP:* Annual per mile wage; a dummy for retirement plan; retirement plan cost	OLS regressions	The existence of a retirement plan led to reductions in insurance costs through a safe on-road behaviour Driver wage and the retirement plan cost did not affect insurance costs
Belzer (2018)	1,014 US truck drivers	SP: Dummy for whether driver could prevent the crash in a situation of critical events CP: Safety bonus, distance-based rate on the	Logistic regression	Safety bonus was associated with a decrease in crash risk

		trip in which the crash occurred		
Belzer and Sedo (2018)	233 US full-time employee drivers survey data collected in 1997-1998	*SP:* Number of work hours per week *CP:* Distance-based rate	Two-stage least squares regression	If the actual average mileage rate of US $0.286 is increased to US $0.395, the average weekly work duration will drop from 64.49 hours to the legal limit of 60 hours
Faulkiner and Belzer (2019)	11,457 US truck drivers observed between September 1995 and February 1998 over 13-month period before a pay raise and over another 13-month period after the raise	SP: Company expected net present income CP: Base Pay, pay raise	Cox proportional hazards and fixed-effects regressions	Hiring experienced drivers and paying them higher wages is beneficial for companies in terms of financial gains
Kudo and Belzer (2019a)	704 US long-haul truck employee drivers in 2010	*SP:* Moving violations during the last 12 months *CP:* Per mile pay, a dummy for retirement benefits, a dummy for health insurance, a dummy for non-driving pay	Negative binomial regression	Higher per mile rates were associated with lower moving violations Drivers receiving health insurance plans were less likely to commit moving violations than others
Kudo and Belzer (2019b)	1,265 long-haul truck drivers	*SP:* Number of hours driven per week *CP:* Distance-based rate, a dummy for payment of non-driving duties	Logistic regression	Payment for non-driving duties is associated with a reduction in the number of driving hours
Mahajan, et al. (2019)	Cross-sectional survey of 453 Indian long-haul driver	*SP:* Self-report of drowsy driving *CP:* Bonus for early or on-time deliveries	Logistic regression	Arrival incentives were associated with 1.5 times higher odds of drowsy driving

2.4.3.1 Payment methods and drug use

Stimulant drug use is commonly reported as one of the consequences of performance-based payments. Hensher, et al. (1991) among a sample of 820 Australian long-distance truck drivers found that 79% of the employee drivers received performance-based payments. This often incentivised them to take drugs to stay awake and travel as much as possible. The use of stimulants was two to three times more prevalent among drivers receiving performance-based payments, such as trip-based or load-based rates, in two surveys of 970 and 1007 Australian truck drivers. Those who deemed their remuneration to be inadequate used drugs to stay awake for longer hours which resulted in fatigue (Williamson, 2007; Williamson, et al., 2006). Drivers receiving per kilometre (km) and per trip rates among 346 Australian long-haul HV drivers were also the most prone to use stimulants while driving (Thompson & Stevenson, 2014).

2.4.3.2 Payment methods and safety performance

Drivers paid on a trip basis drove greater distances, worked longer hours and were subsequently more likely to sleep less and experience fatigue than time-based paid drivers (Williamson & Friswell, 2013). A similar pattern was observed for 28% of some Australian long-haul trips drivers paid on the load, the number of trips or the distance-basis. They were more likely to be fatigued in half or more of their trips. This was less likely to happen for drivers paid by the hour, with 15% of them tending to be fatigued in half or more of their trips (NTC, 2007b). Fatigue and extended driving hours were also related to per km pay rates in a group of 1007 Australian long-distance truck drivers (Williamson, et al., 2001). Lemke, Apostolopoulos, Hege, Sönmez, and Wideman (2016) reported that, among 260 US long-haul truck drivers, the longer distances travelled per week, combined with HOS violations by some drivers, were due to distance-based payments.

2.4.3.3 Payment for non-driving tasks and safety performance

Whether the time and work related to non-driving tasks, such as loading and unloading, are paid also influences driver safety performance. If these activities are not paid, the compensation is not likely to reflect the total value of all the work done. This can encourage drivers to make up the underlying financial loss by driving longer distances which often results in unsafe behaviours (Farrell, Soccolich, & Hanowski, 2016; Helppie & Macis, 2009; Kudo & Belzer, 2019b; Mooren, et al., 2015). An examination of the safety records of some 50 Australian HV companies revealed that good safety performers were those who paid their drivers for all work done (Mooren, et al., 2014). Conversely, drivers who were not paid for the loading and unloading work or for the time spent in queues showed increased likelihood of fatigue in a set of 475 New South Wales long-distance truck drivers (Williamson & Friswell, 2013).

2.4.3.4 Payment methods and speeding

Speeding is another consequence of performance-based payment methods. In a pilot survey of Australian long-distance truck drivers, drivers paid a percentage of the earnings associated with their loads had higher speed levels compared to those paid by other methods (Hensher & Battellino, 1990). In two Australian national surveys in 2006 and 2012, drivers cited pay issues among the reasons for breaching speed regulations (NTC, 2007a, 2012a, 2012b). This result concurs with that of another national survey in which 73% of HV drivers reported the need to earn more money as the reason for speeding (NTC, 2006b). In line with the results of these surveys, in a qualitative analysis of three different Australian HV companies by

Edwards, et al. (2016), drivers declared that their speed choice was linked to their remuneration method. Those paid by the km or a percentage of the income of their loads were incentivised to drive faster because the distance was viewed as money. This was not the case for hourly-paid drivers because driving faster under hourly rates has no effect on earnings.

2.4.3.5 Pay level and safety performance

Based on an analysis of US data, Belzer and Sedo (2018) showed that drivers have a target income and greater compensation can lead them to be more mindful of safety than they would otherwise be. Thus, the level of performance-based rates may also be important in shaping driver behaviour (Corsi, 2004; Pritchard, 2010). Kraas (1993), studying the effects of deregulation on road safety in the United States, found that higher wage rates were significantly associated with decreased crash rates. Britto, et al. (2010) found that greater average wages were significantly related to improved safety performance. Analysing survey data for 573 US truck drivers, Monaco and Williams (2000) reported that a $0.10 per mile increase in the distance-based pay rate reduced crash risk by 1.76%. However, drivers receiving hourly rates were 10.2% less likely to be involved in a crash compared to those receiving per mile rates or a fraction of the income.

Belzer, et al. (2002) explored the effect of various types of compensation on truck driver safety behaviour in the United States. The first study showed that higher pay rates and incentives were significantly linked to fewer crashes. A 10% increase in the compensation variables was significantly linked to a reduction of between 0.5% and 5.2% in the number of crashes. The second study focused on the effect of pay and pay raise on crash occurrence at the driver level. The findings implied that a 10% increase in the base per mileage rate and the pay raise would significantly reduce crash risk by 34% and 6% respectively. Nevertheless, the authors believed that the decrease in crash risk following the pay raise might be due to the endogenous effect that safer drivers are those receiving higher rates. Rodríguez, et al. (2003) used the data set of this second study and reported that greater pay rates and pay raises are related to fewer crashes. The estimations suggested that an additional cent on the driver pay rate per mile significantly decreased crash probability by 2.22% and a 1% increase in the pay raise resulted in a 0.23% reduction in crash risk. The third study reported that a 10% increase in the pay rate and the number of paid days significantly decreased crash risk by 21% and 7%, respectively. Like Belzer, et al. (2002) and Rodriguez, et al. (2006), Faulkiner (2015) used a before-and-after pay increase context and found, as in Nafukho, et al. (2007), that higher pay rates are related to lower crash rates.

In contrast, Rodríguez, et al. (2004) performed a company-level analysis and found that unpaid driving time was related to more crashes while the contribution to a health plan was correlated to fewer crashes. Rodriguez, et al. (2006), in addition to confirming the findings of other studies, sought to separate the direct and indirect effects of driver pay on crash risk by studying the impact of a pay increase on driver behaviour. The indirect effects denoted the ability of the company to reduce driver turnover, which would allow employees to acquire a certain level of company-specific skills. However, their study failed to separate the two effects because the turnover was not statistically significant as a factor that decreased the number of crashes. Thus, Faulkiner and Belzer (2019), in an attempt to separate the direct and indirect effects of driver pay, examined the associations of driver experience at the time of recruitment and turnover with crash involvement when recruited. The study showed that higher wages enable companies to attract more experienced and safer drivers, and reduce driver turnover, crash probability and the average cost associated with a crash. The reduced costs of driver turnover (recruitment and training costs), coupled with the reduced cost of crashes and better safety performance by the company, resulted in a significantly higher net present income for highly-paid experienced drivers recruited than inexperienced drivers recruited at lower pay rates.

2.4.3.6 Incentives and other benefits and safety performance

Incentives and other benefits are entirely voluntary in countries such as Australia (Australian Taxation Office, 2020a, 2020b) and the United States (Werner, et al., 2016). They are discretionary benefits that enable a truck company to influence its drivers' safety performance by offering above-the-market compensations that they might not have elsewhere (Werner, et al., 2016). Some studies have explored the association of incentives and other benefits with driver safety performance. For instance, safety bonus was not a significant predictor of safety performance (Belzer, et al., 2002; Nafukho, et al., 2007; Rodríguez, et al., 2004). Nevertheless it was associated with a better safety performance (Belzer, 2018). Requiring on-time delivery was not a significant predictor of safety performance (Belzer, et al., 2002). Nevertheless, it was associated with a poor safety performance (Mahajan, et al., 2019). Drivers provided with retirement plans (Werner, et al., 2016) or health insurance (Kudo & Belzer, 2019a; Rodríguez, et al., 2004) were more likely to have a better safety performance than others. In contrast, retirement plans (Kudo & Belzer, 2019a) and health insurance (Belzer, et al., 2002) were not significant predictors of safety performance.

In sum, the associations of incentives and other benefits with safety performance is not conclusive. In contrast, studies largely support that performance-based payment methods and the desire to meet unrealistic schedules are associated with unsafe on-road behaviours such as speeding, working during long hours and driving under the effect of stimulants (Mayhew & Quinlan, 2006).

2.4.4 Performance-based payments and safety performance in other industries

The trucking industry is not the only industry where performance-based payment is associated with undesired outcomes. Freeman and Kleiner (2005) examined the compensation system in the US shoe industry in the 1990s and concluded that the drawbacks of piece rates generally outweigh their benefits. They found that piece rates encourage workers to skimp on quality or to overuse the production materials. Under piece rate systems, the workers may be unwilling to share their working skills about how to improve the production because they may think that this can result in the company increasing its productivity that will decrease the level of piece rates. Regarding the clothing industry, some Australian outworkers were more than three times more likely to report injuries than their counterpart factory-based workers (Quinlan & Mayhew, 1999). The key factor explaining this difference was the remuneration method. Outworkers were paid by the unit while factory workers received time-based rates plus bonuses or time-based rates only. Among factory workers, those receiving bonuses reported higher levels of injuries than those paid on time basis.

Performance-based rates abound in the garment industry. Wang et al. (2005) analysed work-related musculoskeletal disorders among sewing machine workers in California between 2003 and 2004. They found that the disorders were more prevalent among workers paid on a piece rates basis, after adjusting for age, gender and ethnicity. Similar results were also reported among Malaysian clothing workers (Nawawi et al., 2015). Those receiving piece rates had greater workloads, faster working speeds, more exhaustion and pressure, and were less likely to take breaks compared to those paid on a time basis. Musculoskeletal pains were also more prevalent among workers paid piece rates.

In the forestry industry, Québec workers in areas such as treatment of plantation and vegetation management paid on piece rates were more likely to have health and safety issues (Toupin, LeBel, Dubeau, Imbeau, & Bouthillier, 2007).

Other studies focused on workplace environment in the general population. An examination of cross-country European survey data about workplace injuries revealed that piece rates were related to working under pressure, increased working speeds and higher risks of being injured (Bender, Green, & Heywood, 2012). Analyses of some UK data sets showed that workers paid by piece rates had higher likelihoods of reporting musculoskeletal pains (Lacey, Lewis, & Sim, 2007) and general health problems (Bender & Theodossiou, 2013; DeVaro & Heywood, 2017; Lacey, et al., 2007). Workplace injuries were more prevalent among some US workers receiving piece rates and bonuses (Artz & Heywood, 2015) while these kinds of rates were related to tight schedules and workplace stress among some Korea workers (Rhee, Kim, & Cho, 2015).

The safety effects of performance-based payments in other industries were also examined in relation to the subcontracting system. As explained in Chapter 1 of this thesis, the subcontracting system provides possibilities to subcontracting companies to access specialist materials and skills that they may not possess (Bazargan, 2016; Nunes, 2012; Quinlan, Hampson, & Gregson, 2013). Nevertheless, this system motivates performance-based payments due to competition for work (Mayhew & Quinlan, 1997).

Besides the economic pressure, the subcontracting system has been associated with disorganisations at workplaces and regulatory failures (Quinlan, et al., 2013; Underhill & Quinlan, 2011). The economic pressure creates income insecurity which adversely influences the safety of work practices. The disorganisation fractures management systems and weakens tasks coordination. Inexperienced and unskilled workers become common, adversely affecting safety practices. The regulatory failure indicates the extent to which safety and employment rules are undermined by precarious work arrangements (Gregson et al., 2015; James, Johnstone, Quinlan, & Walters, 2007; Quinlan, et al., 2013; Underhill & Quinlan, 2011).

The mixture of these flaws has resulted in the subcontracting system being singled out as a source of occupational health issues in several industries. Nenonen (2011) reported hazardous work practices, insufficient risk identifications, human errors, and deficiencies in instruction and guidance in subcontracted operations compared to in-house operations in the Finnish manufacturing industry between 1999 and 2008. Underhill and Quinlan (2011) found that subcontracted workers were the most vulnerable to risk factors among workers in Victoria, Australia, between 1995 and 2001. In the same vein, subcontracted workers from a nationally representative data set in 2010 were more likely to experience health issues than parent company workers in South Korea. They were three times more likely to miss work because of work-related injuries or diseases (Min et al., 2013).

Research also examined the link between the subcontracting system and crash involvement in sectors, such as air transport. Monaghan (2011) examined the association of passenger airline aircraft maintenance subcontracting rates and aircraft crash and incident rates in a sample of 14 US domestic passenger airline companies between 1996 and 2008. The analysis did not find any significant relationship. In contrast, Quinlan, et al. (2013) reported the flaws of the subcontracting system as the reason for six serious incidents, including three fatal crashes in the US air transport sector between 1995 and 2009.

2.5 INDIRECT LINKS BETWEEN DRIVER PAY AND SAFETY PERFORMANCE

Driver turnover and vehicle defects are factors that may increase crash involvement. The relationship between driver pay and safety performance is analysed through the associations of driver pay with driver turnover and vehicle defects.

2.5.1 Driver pay and turnover

2.5.1.1 Driver turnover

The driver turnover rate during a period in a company is the ratio of the total number of drivers leaving the company over the average number of employed drivers for the same period (Stephenson & Fox, 1996). The impact of driver turnover can be negative or positive. It is considered as negative, bad or undesirable when a good performer leaves the company and as positive, good or desirable when an underachiever leaves (Whitaker, 2010). Departures can be voluntary or involuntary (dismissals, retirements, deaths, etc.). The literature mainly deals with the negative and voluntary turnover.

2.5.1.2 Driver turnover and trucking efficiency

Driver retention in the trucking industry has been a critical issue for a long time. When a skilled worker leaves a company, it loses his/her knowledge and know-how. In addition, driver turnover inflates costs and disrupts services. The most detrimental costs of driver turnover are related to driver replacement. The costs to hire a new driver comprise prime mover repositioning fees, drug test fees, road testing and training fees and opportunity costs because all these could have been allocated somewhere in the absence of a turnover. Studies estimated all these costs to be between USD $2,200 and $21,000 per driver (Suzuki, Crum, & Pautsch, 2009). Reduced turnover will also reduce these costs for the company. Moreover, low turnover may contribute to enhanced relationships with business partners (Keller & Ozment, 1999b; Min & Emam, 2003; Min & Lambert, 2002; Richard, LeMay, & Taylor, 1995). For example, some customers may be so familiar with a driver that they will allow him/her to pick up and drop-trailers out of hours. This is unlikely to happen in a high turnover context; turnover accordingly appears as counterproductive.

Driver turnover can also disrupt the supply chain due to inappropriate on-road behaviours (Cantor, et al., 2013; Cantor, Macdonald, & Crum, 2011). Min and Lambert (2002), in contrast to Corsi, et al. (1988), found that driver turnover may not necessarily result in poor safety. They believed that this unexpected finding might be the outcome of tougher safety standards, new equipment, skilled drivers and compulsory drug testing (in the US). However, these improvements may not necessarily lead to good safety outcomes. An analysis of US data by Staplin and Gish (2005) revealed that the crash likelihood increases when a driver changes his/her job more than two times per year. This likelihood tends to double when they change jobs three times or more.

2.5.1.3 Effect of driver pay on turnover

Heavy vehicle drivers are the core of the supply chain system and therefore it is necessary to examine the ways to improve their efficiency and effectiveness by identifying the factors underlying their job satisfaction. Satisfied workers are more inclined to take steps to enhance their job performance while dissatisfied workers tend to leave the company or adopt attitudes which may not be favourable to its expansion (Autry & Daugherty, 2003). In a cross-sectional survey, US truck drivers reported a negative relationship between job satisfaction levels and their willingness to leave jobs (Williams & George, 2013). To reduce driver turnover, trucking companies have designed various policies to hire and retain drivers including pay increases, financial bonuses, upgraded equipment, job promotion opportunities and flexible schedules (Min & Emam, 2003; Min & Lambert, 2002).

Adequate payments have been acknowledged as a key force in increasing HV driver satisfaction and preventing driver turnover. Higher pay levels can decrease turnover but may not be cost-effective. A human resource management policy that decreases workers' intention to leave may simultaneously decrease financial performance (Shaw, Delery, Jenkins, & Gupta, 1998). However, increasing drivers' salary, though expensive, should be weighed against the high expenditures of turnover, crash rates for unskilled drivers and the damage to equipment. Especially for skilled and experienced drivers, an increased payroll may more than counterbalance the direct and indirect charges due to high turnover and the associated unwanted effects (Gupta, et al., 1996). As shown in Figure 2.4, driver pay (Costello & Suarez, 2015; Garver, Williams, & Taylor, 2008; Gupta, et al., 1996; Harrison & Pierce, 2009; Humphreys, 2016; Johnson, Bristow, McClure, & Schneider, 2011; Keller, 2002; Keller & Ozment, 1999b; Min & Emam, 2003; Munasinghe, 2000; Richard, et al., 1995; Sersland & Nataraajan, 2015; Shaw, et al., 1998; Williams, Garver, & Taylor, 2011), time spent at home (Costello & Suarez, 2015; Gupta, et al., 1996; Johnson, et al., 2011; Keller, 2002; Keller & Ozment, 1999b; Richard, et al., 1995; Sersland & Nataraajan, 2015; Shaw, et al., 1998; Williams, et al., 2011), equipment (Garver, et al., 2008; Humphreys, 2016; Min & Emam, 2003), connection with dispatch services (Keller, 2002; Keller & Ozment, 1999a, 1999b) and affiliation with top managers (Garver, et al., 2008) are the top factors that influence driver likelihood to leave a company.

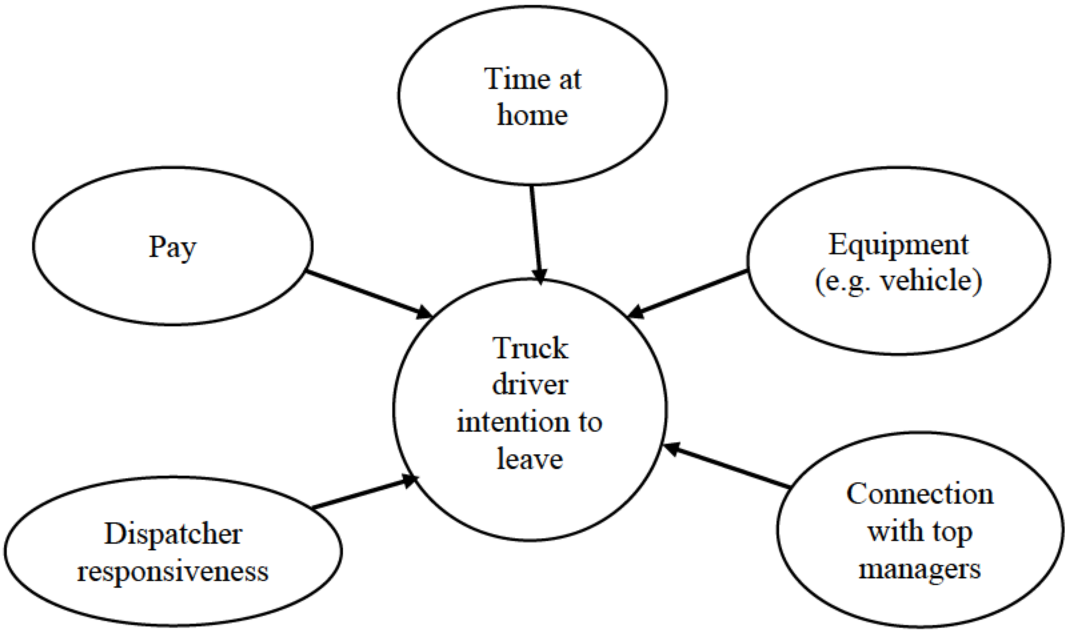


Figure 2.4 Top contributing factors to driver turnover
(adapted from Keller (2002) and Garver, et al. (2008))

As can be seen in Figure 2.4, one factor behind the high turnover among truck drivers is the low pay and its associated benefits. Many companies offer remuneration packages which are likely to be below the market value (Gupta, et al., 1996). In a US survey, HV company managers reported pay as the highest incentive that drivers value while other sources of motivation include the condition of equipment, the amount of time with family, company's reputation and health plans (Southern, Rakowski, & Godwin, 1989). Nearly 42% of the managers also reported that higher pay is an essential element in recruiting and retaining drivers (Min & Lambert, 2002). It is thus vital that truck companies and their clients be aware that increased payments are needed for drivers to minimise driver turnover (Keller, 2002).

Gaertner (1999) found no statistically significant connection between remuneration and job satisfaction and employee commitment. However, several different studies queried this result. Rodriguez, et al. (2006) found that an increase of one cent in the driver distance-based pay rate is associated with an 8.8% reduction in turnover rate. In a US survey, 73% of the drivers reported the expected income as the top reason for guiding their decision to become a truck driver (Stephenson & Fox, 1996). However, almost 60% of surveyed US long-distance truck drivers expressed their unwillingness to recommend this job to their children. The most common reasons were the difficulty in obtaining a reasonably decent income, the high amount of time spent away from home and the non-respect of their occupation (Johnson, et al., 2011). In a study of 227 US trucking companies, drivers' pay was the most correlated factor with their intention to leave a company (Shaw, et al., 1998). Some other US drivers reported inadequate pay and related benefits as the primary reason for which they would leave a company (Harrison & Pierce, 2009). Pay also had the most significant effect on driver turnover rate in a study by Garver, et al. (2008). Vance (2014) found that retirement plans and their amounts are related to decreased turnover. Eligibility for this type of compensation was associated with a 15 to 35% decrease in employee turnover rate.

2.5.2 Driver pay and vehicle condition

2.5.2.1 Vehicle condition and driver performance

Equipment is composed of vehicles and all the technology that can help and facilitate the driver's driving and non-driving tasks. As shown in Figure 2.4, equipment is among the top factors that affect driver turnover in a company. Poor equipment can lead to poor comfort, operational problems, recurrent vehicle defects and therefore, to a deteriorated level of safety (Min & Lambert, 2002). Driving a vehicle in a critical status may dampen the morale of the driver. Drivers working for operators with poorly maintained vehicles are more vulnerable to frustration, anger and carelessness when working. Thus, poorly maintained equipment might increase the likelihood of reckless on-road behaviours (Ouellet, 2010). Driver payment is among the factors that can lead to vehicle defects. Some owner drivers view the time the vehicle spends at the maintenance service as a loss of money. Therefore, a performance-based payment is likely to lead them to postpone vehicle inspections. Financially poor companies may postpone vehicle maintenance and pay their employee drivers based on performance.

2.5.2.2 Effect of driver pay on vehicle defects

Driver payment methods and amounts are linked to vehicle defects. Performance-based payments encourage owner drivers to drive longer hours and postpone vehicle inspections, and financially poor companies tend to postpone maintenance and pay their drivers based on performance. Compensation is related to the quality of job applicants and those who are recruited for a job (Gupta & Shaw, 2014). Thus, companies that pay higher wages can attract, recruit and maintain skilled and experienced drivers. Higher wages incentivise drivers to adopt a good road safety attitude because they are not sure to find better alternatives (Belzer, et al., 2002; Rodríguez, et al., 2004). Corsi (2004) and Britto, et al. (2010) found that operators who devoted a high fraction of their operating expenses to driver pay had significantly improved driver and vehicle safety evaluation scores compared to those who allocated lower fractions to this purpose. Low levels of compensation are likely to be associated with unskilled drivers who are more likely to be unaware of safety technology. In addition, payments based on results put economic pressure on owner drivers. They react to this pressure and tend to breach HOS and speed regulations, ignoring or postponing equipment inspection, maintenance and repairs (Belzer, 2012; Belzer, et al., 2002). In a survey by the Transport Workers' Union of Australia in 2011, 56% of the owner drivers reported skipping vehicle maintenance due to economic pressure (Transport Workers' Union of Australia, 2012). The time devoted to vehicle inspection and repair was viewed as a loss of revenue because they would not be operating during the time required for it (Mooren, et al., 2015).

Financial pressure influences the safety performance of driver and companies. Financially poor companies may be motivated to reduce safety investments. They may, for instance, postpone vehicle maintenance and pay both employee and subcontracted drivers based on the performance which, in turn, may stimulate them to postpone vehicle maintenance (for owner drivers) or drive faster and longer than legally required. Some collaborative solutions to prevent or reduce speeding and fatigued driving and improve vehicle roadworthiness have been implemented or proposed to improve safety in the HV industry. One of these solutions is the CoR legislation, which is explained below within the Australian context.

2.6 CHAIN OF RESPONSIBILITY LEGISLATION

The National Transport Commission (NTC) in Australia and its predecessor, the National Road Transport Commission (NRTC) recognised that the management of safety risk should not solely be the responsibility of vehicle companies and their drivers because the behaviours of both may be affected by the decisions of other parties in the transport logistics and supply chain (e.g. schedulers, loaders, unloaders, loading managers, prime contractors and consigners (NTC, 2007b). Thus, they introduced the CoR legislation in the trucking industry. The CoR legislation aims to improve safety, compliance and productivity, protect infrastructures, involve all the parties in risk management, and protect against the decisions of freight actors in the supply chain that can lead to breach rules. Thus, under the CoR legislation, all parties in the transport logistics and supply chain, not just the driver, have a responsibility to prevent driver fatigue and ensure that the driver complies with the hours-of-service regulations, speed, mass and dimensions limits (NTC, 2007b, 2012b; The Chain of Responsibility Taskforce, 2014).

The CoR principles apply to transport operations that concern involve vehicles of at least 4.5 tonnes. This weight is extended to vehicles of 12 tonnes or more for fatigue-related issues (Jones, 2015). Regarding the specific case of fatigue, the propositions of the Fatigue Expert Group of the NRTC (NRTC, 2001) to alleviate driver fatigue revolve around three points:

1. The need for drivers to have regular and appropriate breaks to sleep;
2. The need to consider the circadian biological clock, which commands that sleep quality is not the same during day and night times; and
3. The need to regulate fatigue aspects of the driving job, including HOS and break periods to recuperate from tiredness.

All the parties for each Transport task in the supply chain must take all reasonable steps to ensure that no one drives while fatigued.

Model CoR legislation was proposed at the Federal Government level. States and territories have the right to decide on which parts of the legislation they will or will not apply and how to apply these (NTC, 2019). For instance, New South Wales has amended the Occupational Health and Safety Act 2000 to emphasise CoR legislation. The Occupational Health and Safety Act 2000, aimed to develop and promote public awareness of occupational health and safety issues, was revised under the Occupational Health and Safety Amendment (Long Distance Truck Driver

Fatigue) Regulation 2005, to regulate further road freight transport (James, et al., 2007). The revised law required the different parties in the supply chain to assess the threats to long-distance truck driver health and safety and initiate actions to remove or control these threats. The law also motivated freight owners not to provide freight transport contracts to long-distance carriers unless they were satisfied with their driver fatigue management plan.

It is hard to disentangle the impact of the CoR legislation on safety from that of changes due to technological innovation, improved roads and vehicle design, and law enforcement. Nevertheless, there is credible evidence that the legislation has been associated with significant improvements of safety in the HV industry (NTC, 2019). However, despite the positive achievements associated with the CoR, crash risk in the Australian HV industry remains significantly high compared to countries such as the United States which have different regulatory frameworks. For instance, during the period that fatalities involving HVs decreased by 10% in Australia, they decreased by 26% in the United States where there is an operator licensing system (Ferro, 2012). Some have argued that the large decrease in the United States could have been due to the financial crisis, which negatively affected vehicle kilometres travelled (Ferro, 2012; Jones, 2015). However, the licensing system in the United States is reinforced by providing customers and other freight actors with reliable and sufficient online data about companies' safety performance to help them make decisions (Mooren & Grzebieta, 2010). This system has been associated with a dramatic reduction in safety violations. Speeding and fatigue remain the most significant proximal contributing factors to HV-related fatal crashes in Australia (Jones, 2015; Mooren, 2016; NTARC, 2017; Stern, et al., 2018) because of economic and reward pressures (Johnstone, et al., 2015; Mooren, 2016; Williamson & Friswell, 2013).

Several inquiries have accordingly suggested the establishment of a framework that ensures the payment of minimum rates that cover driving and non-driving tasks such as loading/unloading and waiting time (NTC, 2008; Quinlan, 2001; Quinlan & Wright, 2008). The effectiveness of this framework would be a pivotal step to reduce risky driving behaviours and improve road safety in the trucking industry. In response to these inquiries, the Federal Labor Government ratified the Road Safety Remuneration (RSR) Act 2012 establishing the Road Safety Remuneration Tribunal (RSRT) which began operating on July 1, 2012 (O'Neill & Thornthwaite, 2016).

The RSR Act 2012 empowered the RSRT to make orders that can impose mandatory regulations on all the actors in the road transport industry for pay and safety of truck drivers. The RSRT established enforceable standards intended to eliminate remuneration-related incentives, pressures and practices that encourage unsafe work practices throughout the road transport supply chain (Johnstone, et al., 2015; Rawling, Johnstone, & Nossar, 2017). These standards were applied nationally across all road transport sectors, including general road transport, distribution, the cash-in-transit industry, and the waste management industry (Johnstone, et al., 2015).

The RSRT made several orders among which was the 2016 RSR Order (RSRO). The 2016 RSRO set minimum hourly and distance-based rates that hirers of drivers in the supermarket retail and long-distance sectors should pay to owner drivers for driving and non-driving time (Rawling, et al., 2017). The supermarket sector was characterised by a pressurised work environment for truck drivers due to the powerful supermarkets passing economic pressures down the supply chain. The long-distance drivers were mostly not paid for non-driving time.

Work providers threatened to not provide work to owner drivers if the 2016 RSRO was implemented. The media then reported the possibility of widespread bankruptcies for owner drivers as the result of the 2016 RSRO. For instance, *The Australian*, in its April 1, 2016 edition, reported that the 2016 RSRO would cause bankruptcy for almost 80% of Australia's owner drivers. The *ABC News* also reported that owner drivers worry about bankruptcies as the result of the 2016 RSRO. These reports have resulted in demands for abolition of the RSRT (Rawling, et al., 2017). The Federal Coalition Government abolished the RSRT in 2016 on the grounds that the 2016 RSRO would make owner drivers less competitive and force some of them out business (Litchfield, 2017).

Other sources, in contrast, claim that establishing minimum pay rates could have been implemented without resulting in widespread bankruptcies. These sources expressed the view that it was exaggeration to connect widespread bankruptcies of owner drivers to the 2016 RSRO (Johnstone, et al., 2015; Litchfield, 2017; Rawling, et al., 2017).

2.7 SUMMARY OF THE REVIEW AND CONCEPTUAL FRAMEWORK

This review showed that driver fatigue and speeding are major contributors to HV crashes. The CoR legislative approach has been associated with significant improvements in HV safety performance. Nevertheless, fatigue and speeding are still significant contributors to poor HV safety performance. Truck companies’ practices regarding driver employment type, driver payment policy and the use of financial resources contribute to the high levels of fatigue and speeding. Nevertheless, the associations of driver employment type and company financial performance with crash involvement are mixed. Driver payment methods may directly or indirectly influence crash involvement. The indirect influence refers to the associations of payment methods with driver turnover and vehicle conditions.

In sum, the review has enabled the identification of the mechanisms through which financial pressure affects safety performance at the company level. A conceptual framework showing these mechanisms is proposed in Figure 2.5 where the arrows show the direction of the influence. An annotated version of Figure 2.5 is provided in Appendix A showing the different studies that supported each arrow. Figure 2.6 shows the theoretical framework of the current research program adapted from the framework presented in Figure 2.5. The commodity type, though not shown in Figure 2.6 is included in the analysis because drivers may operate vehicles more attentively when carrying loads that necessitate specific precautions (Cantor, et al., 2010). Both frameworks use dashed lines (in red), dash-dotted lines (in blue) and full lines (in black). The dashed lines represent the links that have not been examined. The dash-dotted lines indicate the mixed relationships not largely examined while the full lines show the largely examined connections with established or mixed outcomes. For the sake of simplicity, not all the arrows are presented on the graphs. For instance, in Figure 2.5, driver turnover may influence financial performance because of the costs related to the recruitment of new drivers and the potential loss of some business partners with whom drivers were familiar (Keller, 2002; Min & Emam, 2003).

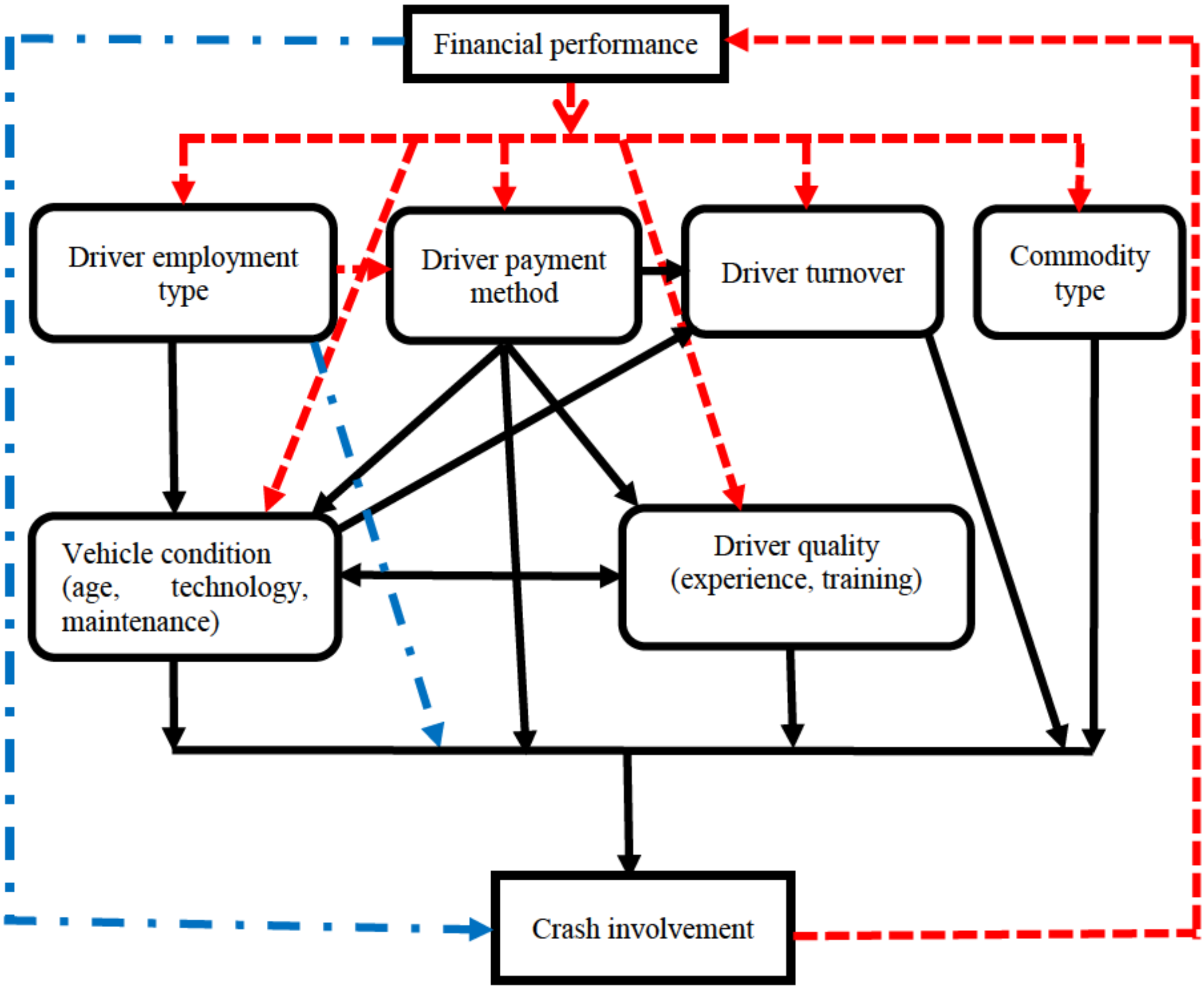


Figure 2.5 Conceptual framework of financial influences on heavy vehicle crash involvement

- - - - - - - - : Not examined so far
— · — · — · : Few examinations with mixed outcomes
——————— : Widely examined with established or mixed outcomes

In Figure 2.6, there may be interactions among employment type, drug use, sleep pattern and driving hours. Some other factors, such as driver distraction also affect crash risk, but the graph focuses on those that are likely to be influenced by driver pay.

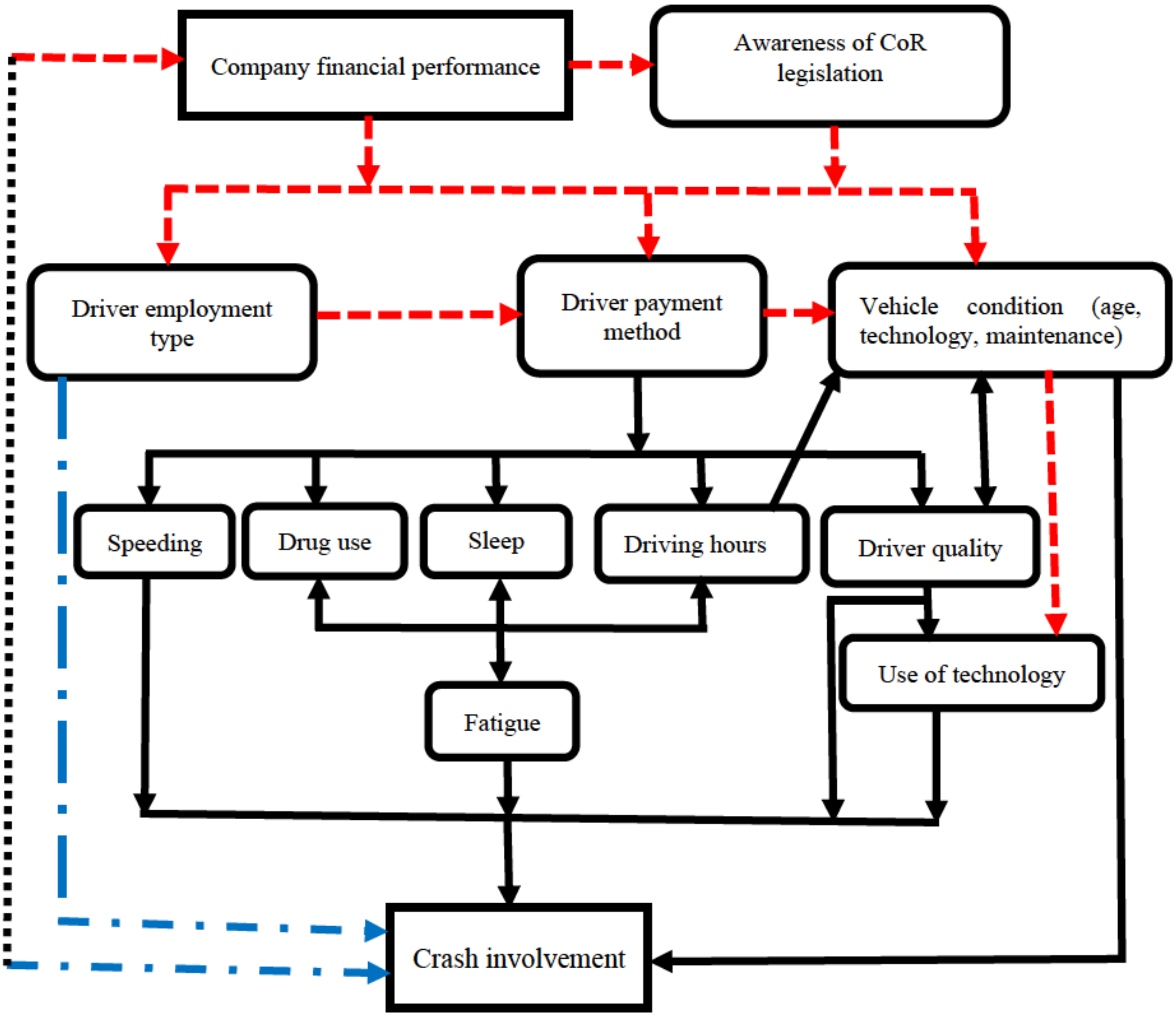
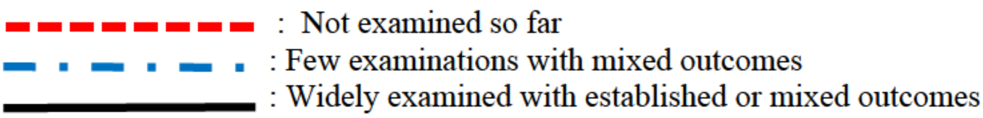


Figure 2.6 Conceptual framework of the research



Regarding the largely examined relationships with established or mixed outcomes in Figure 2.5, greater pay rates may be associated with an increased driver job satisfaction and the prevention or reduction of turnover (Autry & Daugherty, 2003). However, this is not always the case because some drivers may leave a company due to reasons such as stricter safety standards and compulsory drug testing (Min & Lambert, 2002). Driver turnover, in turn, may be associated with an increased crash risk because of good safety performers leaving. A company having a good payment policy is likely to attract experienced and skilled drivers (Gupta, et al., 1996). New vehicles or well-maintained vehicles equipped with advanced technologies can also attract drivers and reduce their willingness to leave a company while old or poorly maintained vehicles could damage driver morale and increase crash risk (Ouellet, 2010). Inexperienced or unskilled drivers may not be aware or familiar with the vehicle manoeuvre and the inside technology. Performance-based payments may encourage drivers or companies to postpone vehicle maintenance because the time devoted to this task would imply a loss of income (Williamson, et al., 2001). Inadequately maintained or older vehicles and inexperienced drivers are vulnerable to crashes. Owner drivers are likely to operate inadequately maintained vehicles because of the financial pressure they face (Quinlan & Wright, 2008). The type of commodity carried may influence driver crash involvement. For instance, the transport of hazardous materials requires vehicles adequately maintained and is accordingly more likely to be associated with lower crash involvement (Beard, 1992).

Figure 2.6 shows that performance-based payments encourage drivers to engage in risky behaviours such as stimulant intake, inadequate sleep and the violation of hour-of-service regulations. These undesired behaviours, in addition to speeding, substantially increase crash risk. Longer driving time may affect vehicle condition mainly because vehicles may not be timely presented for inspection or maintenance.

The financial performance of a company is hypothesised to influence crash involvement through several factors such as employment type, driver payment and vehicle condition. Financially weak companies are likely to pay lower rates to their drivers, and they may also be likely to have older vehicles not equipped with appropriate technology to monitor driver on-road behaviours. Thus, they may tend to adopt a payment method that encourages drivers to comply with safety regulations. Companies with good safety performance are more likely to have higher safety investments (Britto, et al., 2010) and a potentially higher level of familiarity with the CoR legislation. Awareness with the CoR legislation is expected to encourage companies adopting payment policies that are conducive to safety and have their vehicle inspected and maintained appropriately.

The research gaps are identified in the next section. They are based on the conceptual framework that shows the different links and how much they have been examined.

2.8 RESEARCH GAPS

The literature review highlighted several research limitations and gaps as follows.

1. Few studies have examined the link between financial performance and safety performance with mixed findings and there has been no study in Australia;
2. Studies evaluating the impact of safety performance on financial performance are non-existent. Predictions on this issue still rely on theoretical statements;
3. The connection between driver employment type and payment methods has not been established. This may explain the mixture of the findings in terms of safety performance based on employment type;
4. No study has examined the associations of driver employment type and payment methods with the use of safety technology;
5. No study has examined the associations of the CoR legislation with company financial performance, driver employment type and payment methods.

Employment type and payment methods have safety implications mostly in terms of speeding and fatigued driving. This legislation is designed to improve safety in the HV industry; and

6. No study has considered the associations of financial performance with factors such as driver employment type, payment methods, driver quality, load type, the adoption of safety technology and CoR legislation.

2.9 RESEARCH QUESTIONS AND OBJECTIVES

The literature concluded that a comprehensive and consistent knowledge about financial influences on safety performance is lacking. Financial pressure affects road safety outcomes either directly or indirectly through driver payment methods, vehicle condition (age, technology adoption and its usage) and driver employment type. Therefore, the current research seeks to provide a comprehensive analysis of financial influences and the channels through which they affect road safety outcomes. The following research objectives (ROs) and questions have been designed for that purpose:

RO1. Examine the safety impact of driver employment type and payment methods and their relationships with the CoR legislation designed to improve safety in the HV industry

RQ1. Are HV driver employment type and payment methods associated with crash involvement?

RQ2. Are HV driver employment type and payment methods related to driver use of safety technology (cruise control)?

RQ3. Do HV driver payment methods mediate the relationship between driver employment type and fatigue-related behaviours?

RQ4. What is the relationship between HV company awareness of CoR legislation and the driver employment types and payment methods?

RO2. Examine the direct and indirect relationships between HV company financial performance and safety performance.

RQ5. Is there a bidirectional link between company financial performance and HV crash involvement?

RQ6. Is HV company financial performance associated with other factors influencing crash involvement?

2.10 CHAPTER SUMMARY

This chapter began with an overview of the Australian HV industry followed by the factors that influence HV crashes. Then, it showed that there are mixed findings of the relationship between driver employment type and crash involvement on the one hand and between financial and safety performance on the other hand. Concerning driver payment policies, the review showed the mechanisms through which they could influence driver or company safety performance. Research has mostly examined the influence of payment policies on safety performance and reported poor performance for drivers paid on a performance basis. Incentives and other benefits, mostly paid in the United States, have mixed effects on safety performance. The review also showed that the CoR legislation has been associated with considerable progress in safety management, but speeding and fatigue remain major contributing factors to HV-related fatal crashes. A conceptual framework of the research was designed based on the findings. Then, six research gaps were identified, and the objectives and six research questions formulated. The first three questions were related to the direct and indirect associations of driver employment type and payment methods with safety performance. The fourth question concerned the association of the CoR legislation with driver employment type and payment methods, while the remaining questions concerned the interactions between financial and safety performance. The next chapter describes the methodology and research design of the studies conducted to answer the research questions.

Chapter 3: Methodology and research design

3.1 INTRODUCTION

The literature review showed that there is a lack of comprehensive analysis of financial influences on safety performance in the HV industry. Moreover, no study has examined the direct link between financial and safety performance in the Australian HV industry, and existing studies on similar topics elsewhere are inconclusive. Some studies found a positive link (Britto, et al., 2010; Miller & Saldanha, 2016; Pritchard, 2010) while others reported no relationship (Corsi, 2004; Corsi, et al., 1988; Rodríguez, et al., 2004). The current research program is aimed to provide a better understanding of financial influences on safety performance in the HV industry within the Australian context. Financial pressure encourages HV companies to subcontract the driving task and pay performance-based rates or reduce their safety expenditure. Thus, financial pressure may influence safety performance directly or indirectly through safety expenditure, and the driver employment type and payment methods. The current research program firstly examines the safety impact of driver employment type and payment methods and their relationships with the CoR legislation designed to improve safety in the HV industry. Then, it examines the association between financial performance and factors, including driver employment type and payment methods that are likely to influence the safety performance of HV companies.

This chapter provides an overview of the different studies that are designed to achieve the research aim. It describes the different studies, their data sources and their analytical methods. The last two sections of the chapter discuss the ethical issues and summarise the chapter.

3.2 RESEARCH DESIGN AND DATA SOURCES

This research consists of three studies. Study 1 examines the associations of the driver employment type and payment methods with safety performance in the HV industry. This study is divided into three sub-studies. Study 1a and 1c examine the direct connection of driver employment type and payment methods with safety performance represented by crash involvement in Study 1a and fatigue-related behaviours in Study 1c. Study 1c examines the indirect connection of driver employment type and payment methods with safety performance through the use of a speed regulation device (cruise control). Study 2 examines the connection between HV company awareness of CoR legislation and employment type and payment methods. Study 3 examines the relationship between HV company financial performance and safety performance. Each study deals with one or several research questions, as shown in Table 3.1.

Table 3.1 Relevance of the research questions and objectives to the studies

Study		Research question	Objective
1	1a	RQ1	1
	1b	RQ2	
	1c	RQ3	
2		RQ4	
3		RQ5, RQ6	2

Study 1 and 2 are conducted using existing data, while primary data were collected for Study 3. The data for Study 1 were collected between November 2008 and November 2011 in the States of New South Wales and Western Australia by a research team from the George Institute at the University of Sydney, within the framework of an ARC Linkage project, the *Case-control Study of Heavy Vehicle*

Crashes (grant LP0776308). Parts of these data were analysed and presented in earlier publications by Sharwood et al. (2012), Sharwood et al. (2013), Stevenson, et al. (2014), Thompson and Stevenson (2014), Meuleners, Fraser, Govorko, and Stevenson (2015a) and Meuleners, Fraser, Govorko, and Stevenson (2015b). For the current research, the data were obtained from one of the Chief Investigators of this team following the recommendations of the Principal Supervisor of the current research program, who was also among the Chief Investigators of that research team. The data for Study 2 were collected by the National Transport Commission (NTC, 2012b) in a telephone survey, entitled *Survey on Driver Fatigue*, conducted in April and May 2012 from HV companies across Australia within the framework of a research project aimed to assess HV companies' awareness and perceptions of driver fatigue and CoR legislation. The survey was conducted by the Australian Market and Social Research Society. For the current research, the data were obtained from the Chief Investigator of the research team that collected the data following a recommendation of the Project Director-Productivity, Safety and Environment of the National Transport Commission. Table 3.2 presents the design, participants and data collection method for each study.

Table 3.2 Research plan

Study	Design	Participants	Procedure
1	Quantitative analysis of existing cross-sectional case-control data	1038 Australian long-distance HV drivers in New South Wales and Western Australia	A telephone survey for cases and face-to-face interviews for controls between November 2008 and November 2011
2	Quantitative analysis of existing cross-sectional data	400 managers of Australian HV companies	A telephone survey in April and May 2012
3	Exploratory analysis of primary data	69 office-based employees of Australian HV companies	An online survey between February 1 and October 31, 2019

3.3 RESEARCH METHODOLOGY

3.3.1 Study 1: Associations of employment type and payment methods with driver behaviours and safety outcomes

Research showed that the past crash involvement of HV drivers at the time they are recruited is a critical factor of company safety performance. Nevertheless, the relationship between driver employment type and crash involvement is unclear and has been relatively less examined in Australia than elsewhere. Study 1 aims to provide further elucidation of this relationship by also considering driver payment methods which have been largely shown to influence driver safety performance.

3.3.1.1 Method

3.3.1.1.1 Participant recruitment

The participants were drivers of HVs (weight ≥ 12 tonnes) undertaking long-distance trips (distance ≥ 200 kilometres from their base) during the study period (Stevenson et al., 2010). Cases were drivers involved in police-attended crashes in which there were no fatalities and the driver was not seriously injured that occurred during the study period. Controls were drivers who self-reported to have not been involved in such crashes during the previous 12 months (Stevenson, et al., 2014). Figure 3.1 presents the data collection process as described by Meuleners and Fraser (2012) and Elkington and Stevenson (2013). Further information on the driver recruitment process is provided in Chapter 4.

3.3.1.1.2 Analytical method

A variety of modelling methods are used in Study 1 depending on the nature of the outcome variable and the objective of each sub-study. Study 1a and 1b use binary logistic regressions. Study 1c uses a mediation analysis which is based on likelihood ratio tests comparing nested models. In each regression, the explanatory variables are those correlated to the dependent variables in a chi-square test with a P-value<0.2 following the approach taken by Stevenson, et al. (2010) and Thiese et al. (2015) in their examinations of the factors influencing HV crashes in Australia and the United Stated States, respectively. All calculations were performed using Stata 15.0.

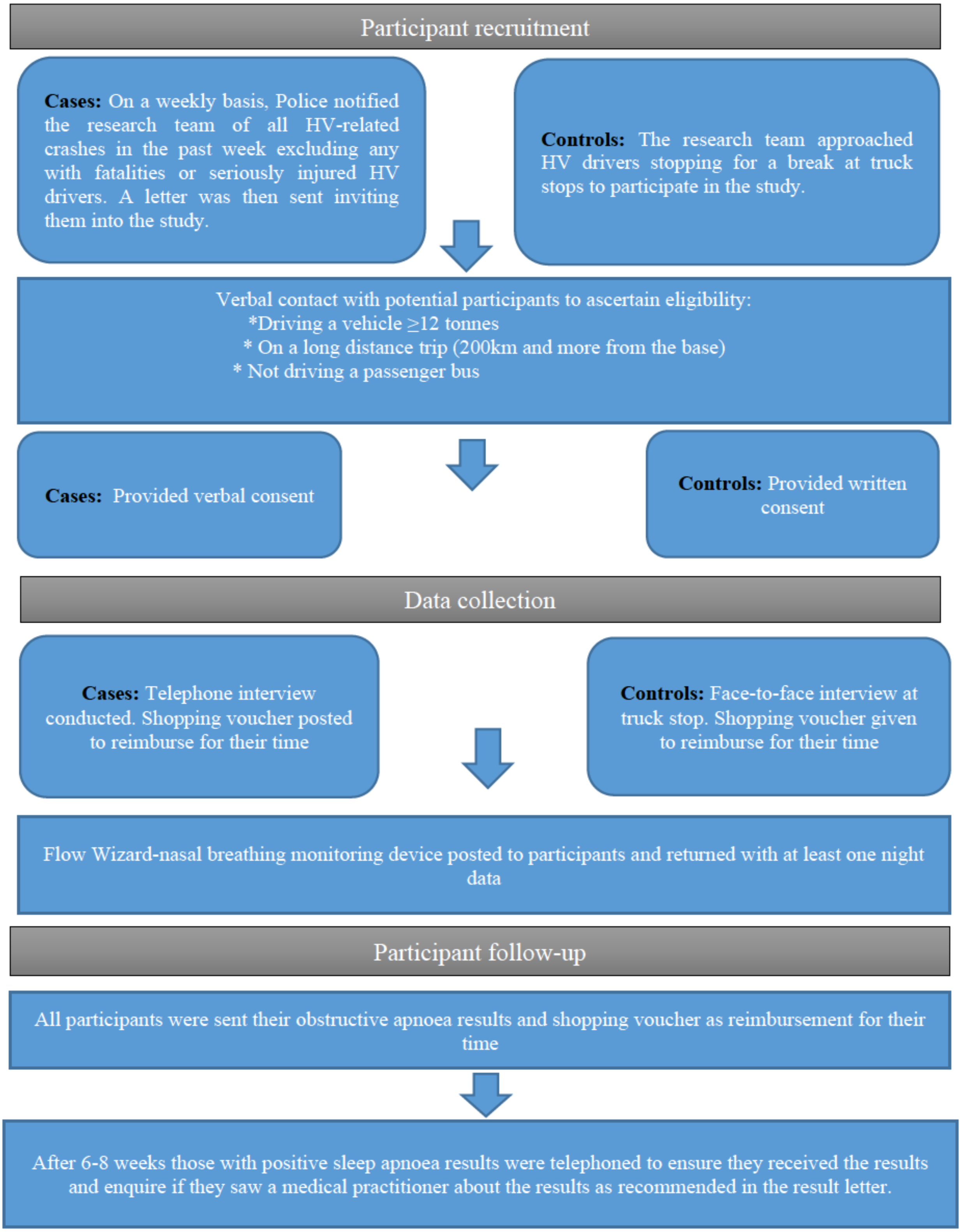


Figure 3.1 Data collection process
(Source: Elkington & Stevenson, 2013; Meuleners & Fraser, 2012)

3.3.1.2 Study 1a: Driver employment type and payment methods as predictors of crash involvement

Study 1a examines the direct link between employment type and payment methods and safety performance. It deals with the following research question.

RQ1. Are HV driver employment type and payment methods associated with crash involvement?

Statistical analysis

The outcome variable in this study is crash involvement represented by a binary equalling 1 for cases and 0 for controls. Thus, logistic regression is estimated using the categorical variables employment type and payment methods while controlling for the effects of other categorical or continuous explanatory variables selected based on their correlations with the crash involvement in a chi-square test with a P-value<0.2.

The logistic regression models the relationship between a binary dependent variable and a set of explanatory variables. Let Y_i be the dependent variable and suppose that $Y_i = 1$ with the probability p_i and $Y_i = 0$ with the probability $1 - p_i$. The logistic regression is developed based on the natural logarithm of the odds using a logit transformation (Washington, Karlaftis, & Mannering, 2010) as given in equations 3.1-3.2.

$$Y_i = logit\ (p_i) = Log\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 X_{1,i} + \beta_2 X_{2,i} + \cdots + \beta_k X_{k,i} \tag{3.1}$$

where β_0 is the constant, β_1, …, β_k are the regression parameters associated with the explanatory variables X_1, …, X_k, respectively, k is the number of variables, and i represents the individual.

The estimated parameters are then used to compute the probability that the dependent variable $Y_i = 1$, Thus,

$$P(y=1)=\frac{EXP[\beta_0+\beta_1 X_{1,i}+\beta_2 X_{2,i}+\cdots+\beta_k X_{k,i}]}{1+EXP[\beta_0+\beta_1 X_{1,i}+\beta_2 X_{2,i}+\cdots+\beta_k X_{k,i}]} \quad (3.2)$$

The estimates of logistic regressions are interpreted in terms of odds ratios (ORs). An OR in a logistic regression measures the strength of the association between the associated explanatory variable and the dependent variable. According to Washington, et al. (2010), an OR in a logistic regression refers to the amount by which the odds of a dependent variable increases (OR>1) or decreases (OR<1) when the associated explanatory variable increases by 1 unit. A lower OR implies a low-probability event while a greater OR implies a greater probability-event.

The goodness-of-fit of the model of the logistic regression is assessed using the P-value associated with the F-statistic of the model. A P-value less than 1% or 5% implies that the model is globally significant at the 99% or 95% confidence level, respectively.

3.3.1.3 Study 1b: Driver employment type and payment methods as predictors of the use of cruise control

Speeding is among the major contributing factors to HV-related fatal crashes. If all HVs were to comply with speed limits, the number of crashes would have been reduced by almost 30% in Australia (Mooren, et al., 2014). Moreover, inadequate following distance was the cause of one in three crashes of National Truck Insurance-insured truck companies in 2017 (NTARC, 2019) suggesting that using CC may help reduce speed-related crash involvement.

Study 1b examines the indirect association of driver employment type and payment methods with safety performance as indicated by the use of CC. It deals with the following research question.

RQ2. Are HV driver employment type and payment methods related to driver use of safety technology (cruise control)?

Statistical analysis

The dependent variable in Study 1b is a binary variable equalling 1 if the driver uses CC and 0 otherwise. As in Study 1a, logistic regression is estimated using the categorical variables employment type and payment methods while controlling for other confounding factors selected based on their correlations with the use of CC in a chi-square test with a P-value<0.2. This study also assesses whether the payment method may moderate the relationship between employment type and the use of CC.

A moderator influences the strength or direction of the association between an explanatory variable and an outcome variable (Baron & Kenny, 1986). The moderator may reduce the strength of the association from strong to moderate. The effect of the moderator as explained by Baron and Kenny (1986) is assessed through interaction terms, in the present case, between employment type and the payment method. Figure 3.2 shows the moderation model whose associated analytical equation is given in equation 3.3 where a_0, a, b and c are the regression parameters and e is the residual, X is a vector containing the other explanatory variables and d is the vector of regression parameters associated with these variables.

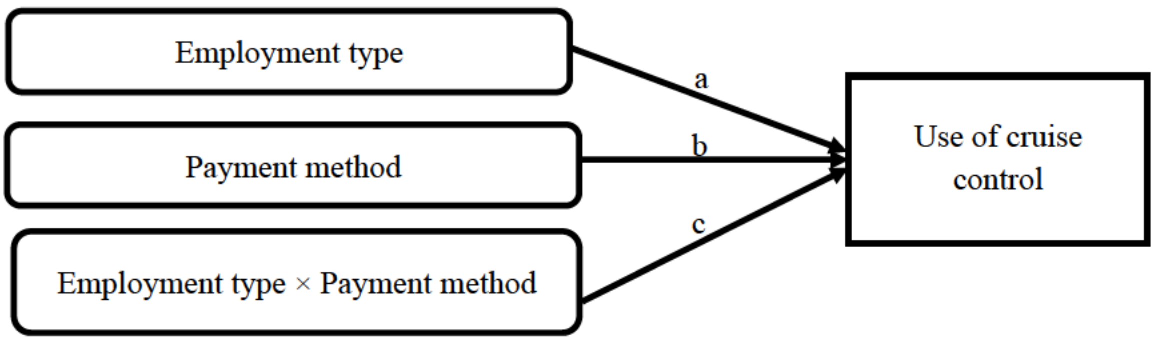


Figure 3.2 Moderation model

$$Use\ of\ cruise\ control = a_0 + a \times Employment\ type + b \times Payment\ method + c \times (Employment\ type \times Payment\ method) + dX + e \quad (3.3)$$

Payment method is a moderator if c is statistically significant irrespective of whether a and b are significant or not. It is preferable that the payment method is uncorrelated with employment type and the use of CC for the analysis to provide meaningful results (Baron & Kenny, 1986).

3.3.1.4 Study 1c: Driver payment methods as a mediator between employment type and fatigue-related behaviours

Fatigued driving is among the major contributing factors to HV driver crash involvement. While Study 1b examines payment methods as a moderator between employment type and the use of CC, Study 1c examines payment method as a mediator between employment type and three fatigue-related behaviours: stimulant intake, frequency of drowsy driving, and rest breaks. A mediator represents the possible mechanism through which an explanatory variable can produce changes in an independent variable (Baron & Kenny, 1986; MacKinnon, Fairchild, & Fritz, 2007). Study 1c deals with the following research question.

RQ3. Do HV driver payment methods mediate the relationship between driver employment type and fatigue-related behaviours?

Mediation analysis

Figure 3.3 shows payment method as a mediator between driver employment type and fatigue-related behaviours. The upper part shows the direct relationship between employment type and the fatigue-related behaviour, while the lower part shows the payment method as a mediator of this relationship. The analytical framework for the payment method as a mediator of this relationship is presented in equations 3.4-3.6.

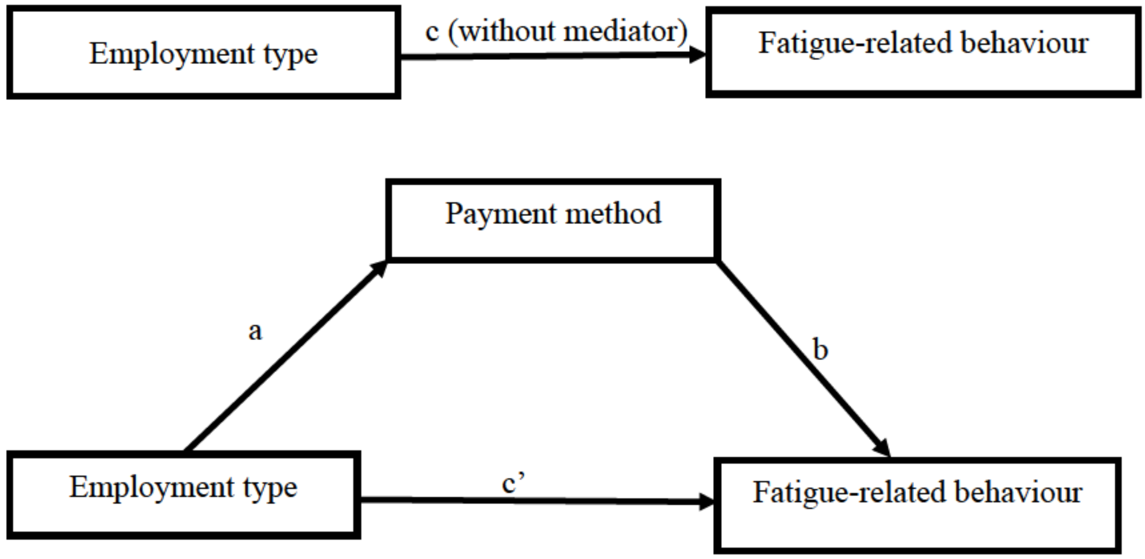


Figure 3.3 Mediation model

$$Payment\ method = i_1 + a \times Employment\ type + e_1 \quad (3.4)$$

$$Fatigue\ related\ behaviour = i_2 + c \times Employment\ type + e_2 \quad (3.5)$$

$$Fatigue\ related\ behaviour = i_3 + c' \times Employment\ type + b \times Payment\ method\ + \ e_3 \quad (3.6)$$

where i_1, i_2, i_3, a, b, c and c' represent regression parameters whereas e_1, e_2 and e_3 are the residuals.

Equations 3.4-3.6 are based on what Baron and Kenny (1986) label as the causal steps approach for mediation analysis, which is based on statistical tests of the regression parameters. In the causal steps approach, payment method mediates the relationship between employment type and fatigue-related behaviour if firstly, Employment type significantly affects the Payment method in equation 3.4; secondly, Employment type significantly affects Fatigue-related behaviour in equation 3.5; thirdly, Payment method significantly affects Fatigue-related behaviour in equation 3.6; and fourthly, the absolute value of the effect of Employment type on Fatigue-related behaviour in equation 3.6 is less than that of Employment type on Fatigue-related behaviour in equation 3.5. There is perfect mediation if Employment type does not significantly affect Fatigue-related behaviour when Payment method is controlled in equation 3.6.

3.3.2 Study 2: Associations of company awareness of CoR legislation with the employment types and payment methods

Under the CoR legislation, all parties in the transport logistics and supply chain, not just the driver, have a responsibility to prevent driver fatigue and ensure that the driver complies with the HOS regulations and speed limits as well as mass and dimensions limits. Transport operators, consignors, receivers, loader and unloaders could be held accountable for any action or inaction that contributes to non-compliance with safety regulations.

Research has shown that HV driver employment type and payment methods have safety implications mostly in terms of compliance with the HOS regulations and speeding. Study 2 examines the link between company awareness of CoR legislation and how companies employ and pay drivers. It deals with the following research question.

RQ4. What is the relationship between HV company awareness of CoR legislation and the driver employment types and payment methods?

3.3.2.1 Participant recruitment

The participants were the logistics or operations or freight managers of companies operating HVs of at least 12 tonnes. The contact information of these managers was retrieved from companies' websites on Yellow Pages. The managers were then telephoned to conduct 45-minute interviews. The survey was conducted by the Australian Market and Social Research Society.

3.3.2.2 Statistical analysis

Driver employment type and payment methods are the two outcome variables in this study. Given that both are unordered categorical variables, multinomial logistic regressions (MLRs) are estimated for each of these variables including some CoR-related variables and other variables correlated with the outcome variables in a chi-square test with a P-value<0.2.

Multinomial logistic regressions provide odds ratios (ORs) which have the same interpretation as ORs in binary logistic regressions, with the comparison being to the reference category (Cameron & Trivedi, 2010). An OR smaller than 1 implies that the outcome has lower odds of being in the comparison category than the reference category. An OR greater than 1 implies that the outcome has higher odds of being in the comparison category than the reference category while an OR of 1 means that there is no difference between the comparison category and the reference category (Garson, 2014).

The MLR models the relationship between an unordered categorical dependent variable and a set of explanatory variables. The standard MLR model as presented by Washington, et al. (2010) is given in equation 3.7.

$$P_n(i) = \frac{EXP[\beta_i X_{in}]}{\sum_{\forall I} EXP[\beta_I X_{In}]} \tag{3.7}$$

where $P_n(i)$ is the probability that individual n chooses alternative i among the available I choices; X_{in} is the vector of explanatory variables and β_i the vector of the regression parameters associated with these explanatory variables.

The goodness-of-fit of the model of the MLR is assessed using the P-value associated with the Wald-statistic for each model. A P-value less than 1% or 5% implies that the model is globally significant at the 99% or 95% confidence level, respectively.

3.3.3 Study 3: Relationships between company financial performance and safety performance

Financial performance has been hypothesised to influence HV company safety performance. Nevertheless, research has not established whether this hypothesis is worthy of support. This study examines this hypothesis and extends it to examine whether safety performance influences financial performance. Moreover, it examines whether the financial performance could indirectly affect safety performance through its relationship with other factors influencing crash involvement. Thus, it deals with the following research questions.

RQ5. Is there a bidirectional link between company financial performance and HV crash involvement?

RQ6. Is HV company financial performance associated with other factors influencing crash involvement?

3.3.3.1 Participant recruitment

The participants were representatives of heavy trucking operators having a sufficient understanding of the financial and safety performance of the company, as well as how drivers are paid and managed (the use of company drivers versus the use of contractors). HV companies telephone numbers were obtained from the Yellow Pages website and the research team telephoned them to explain the purpose of the survey and request the emails of those willing to participate in order to email them the survey. However, participants were less responsive to this option, reducing the likelihood of obtaining sufficient participants. Thus, the survey was emailed to the Safety, Health and Wellbeing Director of the Australian Trucking Association (ATA) to be forwarded to TruckSafe members. TruckSafe is a voluntary industry accreditation scheme established by the ATA (NTARC, 2019). TruckSafe members were more responsive to the survey than companies obtained from Yellow Pages.

3.3.3.2 Statistical analysis

The first part of RQ5, the influence of financial performance on safety performance, is examined using logistic regression with the dependent variable represented by at-fault crash involvement and the main explanatory variable being financial performance. The second part of RQ5, the influence of safety performance on financial performance, and RQ6 could have been examined using an ordered probit or a mixed logit model, but because of the small sample size, they are examined using a correspondence analysis (CA).

3.3.3.2.1 Correspondence analysis

Correspondence analysis is known under several other titles such as homogeneity analysis (Greenacre, 2002), geometric data analysis (Le Roux & Rouanet, 2010), categorical principal component analysis (Di Franco, 2016) and biplot analysis (Kamalja & Khangar, 2017).

The use of CA in road safety research is not new, though it is less common than other statistical techniques such as logit, binomial or multinomial models (Baireddy, Zhou, & Jalayer, 2018). For example, CA has been used to examine the relationships among factors contributing to pedestrian fatalities in South Africa (Mabunda, Swart, & Seedat, 2008), to identify factors contributing to vehicle-pedestrian crashes in Louisiana (Das & Sun, 2015) and pedestrian crashes in rural Illinois (Baireddy, et al., 2018), to examine factors associated with high school drivers crashes in Texas (Das, Minjares-Kyle, Wu, & Henk, 2019), and to explore the association among some US bicyclist fatal crash contributing factors (Das, Jha, Fitzpatrick, Brewer, & Shimu, 2019).

3.3.3.2.2 Description of correspondence analysis

Correspondence analysis is an exploratory and descriptive technique that enables researchers to examine graphically in a low-dimensional space, the associations among either response categories of a variable or response categories of different variables (Greenacre, 1993). It is termed simple CA when it is conducted on a contingency table of two variables, and multiple CA, when the contingency table contains more than two variables. The CA method, as stated by Aktürk, Gün, and Kumuk (2007), is more informative than statistical tests such as chi-square and Fischer's exact tests in the sense that these statistical tests show the existence of a correlation between categorical variables, but cannot reveal the relationships among the different response categories.

Correspondence analysis is an exploratory analysis for categorical variables, like factor analysis for continuous variables, that aims to explain the variance of a model and break this variance down into a low-dimensional display. In other words, it reduces the variability of a model by computing the minimum number of factors that could explain the largest variability of this model (Clausen, 1998). Thus, the CA graphic, also called a correspondence map, is displayed in a multidimensional space showing a cloud of points that represent the rows and columns of a contingency table (Hair, Black, Babin, Anderson, & Tatham, 2010). The standard rule of thumb to decide on the number of dimensions to retain is that this number should explain at least 70% of the variance (Higgs, 1991). Dimension 1 corresponds to the largest percentage of explained variance, dimension 2 corresponds to the next largest variance, and so on (Sourial et al., 2010). The variance or inertia in CA is the dispersion of the row and column points around the average profile (centroid) represented by the origin of the map (Greenacre, 1993). Each dimension has an

Eigenvalue (not greater than 1) indicating its relative contribution to the explanation of the variance (Clausen, 1998; Das & Sun, 2015). It is unlikely to have more than two dimensions in CA because the additional dimensions generally represent negligible proportions of the variance explained (Kudlats, Money, & Hair Jr, 2014).

CA compares how similar or different are row points or column points from each other and from the centroid; the origin of the map (Higgs, 1991). The distance between two row points or two column points on the map is defined by the chi-square distance measured in terms of their relative frequencies and the corresponding marginal frequency (Sourial, et al., 2010). Thus, the closer the row points or the column points, the stronger the association between these points (Le Roux & Rouanet, 2010). However, the distance between row and column points is not mathematically defined (Higgs, 1991; Sourial, et al., 2010). Thus, their degree of association is assessed based on the angle formed by the lines connecting these points from the origin of the map. The sharper the angle, the stronger the points are associated (Higgs, 1991; Tim, 2019a, 2019b). The closer the angle to 90 degrees, the less related are the variables and the closer the angle to 180 degrees, the more negatively correlated the variables (Tim, 2019a, 2019b).

3.4 ETHICAL CONSIDERATIONS

Ethics clearances were sought from QUT for all the data sets used in this research. Ethics exemptions were obtained for Study 1 and 2, and negligible risk/low-risk ethics application was approved for Study 3. Ethics exemption for the data used in Study 1 was obtained from the QUT Human Research Ethics Committee in September 2018, approval number 1800000975. Ethics approval for the original data collection was obtained from the University of Sydney Human Research Ethics Committee in January 2008. Ethics exemption for the data used in Study 2 was obtained from the QUT Human Research Ethics Committee in April 2019, approval number 1900000283. Regarding Study 3, the QUT's Human Research Ethics Committee approved the study on October 15, 2018 under the number 1800000996. Three variations to amend the recruitment process or extend the data collection period were submitted and approved on 20 March 2019; 28 May 2019 and 29August 2019, respectively.

Participants were informed that there might be some inconveniences and minimal risks associated with completing the survey for Study 3. Not only did it take part of their time, but some questions also ask about crash involvement, perception of the financial performance, and other issues (e.g. drivers' management and payment) of companies. The research team suggested that participants should consider their personal situations and whether answering such questions would result in discomfort, before deciding whether to participate. When completing the online survey, they were free to skip any question they did not wish to answer or felt uncomfortable with. Participants were also advised that they could stop the survey at any time by closing their browsers without comment or penalty. However, due to the anonymous nature of the study, if the participant withdrew after starting the survey, it was possible to identify and remove their responses from the study.

3.5 CHAPTER SUMMARY

This chapter presented the three studies of the research program assigning the different research questions to these studies and provided an overview of the survey participants and data sources for each study. Then, it showed the research methodology and provided an overview of the participants, their recruitment methods and the analytical methods that were used in each study. Lastly, it presented the ethical clearances and the chapter summary. The next chapter presents Study 1.

Chapter 4: Study 1 - Associations of employment type and payment methods with driver behaviours and safety outcomes

4.1 INTRODUCTION

The high level of competition in the HV vehicle industry has resulted in some carriers outsourcing the driving task (Houtman, Hesselink, van den Bossche, Berg, & Heuvel, 2004). The use of third-party drivers provides carriers with advantages such as the improvement of profit margins (Quinlan, et al., 2006) and the expansion of services without the need to recruit new drivers (Cantor, et al., 2013), and mitigates exposure to safety risk (Cantor, 2016). However, it is associated with some disadvantages; the outsourced drivers often perform the driving task outside the control of the outsourcing companies (Miller, Golicic, & Fugate, 2018). It is accordingly critical for company managers to ascertain whether it is safer to use their employee drivers or third-party drivers. Moreover, the outsourcing companies to improve profit margins often pay drivers based on the performance. Thus, Study 1 examines the associations of driver employment type and payment methods with safety performance. These factors may directly or indirectly influence driver safety performance. They may directly influence driver crash involvement or fatigue-related behaviours and indirectly influence crash involvement through affecting the use of safety technology such as speed regulation devices. Therefore, Study 1 examines the first three research questions of the research program.

RQ1. Are HV driver employment type and payment methods associated with crash involvement?

RQ2. Are HV driver employment type and payment methods related to driver use of cruise control?

RQ3. Do HV driver payment methods mediate the relationship between driver employment type and fatigue-related behaviours?

The study is divided into three sub-studies 1a, 1b and 1c examining the three research questions, respectively.

4.2 METHOD

4.2.1 Participants

This study uses existing case-control data collected within the framework of an ARC Linkage Project (grant LP0776308) in the States of New South Wales (NSW) and Western Australia (WA) between November 2008 and November 2011. The project aimed to identify the factors that affect crash involvement for HVs. The participants were long-distance (≥ 200 kilometres from the base) drivers of HVs (weight ≥ 12 tonnes) (Stevenson, et al., 2010). Cases were drivers involved in a crash during the survey period while controls were drivers not involved in a crash during the past 12 months. The response rates were 59% for cases and 58% for controls (Sharwood, et al., 2013; Stevenson, et al., 2014) . Each participant was provided with a $50 retail voucher for the time spent in the survey.

Data from this case-control study have previously been used to examine the prevalence of sleepiness and sleep disorders among HV drivers in NSW and WA (Sharwood, et al., 2012; Stevenson, et al., 2014) , to evaluate the link between the intake of caffeinated substances and crash risk in NSW and WA (Sharwood, et al., 2013), the relationship between sleepiness and sleep disorders and crash risk in NSW and WA (Stevenson, et al., 2014), the connection to driver payment methods and to HV driver fatigue and sleepiness (Thompson & Stevenson, 2014), the assessment of sleep disorders and health factors with crash risk (Meuleners, et al., 2015a), and the association between a driver's work environment factors and HV crash risk in WA (Meuleners, et al., 2015b).

4.2.2 Procedure

4.2.2.1 Cases

Both cases were drivers involved in police-attended crashes during the study period. They were identified at the end of each week from police-reported data. Drivers were excluded if they were seriously injured in the crash or if any fatalities resulted from the crash because it was deemed that the survey would be stressful for these drivers. Seriously injured persons were those hospitalised for at least two weeks or who were in a state of unconsciousness due to the crash (Stevenson, et al., 2014).

Eligible participants were sent invitation letters advising them that the research team would telephone them and that participation in the survey was purely voluntary and could be declined. The letter identified the study purpose as "*studying the numerous factors related to heavy vehicle crashes"* to *"identify appropriate ways to manage heavy vehicle safety in Australia"*.

Two weeks after the letter was sent, the driver was telephoned, and after a verbal agreement, a 40-minute interview was immediately conducted to fill out the questionnaire. Drivers not willing to participate in the interview declined their participation by mail or telephone at the time they were contacted. A total of 194 drivers were interviewed as cases.

4.2.2.2 Controls

Controls were selected by approaching drivers, most often during meal or refuelling times, at truck stops in NSW and WA distributed across the routes most frequented by long-distance HV drivers. The purpose of the study was introduced as "*studying truck crashes aiming to identify strategies to improve safety in your industry"*. Drivers were included in the survey if they agreed to participate and self-reported not having been involved in police-attended crashes over the previous 12 months. Drivers who agreed to participate in the interview provided written agreement and were immediately interviewed using a structured protocol which took approximately 30 minutes to complete. Those who agreed, but could not participate directly because of job constraints, provided their contact information. Then, a time for a telephone interview was immediately scheduled within the following two days. A total of 844 drivers were interviewed in the control group.

The interviews for both cases and controls were conducted between 6:00 AM and midnight and spread over different times, days, weeks and months to capture various travel patterns. Each participant was given a $50 supermarket voucher in compensation for the time spent in the interview. They were guaranteed the confidentially and anonymity of the survey.

Both case and control interviews were conducted by the same researchers who were trained based on a standardised protocol. The questionnaire included questions on driver demographics, crash involvement history, schedules and work patterns, employment type, payment methods, types of vehicles and loads. Both samples were given the same questionnaire, except for the question about the number of crashes, which was not included for the controls.

4.2.3 Description of employment type and payment methods, and participant demographics

All cases and 94.4% (N=841) of controls were men. Cases and controls did not differ statistically in terms of age (cases: 44.5 years, SD=10.4; controls: 45.3

years, SD=10.5), driving experience (cases: 16.9 years, SD=11.4; controls: 17.7 years, SD=12.3, N=842), or distance driven during the past week (cases: 3,771 kms, SD=1,667.2, N=191; controls: 3,774 kms, SD=1,773.6, N=836). Driver's age was recoded as a 3-category variable (24-44; 45-64 and 65 and more), following the cut-off values of the World Health Organisation, to test whether the relationship between crash involvement and age is non-linear.

In the survey, drivers were asked to indicate their employment type and the payment method for most of the trips they undertook over the past week. Drivers could be employee drivers, owner drivers, subcontractor drivers or other drivers. In terms of payment methods, drivers could be paid time-based rates, single pay plus overtime rates or performance-based rates. Time-based rates were composed of hourly, daily and weekly rates while performance-based rates were composed of distance and trip-based rates. Single time pay plus overtime rate refers to situations where drivers are paid a fixed salary for working a specified number of hours per day or days per week, and then receive additional payment for any extra hours or days worked. In this study, payment method is represented by a five-category variable: time-based rates, single time pay plus overtime rates, trip rates, distance-based rates and other rates. Table 4.1 shows the cross-tabulation of employment type and payment method for cases and controls. The payment method was quite mixed for employee drivers and about two-thirds of owner drivers and subcontractor drivers were paid performance-based rates (trip or distance-based). The Cramer's V statistic (a measure of correlation among categorical variables) showed a negligible correlation between employment type and payment method for cases (V=0.22), controls (V=0.19) and the combined sample (V=0.18). A V statistic lower than 0.30 indicates a weak to a negligible correlation (Kraska-Miller, 2013).

Table 4.1 Cross-tabulation statistics between employment type and payment methods

	Employment type in past week			
	Employee driver	Owner driver	Subcontractor driver	Other driver
Cases (N=194)				
Payment method in past week	134 (%)	16 (%)	31 (%)	0 (%)
Time-based rate	40 (29.9)	5 (31.3)	5 (16.1)	0 (0.0)
Single time pay plus over time	5 (3.7)	0 (0.0)	0 (0.0)	0 (0.0)
Trip rate	30 (22.4)	6 (37.5)	11 (35.5)	0 (0.0)
Distance-based rate	59 (44.0)	5 (31.2)	15 (48.4)	0 (0.0)
Controls (N=844)				
Payment method in past week	591	102	113	26
Time-based rate	171 (28.9)	16 (15.7)	29 (25.6)	8 (30.8)
Single time pay plus over time	33 (5.6)	0 (0.0)	2 (1.8)	0 (0.0)
Trip rate	143 (24.2)	46 (45.1)	25 (22.2)	7 (26.9)
Distance-based rate	216 (36.6)	21 (20.6)	55 (48.7)	6 (23.1)
Other rate	28 (4.7)	19 (18.6)	2 (1.7)	5 (19.2)

4.3 STUDY 1A: DRIVER EMPLOYMENT TYPE AND PAYMENT METHODS AS PREDICTORS OF CRASH INVOLVEMENT

A modified version of Study 1a was published as part of:

Soro, W., L., Haworth, N., Edwards, J., Debnath, A., K., Wishart, D., & Stevenson, M. (2020). Associations of heavy vehicle driver employment type and payment methods with crash involvement in Australia. *Safety Science.* 127, 104718. https://doi.org/10.1016/j.ssci.2020.104718.

4.3.1 Introduction

The relationship between employment type and crash involvement in the HV industry is not empirically established. Most of the empirical studies were conducted at the company level. Company-level data provide evidence of the aggregate safety performance of companies but not of the individual safety performance of drivers. Thus, these data cannot provide conclusive evidence that employment type influences safety at the individual level (Monaco & Redmon, 2012). The association between employment type and truck driver safety performance has also been relatively less explored in Australia in comparison to the United States. Importantly, none of the previous studies examined the influence of the payment method despite reports that this affects driver behaviours (Belzer & Sedo, 2018; Mooren, et al., 2015; O'Neill & Thornthwaite, 2016). Therefore, Study 1a addresses Research Question 1 (Are HV driver employment type and payment methods associated with crash involvement?).

4.3.2 Variable selection and regression model

An unconditional logistic regression is used to assess the associations of driver employment type and payment methods with crash involvement while controlling for other confounding factors such as payment for the time related to non-driving tasks such as loading and unloading. Payment method for the time related to non-driving tasks had four categories for loading time and unloading time: not paid, same as for driving time, a flat amount and an hourly rate. Nevertheless, the questionnaire did not specify the difference between *same as for driving time* and *hourly rates.* These categories overlap for drivers paid hourly for driving time. Thus, following Kudo and Belzer (2019b), the payment for the time related to these non-driving tasks was turned to a binary variable equalling 1 if both loading and unloading times are paid and 0 otherwise.

Crash involvement as the dependent variable is represented by a binary variable equalling 1 for cases and 0 for controls. The explanatory variables retained for modelling are those related to the dependent variable in a chi-square test with a P-value <0.2 following the practice adopted by Stevenson, et al. (2010) and Thiese, et al. (2015) in their studies of the factors that affect HV crashes in Australia and the United States, respectively.

Among the variables included in the regression estimation, the case group had 35 (18.0%) missing values distributed among employment type (2.1%), payment methods (4.6%), payment for both loading time and unloading time (11.3%) while the controls had 75 (8.9%) missing values distributed among load type (0.2%), driving experience (0.2%), payment methods (1.4%), payment for both loading time and unloading time (7.0%). The missing values were included in the regression using the multiple imputations method, the state-of-the-art technique to handle missing data (Enders, 2010). It uses the distribution of the observed data to estimate a set of plausible values for the missing observations. The logistic regression was estimated using the multiple imputations by chained equations function (White, Royston, & Wood, 2011) in Stata 15.0.

Driving experience and driver age (under its continuous form) were not included in the same model because they were highly and significantly correlated (Pearson correlation coefficient r = 0.68) at the 95% confidence level. The model including age is presented in the study because it has the smallest average relative variance increase. The average relative variance increase in estimations using multiple imputations represents the effects of the loss of information due to missing data on the variance of the model. The lower the average relative variance increase, the less are the effects of missing data on the variance of the model (White, et al., 2011). Truck type was removed from the analysis because there were so few rigid trucks among the cases that it prevented testing other more relevant variables.

4.3.3 Results

Table 4.2 compares the descriptive statistics for cases and controls of the truck type and the variables included in the logistic regression. The logistic regression estimates providing odds ratios (ORs), P-values and confidence intervals (CI) are presented in Table 4.3. The ORs measure the strength of the associations between the explanatory variables and crash involvement. An OR less than 1 suggests that the explanatory variable is associated with a reduction in crash involvement. An OR greater than 1 suggests that the explanatory variable is associated with an increase in crash involvement. An OR of 1 suggests that the explanatory variable does not affect crash involvement.

Table 4.2 Descriptive statistics of truck type and the variables included in the logistic regression

Variable	Cases (N=194)	Controls (N=844)
	(%)	(%)
Employment type in past week		
Employee driver	138 (71.1)	593 (70.2)
Owner driver	20 (10.3)	108 (12.8)
Subcontractor driver	32 (16.5)	115 (13.6)
Other driver	00 (0.0)	28 (3.4)
Missing values	4 (2.1)	00 (0.0)
Payment method in past week		
Time-based rate	51 (26.3)	224 (26.6)
Single time pay plus overtime	5 (2.6)	35 (4.1)
Trip rate	50 (25.8)	221 (26.2)
Distance-based rate	79 (40.7)	298 (35.3)
Other rate	00 (0.0)	54 (6.4)
Missing values	9 (4.6)	12 (1.4)
Payment for time spent loading and unloading in past week		
Yes	96 (49.5)	466 (55.2)
No	76 (39.2)	319 (37.8)
Missing values	22 (11.3)	59 (7.0)
Truck type on the current trip		
Rigid truck	10 (5.1)	67 (7.9)
Semitrailer	87 (44.9)	371 (44.0)
Road train	17 (8.8)	116 (13.7)
B-double	80 (41.2)	290 (34.4)
Load type on the current trip		
General freight or mixed freight	61 (31.4)	292 (34.6)
Livestock and dangerous goods	9 (4.6)	58 (6.9)
Other goods	38 (19.6)	109 (12.9)
Empty	86 (44.4)	383 (45.4)
Missing values	00 (0.0)	2 (0.2)
Driver age (years)		
24-44	99 (51.0)	412 (48.8)
45-64	90 (46.4)	406 (48.1)

65 and more	5 (2.6)	26 (3.1)

Table 4.3 Estimates from the logistic regression of crash involvement

Variable	Odds ratio	P-value	95% CI
Employment type in past week			
Employee driver	1.00	-	-
Owner driver	0.50**	0.008	0.30 to 0.83
Subcontractor driver	0.82	0.37	0.54 to 1.26
Pay method in past week			
Time-based rate	0.67*	0.04	0.46 to 0.99
Single time pay plus overtime	0.44	0.10	0.16 to 1.18
Trip rate	0.56**	0.002	0.39 to 0.80
Distance-based rate	1.00	-	-
Payment for time spent loading and unloading in past week			
Yes	0.50**	<0.001	0.36 to 0.68
No	1.00	-	-
Load type on the current trip			
General freight or mixed freight	0.59**	0.002	0.42 to 0.82
Livestock and dangerous goods	0.45*	0.03	0.21 to 0.95
Other Goods	1.13	0.56	0.73 to 1.75
Empty	1.00	-	-
Driver age			
24-44	1.00	-	-
45-64	0.55**	<0.001	0.42 to 0.73
65 and more	0.46	0.12	0.17 to 1.24

**p<0.01, *p<0.05

There were no “other” employment types or payment methods among the cases, so these categories are not included in the regression. The distance-based rate is considered as the reference category because it had previously been identified as linked to the poorest safety performance (O’Neill & Thornthwaite, 2016; Quinlan & Wright, 2008). The F-test for the overall model provided a statistic of 24.85 with an associated P-value<0.0001, implying that the model is globally significant at the 99% confidence level.

Owner drivers had lower odds of crash involvement than employee drivers. Distance-based rates were associated with higher odds of crash involvement than time-based and trip rates. Drivers who were paid for the time spent loading and unloading had lower odds of crash involvement than those not paid for this time.

4.3.4 Discussion

Previous research has produced mixed evidence regarding the influence of heavy vehicle driver employment type on crash involvement. This study examined this influence, along with that of payment methods, using Australian data. The findings suggest that payment method and employment type are associated with crash involvement.

The lower odds of crash involvement for owner drivers than employee drivers is consistent with the findings of Dammen (2005) and Cantor (2014). Owner drivers, as self-employed persons, face financial pressure to cover their costs. Nevertheless, as reported by Nickerson and Silverman (2003), a crash may necessitate the repair of vehicles with significant cost repercussions and time delays. Moreover, for Cantor, et al. (2013) the time devoted to repairing vehicles may be seen as a loss of money due to the loss of other job opportunities. Thus, owner drivers may be less likely to be involved in crashes than employee drivers. Furthermore, employee drivers may be more likely to be involved in crashes than owner drivers if the employing company allocates fewer resources to equipment maintenance and/or stimulates them to drive faster and longer through distance-based payments (Cantor, 2016). It might also be that owner drivers underreported their crash involvement more than employee drivers.

The results of this study showed evidence of an association between payment method and crash involvement. Drivers paid time-based rates, trip-based rates or other rates had lower odds of crash involvement than those paid distance-based rates. While time-based payments may be associated with driving longer than advisable, distance-based rates incentivise both faster and longer driving (Quinlan & Wright, 2008); the lower the uncertainty of earnings, the lower is the likelihood of crash involvement (Hensher, et al., 1991). This uncertainty is likely to be lower for trip-based rates than distance-based rates. While both types of rates are related to the number of kilometres driven, trip-related earnings appear to be the most predictable because trips are defined between specified origins and destinations. Thompson and Stevenson (2014) found that drivers paid trip rates had lower crash involvement than those paid distance-based rates. The current study used some of the data that these authors used. While they did not explain this result, it might be that trip rates were relatively higher than distance-based rates.

These findings are consistent with previous studies connecting payment methods to crash involvement and other safety outcomes (Belzer & Sedo, 2018; Mooren, et al., 2015; Viscelli, 2016). In another Australian study, logistics and transport companies with good safety records mostly paid their drivers time-based rates (hourly or weekly) or fixed salaries while companies with poorer safety records mostly paid drivers based on loads carried (Mooren, et al., 2014). The majority of Australian heavy vehicle drivers surveyed between September 2015 and August 2016 strongly believed that payments based on distance travelled implicitly encourage unsafe behaviours (O'Neill & Thornthwaite, 2016). As explained by

Williamson and Friswell (2013), drivers work more hours than those simply required to drive non-stop from origin to destination and the total hours worked is influenced by operational factors. Incentive payments (distance-based or trip-based rates) encourage longer hours of working than time-based payment where drivers are paid for all the hours they work (including the time spent waiting for loading and unloading to occur). In addition, drivers operating under distance-based payments are effectively penalised for taking breaks because these are unpaid time (Belzer & Sedo, 2018). Driving without taking breaks makes drivers vulnerable to fatigue and crash involvement (Chen & Xie, 2014; Chen, Fang, Guo, & Hanowski, 2016; Lenné & Jacobs, 2016). Moreover, distance-based payments can encourage drivers to speed, violate hours-of-service regulations and take drugs to stay awake and drive for longer hours, making them further vulnerable to fatigue and crash risk (Quinlan & Wright, 2008; Williamson, 2007; Williamson, et al., 2006; Williamson & Friswell, 2013).

The drivers paid for the time associated with the non-driving tasks such as loading and unloading had lower odds of crash involvement than those not paid for this time. Drivers in the current study, as shown in Table 4.2, were mostly paid distance-based rates (40.7% of cases and 35.3% of controls), implying that they only make money when driving. In such situations, the time related to unpaid, non-driving duties becomes an opportunity cost because it decreases driving time resulting in lower income for drivers. Drivers are accordingly motivated to drive faster and longer than legally required increasing the risk of fatigued driving and crash risk (Kudo & Belzer, 2019b; NTC, 2008; Office of the Inspector General, 2018).

Drivers carrying general or mixed freight, or livestock and dangerous goods had lower odds of crash involvement compared to drivers driving empty trucks. It is more likely that drivers operate vehicles more attentively when transporting freight that requires particular precautions (Cantor, et al., 2010). The findings may reflect the need for drivers with empty load vehicles to travel to destinations quickly, and consequently speed in order to secure another load. It may also be related to the handling issues of empty trucks like trailer sway, which may increase the risk of rollover crash (Blower, Campbell, & Green, 1993).

The lower odds of crash involvement for drivers aged between 45 and 64 years old compared to drivers aged between 24 and 44 years old could be the result of the risk-taking behaviours, such as speeding, by drivers aged between 24 and 44 years old and their relatively low driving experience compared to others (Cantor, et al., 2010).

4.3.4.1 Limitations and future studies

This research has some limitations. It only examined factors associated with moderate severity crashes because drivers involved in fatal crashes and drivers who were severely injured were excluded. While the payment for the time related to the loading and unloading tasks is associated with lower odds of crash involvement, it is not known whether drivers themselves performed these tasks. The loading and unloading tasks, when performed by the drivers, may constitute a significant source of fatigue irrespective of whether they are paid or not (Williamson, et al., 2001).

The use of crash involvement as a measure of safety performance has been criticised on the grounds that it does not reveal the actual safety performance of a logistics and transport company because the driver may not be at-fault (Beard, 1992; Savage, 1999). The research team did not collect information from police records regarding whether case drivers were at-fault in the crash. Thus, it may be more appropriate to use safety behaviour variables, such as hours-of-service compliance, speeding and vehicle maintenance, because they reflect the efforts of companies more than crash involvement (Miller, et al., 2018; Miller & Saldanha, 2016). Case-control studies could be used to examine these behaviours based on driver employment type (Cantor, 2016). Researchers could also explore whether the different types of drivers perceive different advantages for diverse safety violations given the various job constraints they face (Miller, et al., 2018).

Other authors have claimed that it is the pay level per se, rather than payment method, which encourages undesired safety behaviours, because drivers are in the quest for an acceptable net income (Hensher & Battellino, 1990; Hensher, et al., 1991). A safe payment system should consider the pay level, payment method and other elements, such as the payment for non-driving time (NTC, 2008). While the influences of payment method and the payment for non-driving time on safety have been analysed in Australia, studies about pay level are missing, despite drivers reporting that low pay rates are a key threat to safety in Australia (O'Neill & Thornthwaite, 2016; Williamson, et al., 2001). Higher pay rates have been reported to improve safety performance in the United States (Belzer, et al., 2002; Belzer & Sedo, 2018; Britto, et al., 2010; Kraas, 1993; Monaco & Williams, 2000; Rodríguez, et al., 2003; Rodriguez, et al., 2006). One US study based on data collected in 1997-1998 showed that drivers were more likely to reduce the amount of driving time when the distance-based pay rate increased (Belzer & Sedo, 2018). The authors concluded that drivers have a target level of earnings, and greater compensation can lead them to be more mindful of safety. Drivers who cannot obtain their target revenue while adhering to safety regulations will be tempted to breach them.

Several inquiries have suggested the setting of minimum pay rates and pay rates that cover driving and non-driving tasks to ensure a safe payment system which discourages risky driving behaviours (Quinlan, 2001; Quinlan & Wright, 2008).

Some researchers, such as Litchfield (2017), have suggested that the Road Safety Remuneration Tribunal (RSRT) or a similar tribunal be put again on the political agenda. The RSRT, as discussed in Chapter 2, was established by the Federal Labor Government in July 2012 to ensure that drivers have fair jobs contracts and receive payments that cover the fixed and variable costs of their activities. The Federal Coalition Government abolished this tribunal in 2016 on the grounds that it made owner drivers less competitive and forced some of them out business.

There is a need to explore driver pay level and safety outcomes in the Australian HV industry to help identify the pay rate levels that are conducive to safety. This could be achieved by examining the factors that affect pay satisfaction. Studies in the HV industry mostly identified pay level as among the top factors that affect HV driver job satisfaction (Humphreys, 2016; Sersland & Nataraajan, 2015), but pay satisfaction itself is still to be explored. For instance, one of the important influencing factors of pay satisfaction is the gap between the perceived and the actually received amounts (Miceli & Lane, 1990). Drivers who are satisfied with their payment level may be more willing to comply with safety regulations (Fehr & Schmidt, 2000; Milgrom & Roberts, 2002).

4.4 STUDY 1B: DRIVER EMPLOYMENT TYPE AND PAYMENT METHODS AS PREDICTORS OF USE OF CRUISE CONTROL

4.4.1 Introduction

Study 1a examined the direct association of driver employment type and payment methods with crash involvement. The results showed that owner drivers have lower odds of crash involvement than employee drivers. Likewise, time-based and trip rates payments are associated with lower odds of crash involvement than distance-based payments. Research showed that speeding is one of the major factors that mediate the relationship between payment methods and crash involvement with distance-based payments more likely to encourage speeding than time-based payments. It has been estimated that if all HVs were to comply with speed limits, the number of crashes would be reduced by 29% in Australia (Mooren, et al., 2014). Cruise Control (CC) is an in-vehicle speed regulation technology that drivers can use to maintain vehicle speeds at selected levels (described in more detail in the following section). It has the potential to reduce speeding in the HV industry if used by drivers. Yet, employment type and payments methods could influence the use of CC in different ways. It could be hypothesised that performance-based rates may discourage the use of CC because it may interfere with driver speeding behaviours. Nevertheless, performance-based rates may encourage the use of CC because it is designed to reduce the driver's workload that may reduce driving stress and crash risk. The same dilemma may also appear regarding driver employment type. Employee drivers may be more likely to use CC compared to owner drivers because of company regulations and on-road monitoring, but vehicle ownership which may make owner drivers more inclined to use CC in order to protect their assets from crash involvement. Thus, Study 1b addresses Research Question 2 (Are HV driver employment type and payment methods related to driver use of CC?).

4.4.2 Cruise control and speed limiters

Cruise Control (CC)—an in-vehicle speed regulation technology that helps drivers maintain vehicle speeds at selected levels—is one of the measures taken to reduce the speeding problems in the HV industry. At the time that the data were collected for Study 1b, current CC technology could not adapt to the presence of other vehicles and relied on the driver to manually override the CC to reduce speed whenever needed (e.g. when approaching another vehicle or on a curve). The newer technology of adaptive CC has been designed to automatically adapt speed levels to in-front vehicles in the traffic in order to keep a safe stopping distance between vehicles (Nilsson, 1995; Stanton, Young, & McCaulder, 1997; Strand, Nilsson, Karlsson, & Nilsson, 2011; Xiao & Gao, 2010; Yang et al., 2018). Driver may accordingly be more likely to use the newer CC because of its greater likelihood of being effective in rear-end crash avoidance than the standard CC (US DOT, 2007).

Speed limiters enable drivers to ensure compliance with speed limits and CCs enable them to set the speed at specified levels. In Australia, all HVs of at least 12 tonnes gross vehicle mass manufactured on or after January 1991 are required by law to be equipped with a speed limiting device and drivers failing to comply with speed limits are subject to monetary fines and demerit points (Haworth, Regan, Tomasevic, & Stephan, 2005; NTC, 2016). Thus, almost all HVs in the study would have been fitted with speed limiters, but only some would have had CC.

Table 4.4 compares speed limiters to CC technology in terms of their aim, function and limitations. Speed limiters enable drivers to ensure compliance with speed limits. Drivers in a focus group discussion considered speed limiters to be valuable tools for avoiding speeding fines (Pereira et al., 2013). While this is not the case for CC technology, it may allow the driver to perform some non-driving tasks such as using a navigation system, texting or talking on the phone or completing paperwork (Rudin-Brown & Parker, 2004). Both speed limiters and the CC technology are speed regulation devices. However, CCs allow the driver to set the desired speed level (which may be lower or higher than the posted speed limit) but speed limiters have a fixed value (100 km/h according to the Australian Design Rule) which also may be lower or higher than the posted speed limit. Thus, CC may be used independently or in conjunction with speed limiters (Pereira, et al., 2013). The joint usage of the two types of technologies could improve driving comfort while ensuring compliance with speed limits. However, speed limiters may conflict with drivers' speed choice for those drivers who wish to exceed the speed limit. Some drivers or companies illegally tamper with speed limiters by installing Engine Computer Programs that alter the data transferred from the electronic systems to the engine itself (Myfleet, 2020). The illegal manipulation of speed limiters can jeopardise the safety of all road users and business profits. Company use of safety technologies, such as GPS tracking or other satellite technologies, to monitor vehicle trips in real-time and determine speed levels are alternatives to avoid or reduce driver tampering with speed limiters (Myfleet, 2020).

Table 4.4 Comparison of speed limiter and cruise control technology

	Speed limiter		Cruise control technology	
	Standard speed limiter	Intelligent speed limiter	Standard cruise control	Adaptive cruise control
Aim	To assist driver in not exceeding speed limits (Paine, Paine, & Faulks, 2009)		To manage speed level and reduce rear-end crash risk (US DOT, 2007)	
Function	The driver may drive at any speed level that is not higher than the maximum threshold level established by law		It keeps vehicle speed at driver desired preset level at which he/she would like to drive (Nilsson, 1995; Stanton, et al., 1997)	
	The maximum threshold speed level determined by the law and set by the manufacturer of the speed limiter	The maximum threshold speed level is the posted speed limit (Haworth, et al., 2005) The device alerts the driver and/or automatically limits speed level when he/she exceeds the posted speed limit in a given location (Haworth, et al., 2005)	It requires the driver to manually change the initial preset speed level (Nilsson, 1995; Stanton, et al., 1997)	It automatically adapts the initial preset speed level to keep a safer stopping distance to the vehicle in front (Nilsson, 1995; Stanton, et al., 1997)
Limitation	May increase the risk of rear-end collisions due to differences in speed levels among vehicles on the same road		Inability to automatically operate, limiting its usage to low or smooth traffic flows (Nilsson, 1995)	The driver must stay alert and promptly respond in case of unexpected situations such as failure of the device to identify an obstacle on the road and inappropriate behaviours, such as hard braking of the leading vehicle (De Winter, Happee, Martens, & Stanton, 2014)

The use of standard CC has been associated with crash reductions for HVs (Hertz, Hilton, & Johnson, 1996; US DOT, 2007). Moreover, CC technology has been identified among the technologies for both light vehicles and HVs that can significantly reduce road crashes and associated injuries in the next 20 to 30 years in Australia (Searson, Ponte, Hutchinson, Anderson, & Lydon, 2015). Nevertheless, these benefits can be achieved only if drivers use the technology as intended. Drivers may turn it off or use it in ways that are not consistent with the designer prescriptions (Regan, Stevens, & Horberry, 2014). Usage is considered voluntary if the user has the choice to use or turn off the technology without any retribution, and mandatory when the user is required to use the technology under threat of punishment (Parasuraman & Riley, 1997; Rawstorne, Jayasuriya, & Caputi, 1998).

4.4.3 Variable selection and regression model

4.4.3.1 Variable selection

The outcome variable is the use of CC defined as a dichotomous variable (1 = CC was activated, 0 = otherwise). The use of standard CC has the potential to improve road safety (Hoedemaeker, Brouwer, Malone, & Klunder, 2006; Regan & Young, 2004). In a comprehensive review, Van Kampen (1996) found that the use of standard CC is associated with lower average speeds, lower speed variability and more stable traffic flow. The same review reported different field tests performed with and without standard CC. These tests showed that widespread use of CC would be associated with a decrease of 50% in car crash involvements as the result of a reduction of lane changes, overtaking manoeuvres and braking. Participants were asked about the presence of CC in their trucks on their current trip. Those who reported its presence were then asked if they were using it on that trip. The study focuses on use of CC by those drivers whose trucks were equipped with CC.

Figure 4.1 groups together the factors identified by various authors as likely to influence driver use of an in-vehicle safety technology into background, contextual and device-related factors (Adell, 2009, 2010; Marangunić & Granić, 2015; Regan, Mitsopoulos, Haworth, & Young, 2002; Regan, et al., 2014; Vlassenroot & Brookhuis, 2014; Vlassenroot, De Mol, Marchau, Brookhuis, & Witlox, 2010). Additional factors such as road type (e.g. suburban vs urban), time of day and the length of the trip may also affect the use of technology.

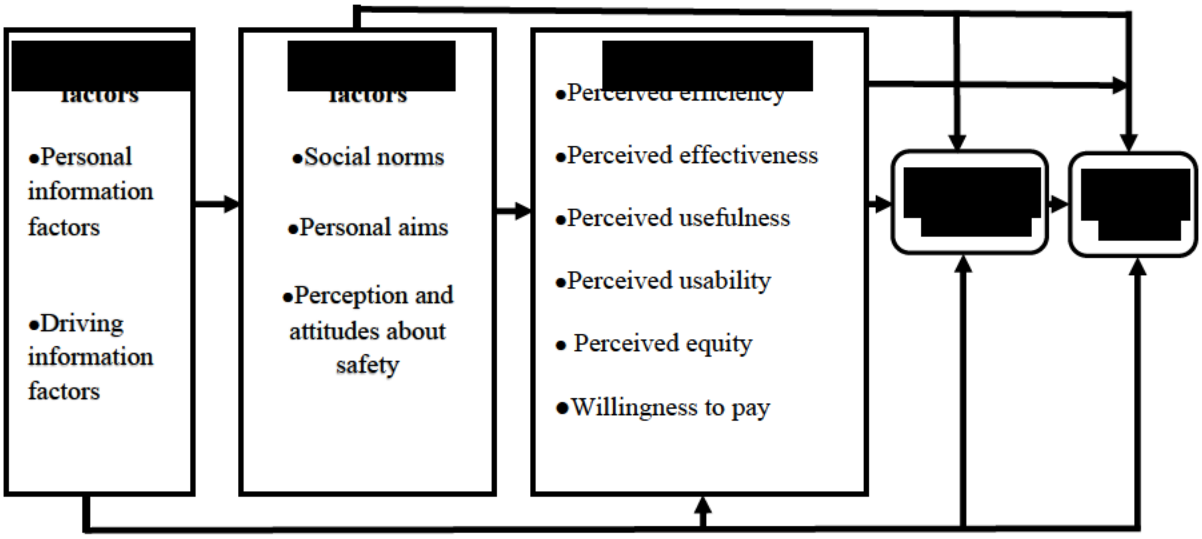


Figure 4.1 Conceptual framework for the use of safety technology (cruise control)

Personal information factors are related to the user socio-demographic characteristics such as age, gender, marital status, education, employment and income while the driving information factors include factors such as driving experience, distance travelled, crash involvement, type of vehicle, and vehicle ownership (Vlassenroot & Brookhuis, 2014; Vlassenroot, et al., 2010). Load type would likely be included in the driving information factors for HV drivers. The personal information factors can influence the driving information factors (for instance, young men are more likely to be involved in crashes than old men and young women) and both of them can affect any other variable in the framework (Johnsen, Kraetsch, Možina, & Rey, 2017; Lee, Ward, Raue, D'Ambrosio, &

Coughlin, 2017; Shinar, Schechtman, & Compton, 2001; Vlassenroot & Brookhuis, 2014; Zmud, Sener, & Wagner, 2016). Users are often constrained by their personal aims and social norms regarding the attitudes towards a given technology. All the contextual factors are likely to influence the user's perception of safety technology (Vlassenroot & Brookhuis, 2014).

Perceived efficiency refers to the expected benefits of the device compared to other devices, while the perceived effectiveness indicates the way the device is expected to function. Perceived usability denotes the capability to operate the system without much effort and distraction, while the perceived usefulness is the extent to which the user believes the device will increase driving performance. Equity refers to the expectation that technology will not violate user privacy and freedom. Willingness to pay is related to the cost of the technology. Users will most likely be unwilling to buy a technology which they believe is costly (Regan, et al., 2002; Vlassenroot & Brookhuis, 2014).

The data used in the current study contain information on only the background factors. Background factors are composed of driver demographics and work-related factors (employment type, payment methods, load type, truck type, etc). Thus, the set of independent variables considered in the regression model includes driver employment type and payment methods and those other background factors correlated to the use of CC in a chi-square test with a P-value <0.2. Only the data from controls are used in this study because it is unknown whether cases were using CC at the time of the crash. Table 4.5 and Table 4.6 provide the descriptive statistics of these variables.

Income and gender were not considered in the regression analysis because of the large percentages of missing values for income (59.3%) (Kristman, Manno, & Côté, 2004) and the predominance of men (99%) among the participants.

4.4.3.2 Regression model

A logistic regression was used to examine the relationship between the independent variables and the use of CC. The estimations were conducted in Stata 15.0.

Driver's age and driving experience showed a significantly high correlation coefficient (r=0.68) at the 95% confidence level. When separate regression models were calibrated for each variable, the results were similar in terms of significance levels and magnitudes of the odds ratios. For simplicity, only the regression analysis containing the age variable is presented in the study.

4.4.4 Results

Almost 88.9% of the 844 interviewed drivers reported the presence of CC technology in their vehicles. Table 4.5 contains descriptive statistics of drivers' age, distance driven in the previous week and driving experience based on whether they reported or not the presence of CC in their vehicle. Drivers with CC were aged between 22 and 74 years and those without CC were aged between 23 and 74 years. During the past week, drivers with CC drove a maximum of 12,000 (N=742) kms and those without CC drove a maximum of 9,000 kms. Both drivers with CC or without CC had a maximum driving experience of 57 years.

Table 4.5 Descriptive statistics of driver's age and work experience

Variable	Presence of CC N= 750		Absence of CC N=94	
	Mean	SD	Mean	SD
Age (years)	45.3	10.5	44.9	11.0
Distance driven in past week (km)	3,832	1,739	3,315	1,972
Driving experience (years)	18.1	12.1	14.6	13.2

More than half of the drivers who reported the presence of CC, reported using it on their current trip (53.5%). The descriptive statistics of the remaining variables included in the regression are presented in Table 4.6. Excluding the unspecified categories for employment type and payment methods, owner drivers (54.5%) and drivers paid distance-based rates (57.5%) were the most likely to use CC.

Table 4.6 Descriptive statistics of trucks with cruise control fitted only

Variable	N=750		
	Drivers using CC	Trucks fitted with CC	% of drivers using CC
Employment type in past week			
Employee driver	283	525	53.9
Owner driver	54	99	54.5
Subcontractor	48	101	47.5
Other driver	16	25	64.0
Payment method in past week			
Time-based rate	103	201	51.2
Single time pay plus overtime	14	28	50.0
Trip rate	97	197	49.2
Distance-based rate	153	266	57.5

Other rate	29	48	60.4
Truck type on the current trip			
Rigid truck	18	42	42.9
Semitrailer	168	338	49.7
Road train	69	111	62.2
B-double	146	259	56.4
Load type on the current trip			
General or mixed freight	145	258	56.2
Livestock and dangerous goods	19	47	40.4
Other goods	40	95	42.1
Empty	196	348	56.3
Antilock brakes system	315	575	54.8
Driver age (years)			
19-39	125	226	55.3
40-59	238	457	52.1
60 and more	38	67	56.7

O'Neill and Thornthwaite (2016) reported that time-based rates are the safest rates, while distance-based rates are the least safe rates. Therefore, the interaction of time-based rates and distance-based rates with employment type on the use of CC was examined. Table 4.7 provides the cross-tabulation statistics between employment type and payment methods for drivers with CC.

Table 4.7 Cross-tabulation statistics between employment type and payment methods for control drivers with CC

	Employment type in past week			
	Employee driver	Owner driver	Subcontractor driver	Other driver
N=740	524 (%)	93 (%)	99 (%)	24 (%)
Payment method in past week				
Time-based rate	153 (29.2)	14 (15.1)	26 (26.3)	8 (33.4)
Single time pay plus over time	26 (5.0)	0 (0.0)	2 (2.0)	0 (0.0)
Trip rate	125 (23.8)	43 (46.2)	23 (23.2)	6 (25.0)
Distance-based rate	194 (37.0)	20 (21.5)	47 (47.5)	5 (20.8)
Other rate	26 (5.0)	16 (17.2)	1 (1.0)	5 (20.8)

The results of the logistic regression are presented in Table 4.8. The regression was estimated after screening for missing data to obtain a complete sample of size N= 712. The model is globally significant at the 99% confidence level with a Wald statistic of 62.66 with a P-value<0.0001.

Table 4.8 Logistic regression of the use of cruise control

Variables	OR	P-value	95% CI
Employment type in past week			
Employee driver	1.00	-	-
Owner driver	1.36	0.36	0.71-2.62
Subcontractor	3.26*	0.02	1.24-8.59
Other driver	2.96	0.14	0.71-12.33
Payment method in past week			
Time-based rate	0.33	0.33	0.04-3.06
Single time pay plus overtime	0.41	0.12	0.13-1.25
Trip rate	0.24**	0.003	0.09-0.62
Distance-based rate	1.00	-	-
Other rate	0.41	0.13	0.15-1.29
Interaction between employment type and time-based rate			
Employee driver × time-based rate	1.53	0.70	0.18-12.59
Owner driver × time-based rate	0.85	0.90	0.08-9.65
Subcontractor × time-based rate	0.13	0.10	0.01-1.46
Other driver × time-based rate	¥	¥	¥
Interaction between employment type and distance-based rate			
Employee driver × Distance-based rate	0.42	0.08	0.16-1.09
Owner driver × Distance-based rate	0.92	0.92	0.20-4.25
Subcontractor × Distance-based rate	0.09**	0.001	0.02-0.36
Other driver × Distance-based rate	0.40	0.53	0.02-7.02
Truck type on the current trip			
Rigid truck	1.00	-	-
Semitrailer	1.30	0.48	0.62-2.67
Road train	1.95	0.11	0.87-4.40
B-double	1.27	0.54	0.60-2.68

Load type on the current trip			
General or mixed freight	1.00	-	-
Livestock and dangerous goods	0.52	0.07	0.26-1.04
Other goods	0.57*	0.04	0.34-0.96
Empty	1.05	0.78	0.74-1.50
Driver age (years)			
19-39	1.00	-	-
40-59	0.83	0.31	0.59-1.18
60 and more	1.02	0.95	0.56-1.85
Distance driven over last week	1.0002**	<0.001	1.0001-1.0003
Antilock brakes system	1.35	0.12	0.92-1.99
Wald statistic		62.66**	

**p<0.01, *p<0.05, ¥: dropped because of multicollinearity

Subcontractor drivers had 3.26 times higher odds of using CC than employee drivers. There was no statistically significant difference in the odds of using CC when employment type was interacted with time-based rates. However, the interaction variables showed that subcontractor drivers paid distance-based rates had odds of using CC less than 1 compared to subcontractor drivers not paid distance-based rates. Drivers paid trip rates had odds of using CC less than 1 compared to those paid distance-based rates. Compared to drivers carrying general or mixed freight, drivers carrying other goods had odds of using CC less than 1. Every additional 100 kilometres driven in the last week was associated with a 0.02% increase in the odds of using CC.

4.4.5 Discussion

Speeding is a major crash influencing factor for HV drivers. Theoretically, driver employment type and payment methods are factors that could favour or deter driver use of CC. This study assessed the relationship between these factors and the use of CC among a sample of long-distance HV drivers in Australia. The descriptive statistics showed that among the drivers who reported the presence of CC more than 50% of them reported using it on their last trip.

Drivers paid trip rates had lower odds of using CC compared to those receiving distance-based rates. Past studies showed that trip and distance-based rates encourage speeding because both are linked to the number of kilometres driven. Nevertheless, the current result is consistent with Thompson and Stevenson (2014) as the study used some of the data used by these authors. Thompson and Stevenson (2014) were the first researchers, to this researcher's knowledge, to compare the safety performance associated with distance-based and trip rates. They found trip rates to be associated with safer driving than distance-based rates. While they did not provide any explanation, in the present study, it might be that trip rates were relatively higher than distance-based rates. Lower distance-based rates encourage drivers to venture into risky behaviours such as speeding (Belzer, et al., 2002; Hensher & Battellino, 1990; Hensher, et al., 1991; Mooren, et al., 2015; NTC, 2008; O'Neill & Thornthwaite, 2016; Quinlan & Wright, 2008), stimulant intake, and driving while fatigued (Hensher & Battellino, 1990; Williamson & Friswell, 2013; Williamson, et al., 2001). Thus, they may consider CC as a way to reduce their workload, improve their driving performance and be able to drive over longer distances, implying increased earnings. They may also see CC as more important to ensure they are never below speed limits unnecessarily. This could explain why distance driven was positively associated with a higher likelihood of using CC.

Nevertheless, subcontractor drivers had higher odds of using CC overall, but lower odds of using it when paid distance-based rates. This may be due to the payment method, because subcontractors were paid trip rates less (11.7%) than employee drivers (63.5%) and owner drivers (21.8%). On the other hand, as distance-based payments are the payment type most associated with speeding (O'Neill & Thornthwaite, 2016), the CC as a speed regulator may conflict with speeding behaviours of distance-based paid drivers, leading them to turn it off. Thus, it appears that payments based on distance can both encourage and discourage the use of CC.

The type of load was also significantly associated with the use of CC because the different loads have particular characteristics that require specific policies (Burks, Belzer, Kwan, Pratt, & Shackelford, 2010; Cantor, Corsi, Grimm, & Singh, 2016). For instance, drivers of empty loads have been shown to be more likely to be involved in crashes, (Blower, et al., 1993; Stein & Jones, 1988) probably due to speeding (Sharwood, et al., 2013) and/or handling issues like trailer sway, which may increase the risk of rollover crash (Blower, et al., 1993).

4.4.5.1 Limitations and future research

This study has some limitations. The conceptual framework for the factors affecting the use of technology showed that these factors could be related to driver demographics and work, the social contextual or the technology itself and other factors not included in the framework (e.g. road type, time of day). This study considered driver demographics and work-related factors. While these factors are useful in terms of policy design regarding driver work characteristics, the examination of the contextual and technology-related factors could also provide more information about the reasons why drivers used CC or not.

The researchers relied on self-reported information from drivers and did not check whether the CC was actually present or not and activated or not. Asking drivers to provide an estimate of the percentage of the current trip on which they had been using CC would have provided further weight to the use of CC as the outcome variable.

The use of CC may also have been over-reported because some drivers would like to show compliance with good safety practices, while other drivers may deny the presence of the system in their vehicles just to avoid further questions about this device. Some drivers may have thought that the researchers were asking about speed limiters instead of CC, and responded that their vehicle was equipped with CC when it had a speed limiter, but no CC.

The age of the data means that they reflect the effects of standard CC, rather than adaptive CC, which is only a recently emerging technology in the Australian HV industry. Standard CC requires the driver to stay alert and adjust speed when necessary, which may deter some drivers from using it. The use rate could have been higher were the trucks fitted with adaptive CC. Drivers paid based on performance, particularly those in a rush, may have been more likely to decline participation. Concerning future research, this study highlighted that the evaluation of the factors that affect the use of CC and, more generally, safety technologies in the HV industry, is still embryonic. The data used in the study were collected between 2008 and 2011; some ten years ago. Thus, this study is meant to serve as a benchmark mainly within the Australian context because of the recent emergence of many new safety technologies (e.g. adaptive CC, electronic stability control, emergency braking systems, and fatigue warning systems) in the HV industry. Findings about the factors that affect driver use of the standard CC could help identify the factors that favour or impede driver use of the technology in order to improve the design of the new technologies. There is a need to conduct further studies examining the association of driver demographics and work-related factors with the use of emerging technologies and then assess the mediating or moderating role of these characteristics between contextual and technology-related factors and the use of technology.

4.5 STUDY 1C: DRIVER PAYMENT METHOD AS A MEDIATOR BETWEEN EMPLOYMENT TYPE AND FATIGUE-RELATED BEHAVIOURS

4.5.1 Introduction

Study 1a showed that employment type is significantly related to safety outcomes with owner drivers having lower odds of crash involvement than employee drivers. Concerning payment methods, drivers paid time-based rates had lower odds of crash involvement than those paid distance-based rates. Study 1b extended these findings by showing that distance-based payments could moderate (reduce the strength) the relationship between subcontractor drivers and the use of CC. Thus, due to their direct and indirect (use of CC) influence on the relationship between employment type and safety outcomes, payment methods may constitute an explanatory mechanism of this relationship.

The critical factors that might explain the different effects of employment type on safety have been suggested to be vehicle ownership for owner drivers (Cantor, 2016; Cantor, et al., 2013; Miller, et al., 2018; Monaco & Redmon, 2012; Nickerson & Silverman, 2003), company in-vehicle monitoring for employee drivers (Monaco & Redmon, 2012; Swartz & Douglas, 2009), and fines (e.g. penalties for late arrivals) for both types of drivers (NTC, 2006b). Owner drivers may be safer than employee drivers because risky behaviours may put owner drivers' capital at risk (Nickerson & Silverman, 2003). However, because of financial pressure (Cantor, et al., 2013) owner drivers may be tempted to engage in more hazardous practices compared to employee drivers.

Differences in payment methods may underlie the mixed findings of safety outcomes for the different types of employment, but this remains to be explored in the literature. Driver fatigue is a major contributing factor to HV-related fatal crashes in Australia. Study 1c examines whether payment methods represent a mechanism that can explain fatigue-related behaviours for the different types of HV drivers. It addresses Research Question 3 (Do HV driver payment methods mediate the relationship between driver employment type and fatigue-related behaviours?)

4.5.2 Variable selection and regression model

4.5.2.1 Description of the variables

Five main variables were included in the analysis: driver employment type, payment method and three fatigue-related behaviours. Driver employment type was the predictor, while payment method was the mediator.

Three variables represented fatigue-related behaviours: self-reported stimulant intake, drowsy driving and rest breaks. Drivers were asked to report the frequency at which they used stimulants (prescription or over the counter medications, not caffeinated drinks) to help them stay awake during the past month. More than 95% of those who responded to this question reported having never used any stimulants during the past month. Thus, the variable referring to the use of stimulants in the study was turned to a binary variable indicating whether the driver took stimulants to stay awake during the past month or not. Drowsy driving was represented by an ordinal variable indicating the frequency (never, once or twice, once or twice a week, three or four times a week, most days) drivers reported having trouble staying awake while driving over the past month. Rest breaks were represented by another ordinal variable indicating how often (never, rarely, sometimes, often, always) drivers took breaks or naps when they felt tired while driving over the past month. Only data from non-crash-involved (control) drivers in the case-control study were used because the inclusion of the cases is likely to have overestimated the prevalence of unsafe behaviours. Table 4.9 provides the descriptive statistics of the three fatigue-related behaviour variables.

Table 4.9 Descriptive statistics of fatigue-related behaviour variables

N=828*	Stimulant intake in past month	
Variable	Yes (%)	No (%)
Frequency of drowsy driving in past month	31 (3.7)	797 (96.3)
Never	13 (41.9)	514 (64.5)
Once or twice	6 (19.4)	161 (20.2)
Once or twice a week	7 (22.6)	89 (11.1)
Three or four times a week	4 (12.9)	15 (1.9)
Most days	1 (3.2)	18 (2.3)
Rest breaks or naps when tired in past month	31 (3.7)	765 (92.4)
Never	2 (6.5)	37 (4.8)
Rarely	2 (6.5)	25 (3.3)
Sometimes	5 (16.1)	76 (9.9)
Often	4 (12.8)	59 (7.7)
Always	18 (58.1)	568 (74.3)

* less than the actual sample size of 844 drivers because of missing data

4.5.2.2 Mediation analysis

The graphical design of payment method as a mediator between driver employment type and fatigue-related behaviours has already been introduced in Figure 3.3, Section 3.3.1.4. The analytical method of the mediation model was presented within the framework of the causal steps approach designed by Baron and Kenny (1986) which is based on statistical tests of the regression parameters.

Despite the popularity of the causal steps approach, it has been shown to have several limitations. If one of the tests in the process is not significant, payment method is not a mediator. However, the more the tests are performed, the more likely is the possibility of false rejection or acceptance (Hayes, 2013). Moreover, this approach no longer holds when the relationship between the predictor and the outcome variable is not linear (Hayes & Preacher, 2010) or some or all of the variables in the analysis are categorical (Hayes & Preacher, 2014; Iacobucci, 2012), as is the case of the present study.

It is better to reduce the number of statistical tests to a single test that assesses the presence or absence of the mediated effects (Hayes, 2013). Thus, He, Wang, and Curry (2017) proposed the likelihood ratio test (LRT), which is based on the likelihood ratio principles rather than the regression coefficients. The LRT works irrespective of the types of variables (continuous, binary or categorical) and nature (linear or nonlinear) of the relationship between the predictor and the outcome variable. When the primary interest is to assess the presence or absence of mediation, this test is more appropriate.

The LRT in this study consists of comparing the restricted model in equation 3.5 to the full model in equation 3.6 under the null hypothesis that the restricted model fits the data better than the entire model. The rejection of the null hypothesis implies the alternative assumption that the full model is the best and that the mediator significantly affects the outcome variable, suggesting the presence of mediation effects accordingly. The LRT statistic follows a chi-square distribution. If the associated P-value is less than 5%, the null hypothesis is rejected at the 5% significance level suggesting the presence of mediation.

The LRT is based on an ordinary least squares regression when the outcome variable is continuous, a logistic regression when it is binary, an ordinal regression when it is ordinal and a multinomial regression when it is categorical. The estimations in this study are conducted using Stata 15.0.

4.5.3 Results

During the month prior to taking the questionnaire, most drivers (73.8%) reported that they always took rest breaks when they felt tired while driving. During the same month, most of them reported good sleep quality (64.4%) on average, and felt that they had had sufficient sleep both while working (81.2%) and when they woke up in the mornings (81.3%). The majority also reported "rarely" having snoring (84.5%) or breathing troubles (83.9%). Almost none took any stimulants to stay awake during the past month (96.3%), and most (63.6%) reported never experiencing drowsy driving during the same month. In three days before the survey, the schedule structures allowed on-time deliveries for 91.9% of the drivers. Drivers may overreport sleep quality and underreport illegal behaviours. Payment methods were almost equally distributed, and employees comprised the majority of drivers for each payment method. Table 4.10 provides the distribution of the employment type across payment methods and fatigue-related variables.

After screening for missing data, a sample of size N=596 was obtained. The mediation of payment methods between employment type and each of the fatigue-related behaviour variables was then assessed using Chi-square tests and LRTs. The chi-square tests showed that employment type was significantly correlated with payment methods ($\chi^2(12) = 72.58$; $p < 0.001$). Nevertheless, neither employment type nor payment methods were associated with any of the fatigue-related variables, as shown in Table 4.11 by the P-values, which are all greater than 5%.

Table 4.10 Driver employment type, payment methods and fatigue-related variables

Variable	Employee driver N (%)	Owner driver N (%)	Subcontractor N (%)	Other driver N (%)
Payment method in past week	591	102	113	26
Time-based rate	171 (28.9)	16 (15.7)	29 (25.6)	8 (30.8)
Single time pay plus overtime	33 (5.6)	0 (0.0)	2 (1.8)	0 (0.0)
Trip rate	143 (24.3)	46 (45.1)	25 (22.1)	7 (26.9)
Distance-based rate	216 (36.5)	21 (20.6)	55 (48.7)	6 (23.1)
Other rate	28 (4.7)	19 (18.6)	2 (1.8)	5 (19.2)
Stimulant intake in past month	583	108	113	25
Yes	23 (3.9)	5 (4.6)	1 (0.9)	2 (8.0)
No	560 (96.1)	103 (95.4)	112 (99.1)	23 (92.0)
Frequency of drowsy driving in past month	592	108	115	28
Never	378 (63.9)	78 (72.2)	64 (55.7)	16 (57.1)
Once or twice	118 (19.9)	17 (15.7)	29 (25.2)	6 (21.4)
Once or twice a week	67 (11.3)	9 (8.3)	17 (14.8)	4 (14.3)
Three or four times a week	15 (2.5)	2 (1.9)	3 (2.6)	1 (3.6)
Most days	14 (2.4)	2 (1.9)	2 (1.7)	1 (3.6)
Breaks or nap stops in past month	573	105	106	27
Always	429 (74.9)	78 (74.3)	73 (68.9)	19 (70.4)
Often	47 (8.2)	5 (4.8)	8 (7.6)	4 (14.8)
Sometimes	48 (8.4)	14 (13.3)	18 (17.0)	2 (7.4)
Rarely	21 (3.7)	2 (1.9)	4 (3.7)	0 (0.0)
Never	28 (4.8)	6 (5.7)	3 (2.8)	2 (7.4)

Table 4.11 Chi-square tests

Fatigue-related behaviour	Employment type		Payment methods	
	Statistic	P-value	Statistic	P-value
Stimulants intake	2.67	0.45	10.30*	0.04
Drowsy driving	11.13	0.52	18.36	0.30
Breaks or naps stops	15.04	0.24	8.15	0.94

* p<0.05

The nonsignificance of the chi-square tests implies that if the analysis is based only on the causal steps approach of mediation analysis, payment methods do not mediate the relationships between employment type and the selected variables. Nevertheless, the limitation of the causal steps approach to handling categorical variables requires the use of LRTs to support or reject the mediation (He, et al., 2017). Thus, LRTs were used to compare restricted models to full models for each of the fatigue-related behaviour variables. In addition to employment type and payment methods, other predictors were included in each restricted and full models to reduce the likelihood that omitted variables influence the estimates (Miller, et al., 2018). The selected predictors for each regression were those associated with the outcome variable in a chi-square test with a P-value <0.2. The three fatigue-related behaviours, frequency of breathing troubles in past month (never, rarely, some, frequently, always), frequency of snoring in past month (never, rarely, some, frequently, always), average sleep quality in the past month (poor, fair, good, excellent), measures with a Likert scale, were used in the analysis as continuous variables. Ordinal variables can be used as continuous without any harm to the results of an analysis (Johnson & Creech, 1983). Age was not considered as continuous because of the potential nonlinear relationship between age and safety performance. The remaining variables, apart from employment type and payment methods that are categorical variables, were either binary or continuous variables.

The correlation coefficients were computed among the different variables used in the regression to avoid the risk of multicollinearity due to high correlations among the different variables. The values of Cramer's V, the correlation coefficient for categorical variables, are presented in Table 4.12. The general rule-of-thumb of Cramer's V is that a V less than 0.30 indicates a weak to negligible association, a V between 0.30 and 0.70 denotes a weak to fairly strong association and a V higher than 0.70 indicates a strong association (Kraska-Miller, 2013). The V statistics among the independent variables are all less than 0.70, implying the absence of a strong correlation among these variables.

The results of the LRTs comparing restricted models (RMs) to full models (FMs) for each of the fatigue-related behaviour variables are provided in Table 4.13. The estimates contain the OR at the 95% CI.

Table 4.12 Correlation coefficient among the selected variables

	SI	DD	RB	EMP	PAY	BT	SN	FSSM	ODS	FSSW	ASQT	AGE
SI	1											
DD	0.16*	1										
RB	0.07	0.20**	1									
EMP	0.07	0.06**	0.08	1								
PAY	0.11*	0.07**	0.05	0.18*	1							
BT	0.15*	0.15	0.10**	0.06	0.06	1						
SN	0.12*	0.12	0.11**	0.08	0.07	0.45**	1					
FSSM	0.08*	0.26**	0.23**	0.07	0.05	0.20**	0.20**	1				
ODS	0.08*	0.18**	0.16**	0.05	0.09	0.13	0.03*	0.11**	1			
FSSW	0.14*	0.22**	0.12*	0.07	0.12*	0.10	0.11	0.16**	0.07	1		
ASQT	0.10*	0.16**	0.15**	0.06	0.09*	0.19**	0.17**	0.39**	0.06*	0.22*	1	
AGE	0.06	0.07	0.07	0.05	0.08	0.07	0.27	0.04	0.04	0.009	0.06	1

**p<0.01, *p<0.05, SI: Stimulant intake, DD: Drowsy driving, RB: Rest breaks, EMP: Employment type, PAY: Payment method, BT: Breathing troubles, SN: Snoring, FSSM: Feeling of sufficient sleep in mornings, ODS: On-time delivery schedules, FSSW: Feeling of sufficient sleep during work, ASQT: Average sleep quality time, AGE: Age

Table 4.13 Likelihood ratio tests for restricted vs. full models

	Restricted Model SI	Full Model SI	Restricted Model DD	Full Model DD	Restricted Model RB	Full Model RB
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Employment type						
Employee driver	1.00	1.00	1.00	1.00	1.00	1.00
Owner driver	1.02 (0.97-1.06)	0.99 (0.95-1.04)	1.27 (0.99-1.62)	1.25 (0.96-1.62)	0.95 (0.71-1.28)	0.88 (0.65-1.19)
Subcontractor	0.97 (0.93-1.02)	0.97 (0.92-1.01)	1.27(0.98-1.63)	1.21 (0.95-1.55)	1.02 (0.76- 1.37)	1.02 (0.76-1.35)
Other driver	0.97 (0.88-1.07)	0.96 (0.87-1.06)	0.96 (0.55-1.68)	1.02 (0.59-1.77)	0.83 (0.44-1.57)	0.83 (0.44-1.56)
Payment methods						
Time-based rate	-	1.00	-	1.00	-	1.00
Single time pay plus overtime	-	0.98 (0.90-1.06)	-	1.39 (0.92-2.12)	-	1.58 (0.97-2.57)
Trip rate	-	1.06 (1.01-1.10)**	-	1.29 (1.03- 1.62)*	-	1.52 (1.17-1.97)**
Distance-based rate	-	1.03 (0.98-1.06)	-	1.58 (1.30-1.93)**	-	1.77 (1.40-2.24)**
Other rate	-	1.05 (0.97-1.13)	-	1.14 (0.78-1.69)	-	1.85 (1.19-2.89)**
Breathing troubles in past month	1.01 (0.99-1.04)	1.01 (0.99-1.04)	1.41(1.25-1.60)**	1.38 (1.22-1.56)**	1.17 (1.01-1.35) *	1.14 (0.99-1.32)
Snoring in past month	1.02 (0.99-1.04)	1.02 (0.99-1.04)	1.22 (1.09-1.37)**	1.18 (1.05-1.32)**	1.12 (0.98-1.28)	1.09 (0.96-1.25)
Feeling of sufficient sleep in mornings in the past month						
Yes	0.99 (0.94- 1.03)	0.97 (0.93-1.01)	1.61 (1.39-1.87)**	1.39 (1.18- 1.64)**	2.06 (1.58-2.67)**	1.91(1.48-2.48)**
No	1.00	1.00	1.00	1.00	1.00	1.00

Schedules allowed on-time delivery in the past 3 days			-			
Yes	0.95 (0.90-1.007)	0.95 (0.90-1.007)	-	-	4.06 (2.96-5.58)**	3.71 (2.71-5.09)**
No	1.00	1.00	-	-	1.00	1.00
Driving experience	1.0002 (0.99-1.001)	1.00004 (0.99-1.001)	-	-	1.006 (0.99-1.01)	1.004 (0.99-1.01)
Feeling of sufficient sleep during work time in the past month						
Yes	-	-	1.82 (1.51-2.20)**	1.72 (1.43-2.08)**	1.05 (0.84-1.31)	0.99 (0.80-1.23)
No	-	-	1.00	1.00	1.00	1.00
Driver age						
22-44	-	-	1.00	1.00	-	-
45-64	-	-	1.34 (1.13-1.57)**	1.27 (1.08-1.49)*	-	-
65 and more	-	-	0.91 (0.52-1.59)	0.85 (0.49-1.47)	-	-
Average sleep quality in the past month	-	-	-	-	1.99 (1.77-2.25)**	1.92 (1.70-2.16)**
Log-likelihood	144.84	149.70	-866.40	-855.72	-948.16	-935.83
LRT statistic for RM vs. FM	9.70*		21.36**		24.66**	

**p<0.01, *p<0.05, SI: Stimulant intake, DD: Drowsy driving, RB: Rest breaks

4.5.4 Discussion

Thompson and Stevenson (2014) showed that performance-based payments are significantly associated with longer distance driven, higher driving time between rest breaks, higher total driving time and higher number of worked hours per week, which increase the likelihood of fatigued driving. Nevertheless, examinations of these outcomes based on driver employment type are missing, despite the mixed findings of the relationship between employment type and safety outcomes. The current study, using some of the data used by Thompson and Stevenson (2014), showed that payment methods for HV drivers could mediate the relationship between driver employment type and safety performance. Safety performance is represented by three fatigue-related behaviours: stimulant intake, drowsy driving and rest breaks.

Performance-based payments such as distance and trip-based rates often imply the need to travel more to obtain an acceptable net revenue. Therefore, drivers in the quest of this net revenue may be encouraged to use stimulants to stay awake and drive as many kilometres or trips as possible (Hensher, et al., 1991; Williamson, 2007; Williamson, et al., 2006). Owner drivers, because the remuneration they receive is the only basis to support their business activity (Quinlan & Wright, 2008), are likely to face a greater financial pressure compared to employee drivers and subcontractors (Cantor, et al., 2013; Kudo & Belzer, 2019b). Owner drivers may accordingly be more motivated to driver longer and faster, as the result of performance-based payments, than employee drivers and subcontractors. Thus, owner drivers may be the least likely to comply with driving hours regulations and this could interfere with their sleeping patterns in the long term (Chen & Xie, 2014; Lemke, et al., 2016; Quinlan, 2001; Williamson & Friswell, 2013) and may result in drowsy driving and increase the likelihood of fatigued driving.

4.5.4.1 Limitations

This study has some limitations. Drivers were asked about issues related to driver fatigue such as stimulant intake, drowsy driving and rest breaks when feeling tired while driving. They may be concerned about revealing such behaviours that might be unlawful or not well appreciated by their employers or even the research team. Thus, it is reasonable to believe that some of them could underreport illegal behaviours. The study also did not ask drivers about what they did during rest breaks. It is possible that this time might have been devoted to tasks other than resting.

4.6 Overall summary of Study 1

Study 1 provided further insight into the likelihood of driver employment type and payment methods influencing safety performance in the HV industry. It was divided into three sub-studies which analysed how driver employment type and payment methods could influence safety outcomes directly (Study 1a and c) or indirectly through the use of CC (Study 1b).

Study 1a showed that owner drivers have lower odds of crash involvement than employee drivers and that time-based payments and trip rates were associated with better safety performance than distance-based rates. These findings provided a background for Study 1b which found that drivers paid trip rates had lower odds of using CC than those paid distance-based rates. Distance-based rates had a moderating effect on the use of CC for subcontractor drivers. Overall, these drivers were more likely to use CC, but those paid distance-based rates were less likely to use CC than those not paid distance-based rates. Thus, Study 1c hypothesised that payment methods could help explain safety outcomes between the different types of drivers. Its findings showed that payment methods represent a mechanism than can differentiate safety performance based on employment type. Poor fatigue-related behaviours are more likely to be common among owner drivers than employee drivers because of the difference in earnings calculations. In sum, Study 1 provided support that driver payment methods have a critical role in managing driver safety performance in the HV industry.

4.6.1 Limitations and future studies

Study 1 used self-reported data. While self-report data are economical and easy to collect, they may contain some errors and potential sampling bias. Drivers under time constraints could be more preoccupied with finishing the interview rather than giving candid answers. More importantly, they may not have agreed to participate at all. However, the anonymous nature of the survey that was guaranteed to the participants was likely to reduce the under-reporting and increase the likelihood of candid answers. Controls were selected by approaching drivers at truck stops during mealtime. This selection process could omit those of them who did not often use truck stops for their meals. However, the survey was spread over different times, days, weeks and months to capture various travel patterns. Another issue is that drivers who only made money through productivity, and particularly those who were more pressured for time, were at a higher personal cost to stop and participate in the research and so may have been less likely to attend. Drivers who use the freeway for short distances would be less likely to need to stop on the freeway and thus may be underrepresented in the study sample. Another limitation is that the survey was designed to collect data that reflect the general population of heavy vehicle drivers. Almost 70% of Australian carriers are single-vehicle operators, whereas owner drivers represented only 12% of the sample here (NTARC, 2017). It may be that they were less likely to participate in the survey.

4.7 CHAPTER SUMMARY

Study 1 was motivated by research that emphasised driver employment type and associated remuneration policies as critical factors to manage if undesired on-road driver behaviours are to be prevented or reduced. The findings showed that both employment type and payment methods could significantly influence driver attitudes and safety performance. Thus, it is important to examine the associations of the HV safety regulatory frameworks with driver employment type and payment methods. The next chapter presents Study 2, examining the influence of the CoR legislation on HV driver employment type and payment methods.

Chapter 5: Study 2 - Associations of company awareness of CoR legislation with the employment types and payment methods

5.1 INTRODUCTION

Study 1 showed that driver employment type and payment methods may directly or indirectly influence driver safety performance. The analysis of the direct influence showed that distance-based rates are associated with higher odds of crash involvement than time-based and trip rates. Owner drivers have lower odds of crash involvement than employee drivers. However, payment methods can mediate the relationship between employment type and fatigue-related behaviours, with performance-based payments being related to higher levels of undesired fatigue-related behaviours for owner drivers than employee drivers. The analysis of the indirect influence showed that distance-based rates may affect safety performance by moderating the relationship between employment type and the use of cruise control. Thus, both driver employment type and payment methods have safety implications but their relationship with the CoR legislation has not been examined. Therefore, this study examines the associations of the HV companies' awareness of the CoR legislation with their practices regarding driver employment type and payment methods. This chapter addresses Research Question 4 (What is the relationship between HV company awareness of CoR legislation and the driver employment types and payment methods?).

5.2 METHODS

5.2.1 Participants

This study uses existing data collected within the framework of an NTC project designed to assess transport and logistics companies' awareness, attitudes and behaviours towards driver fatigue. The sample includes 400 companies surveyed across Australia in April and May 2012. The participants were managers of companies operating HVs of at least 12 tonnes. A research team from the Australian Market and Social Research Society conducted the survey under the Code of Professional Behaviour of this society.

The NTC conducted a survey in 2006 to assess HV companies' awareness, attitudes and behaviours towards driver fatigue. The findings were used as a baseline for a reform of HV driver fatigue in 2008. The 2008 reform implemented fatigue management schemes, which revised work and rest hours for drivers of HVs of at least 12 tonnes. The 2012 survey was conducted to assess the effectiveness of the 2008 reform. In addition to companies' awareness, attitudes and behaviours towards driver fatigue, the 2012 survey collected information about companies' awareness of the CoR legislation, which was not collected in 2006.

The 2012 survey showed that companies' perception that driver fatigue is well managed in the industry improved in 2012 compared to 2006 (80% vs 68%). Eighty percent (80%) of the companies considered that the existing regulations enabled them to manage driver fatigue appropriately. This implied an improvement compared to the 2006 survey (73%). The major problem raised by those who reported that the existing regulations did not enable them to appropriately manage driver fatigue was the perceived absence of flexibility in the management of working hours.

5.2.2 Procedure

The companies were sampled among hire and reward operators. These are companies whose main activity is to offer transport services to other companies on contractual bases (BITRE, 2003). They were obtained online from the Yellow Pages website in the categories of *Transport* and *Transport and forwarding agents*. The contact information for the logistics, operations, or freight managers of companies was retrieved from companies' websites, and they were then telephoned to conduct 45-minute interviews. The purpose of the study was introduced as "*research on day to day issues faced by businesses in transporting freight, and the responsibilities of all players in the supply chain*". The questionnaire contained information such as company profile (state, size, driver employment type and driver payment method), freight transport profile (load type, truck type, length of trips), fatigue management policies, perceptions of driver fatigue and fatigue contributing factors, and awareness about the CoR legislation.

Concerning fatigue management, participants were asked to select among various fatigue management schemes those that their company used and indicate on a scale their understanding of the area of fatigue management schemes. The perceptions of driver fatigue were related to participants' perceived changes in their company and HV industry awareness of driver fatigue over the last 5 years and the way it had been managed. Participants were also asked to assess their company familiarity with the CoR legislation and rate its ability to place responsibility on the company and the other actors in the transport logistics and supply chain regarding the breaches of safety regulations.

The questionnaire was developed and tested in preliminary in-depth telephone interviews with 10 companies. Participants in both pilot and actual surveys were paid $80 per individual and were guaranteed confidentially regarding the information they would provide.

The survey was designed to assess HV companies' awareness and perceptions of driver fatigue and CoR legislation in order to examine the effectiveness of the CoR legislation in reducing the number of fatigue-related incidents and crashes. However, the survey did not analyse the association between awareness and perceptions on one hand, and driver employment type and payment methods on the other hand, despite their reported critical roles in driver safety performance.

5.2.3 Variable selection and regression model

5.2.3.1 Variable selection

5.2.3.1.1 Outcome variables

Driver employment type and payment method were the two outcome variables in the current study and were represented by categorical variables in the questionnaire. While in Study 1, participants were asked to select only one category for each of these variables, in Study 2, they were asked to select all categories that apply for each variable. Thus, in this Study 2, employment type and payment method were recoded as explained in what follows.

There were four categories of employment type in the survey: employee drivers, subcontractor drivers, owner drivers and other types of drivers. Participants were asked to choose all options that applied to them. Therefore, the team undertaking the current research recoded employment type into four categories: (1) companies using employee drivers only; (2) companies outsourcing only, which were companies that used either subcontractor drivers only, owner drivers only, or both; (3) companies using both employee drivers and outsourcing, which were companies that used any combination of employee drivers and outsourcing; and (4) companies using drivers not falling in any of the previous categories. The second category (outsourcing only) was obtained from three combinations of employment types.

Similarly, the third category (employee drivers and outsourcing) was obtained from three combinations of employment types.

In terms of payment methods, time-based rates in the survey were composed of hourly, daily and weekly rates, while performance-based rates included distance or tonnage and/or load-based rates. Participants were asked to choose all options that applied to them. Therefore, the team undertaking the current research recoded payment method into four categories: (1) companies paying time-based rates only; (2) companies paying performance-based rates only; (3) companies paying any combination of time-based and performance-based rates; and (4) companies paying other types of rates. Time-based rates were the results of seven combinations, performance-based rates were obtained from three combinations, and mixed rates were obtained from sixteen combinations. Due to the large number of these categories, only the summarised categories are presented in the study. A detailed description of the different combinations with their descriptive statistics is provided in Appendix B. Table 5.1 shows the descriptive statistics of employment type and payment method.

Table 5.1 Distribution of employment type and payment methods

Outcome variable	N=400
Employment type	(%)
Employee driver only	111 (27.8)
Outsourcing only	48 (12.0)
Owner driver	10 (2.5)
Subcontractor driver	17 (4.3)
Owner driver and subcontractor driver	21 (5.2)
Employee driver and outsourcing	218 (54.5)
Employee driver and subcontractor driver	53 (13.2)
Employee driver and owner driver	28 (7.0)
Employee driver, subcontractor driver and owner driver	137 (34.3)
Other driver	23 (5.7)
Payment method	
Time-based rate	198 (49.5)
Performance-based rate	27 (6.7)
Mixed rate	138 (34.5)
Other rate	37 (9.3)

5.2.3.1.2 Explanatory variables: CoR-related variables

Several variables were used to represent companies' perception of the CoR legislation. The participants were asked to assess company familiarity with the CoR legislation and the extent to which it has extended liability to the company and other parties in the transport logistics and supply chain. Then, they were asked to evaluate the company awareness of driver fatigue at the company and industry levels over the last 5 years. Another question asked them to evaluate their company understanding of fatigue management schemes. In sum, the influence of CoR legislation was represented by six categorical variables: company familiarity with the CoR, extension of CoR liability to the company, extension of CoR liability to other parties, company awareness of driver fatigue over the last 5 years, industry awareness of driver fatigue over the last 5 years, and company understanding of fatigue management schemes.

Fatigue management (FM) schemes include elements such as a standard for working hours, a basic fatigue management (BFM) scheme and an advanced fatigue management (AFM) accreditation scheme (NTC, 2006a, 2007b).

The standard working hours prescribe minimum and maximum working hours while the BFM allows additional working hours with increased fatigue management and more compliance duties on operators (NTC, 2007b). The AFM accreditation stimulates HV operators to take more responsibility for managing driver fatigue while motivating drivers to be active in managing their fatigue (NTC, 2006a). It requires operators to save driving records for each driver as proof that they meet fatigue management standard. These records should be related to the work diary, payment, fuel, etc. Accredited operators are periodically audited to ensure that they comply with regulations; otherwise, they are requested to improve their safety policy before any renewal of the accreditation.

5.2.3.2 Regression model

After the descriptive statistics of the variables were calculated, the relationship between each outcome variable (employment type and payment method) and the selected explanatory variables was examined using a multinomial logistic regression (MLR). All the calculations and estimations were conducted using Stata 15. The MLR is the extension for the binary logistic regression when the outcome variable has more than two unordered categories. The estimation of the MLR requires the specification of one of these categories as a reference category. Employee drivers were selected as the reference category for employment type, and time-based rates were the reference category for payment methods. The literature review suggested that these two categories are likely to be associated with better safety outcomes than their counterparts, respectively.

The estimates of MLRs provide odds ratios (ORs) which have the same interpretation as ORs in binary logistic regressions, with the comparison being to the reference category (Cameron & Trivedi, 2010). An OR smaller than 1 implies that the outcome has lower odds of being in the comparison category than the reference category. An OR greater than 1 implies that the outcome has higher odds of being in the comparison category than the reference category, while an OR of 1 means that there is no difference between the comparison category and the reference category (Garson, 2014). For instance, setting time-based rates as the reference category, an OR less than 1 for performance-based rates for companies which are very familiar with CoR legislation would imply that these companies have lower odds of paying performance-based rates than time-based rates. Nonetheless, an OR higher than 1 would imply that these companies have higher odds of paying performance-based rates than time-based rates while an OR of 1 would infer that there is no difference for these companies between paying time-based rates and paying performance-based rates.

The MLRs were estimated using the CoR-related variables that were correlated to each dependent variable in a chi-square test with a P-value<0.2 after adjusting for two other categorical variables (company size and the number of trips over 100 kilometres) selected based on the same cut-off P-value. Company size in the survey referred to the number of trucks of at least 12 tonnes gross vehicle mass. As defined by NTC (2012b) for the survey, companies operating four and fewer trucks were considered to be small companies. Those operating between 5 and 29 trucks were medium companies while large companies operated 30 or more trucks.

The risk of high correlation among the selected explanatory variables was assessed using Cramer's V statistics. These statistics show the extent to which categorical variables are associated. A statistic closer to 1 implies a strong association and closer to 0, a weak association.

5.3 RESULTS

5.3.1 Descriptive statistics

Eighty-seven percent (87%) (N=377) of the drivers reported that they were paid for non-driving tasks such as loading and unloading. Table 5.1 shows the descriptive statistics of employment type and payment method and Table 5.2 contains the statistics relating the two variables. More than half (54.5%) of the companies used either subcontractor drivers and/or owner drivers in addition to employee drivers while 27.8% of them used employee drivers only. Of the companies which used either subcontractor drivers and/or owner drivers in addition to employee drivers, the majority (62.8%) used all types of drivers while 24.4% of them used subcontractor drivers in addition to employee drivers and few companies (12.8%) combined owner drivers with employee drivers.

Of the companies which used outsourcing only, 43.8% of them used both owner drivers and subcontractor drivers, while 20.8% of them used owner drivers only. Concerning payment methods, time-based rates were the most common (49.5%), while performance-based rates were the least common (6.7%). Irrespective of the employment type, companies mostly paid time-based rates.

Table 5.2 Association between employment type and payment method

N=400	Employee driver only 111 (27.8%)	Outsourcing only 48 (12.0%)	Employee driver and outsourcing 218 (54.5%)	Other driver 23 (5.7%)
Time-based rate	74 (66.7)	23 (47.9)	101(46.3)	0 (0.0)
Performance-based rate	7 (6.3)	8 (16.7)	12 (5.6)	0 (0.0)
Mixed rate	28 (25.2)	9 (18.7)	101(46.3)	0 (0.0)
Other rate	2 (1.8)	8 (16.7)	4 (1.8)	23 (100.0)

Table 5.3 and Table 5.4 show the descriptive statistics by employment type and payment method. The majority of the participants (75.8%) reported that their companies were very familiar with the CoR legislation; however, only a minority of all the participants believed that the CoR had extended liability to a substantial extent to their companies (29.3%) and other parties in the transport logistics and supply chain (26.9%).

The majority of the participants also reported an increased awareness of driver fatigue in their company (78.8%) and in the HV industry (88.8%) over the last 5 years. Nonetheless, only half of them reported that their companies understood FM schemes very well. Most of the companies were medium-sized companies (between 5 and 29 trucks) and undertook trips of more than 100 km.

Table 5.3 Descriptive statistics by employment type

Variable	Employee driver only	Outsourcing only	Employee driver and outsourcing	Other driver	
Familiarity with CoR	(%)	(%)	(%)	(%)	N=400 (%)
Very familiar	83 (27.4)	32 (10.6)	175 (57.7)	13 (4.3)	303 (75.8)
Have heard about it	26 (31.3)	14 (16.9)	34 (40.9)	9 (10.9)	83 (20.7)
Have not heard about it	2 (14.3)	2 (14.3)	9 (64.3)	1 (7.1)	14 (3.5)
Extension of CoR liability to the company*					N=386
To a substantial extent	28 (24.8)	6 (5.3)	69 (61.1)	10 (8.8)	113 (29.3)
To some extent	42 (27.6)	24 (15.8)	82 (53.9)	4 (2.7)	152 (39.4)
No change	39 (32.2)	16 (13.3)	58 (47.9)	8 (6.6)	121 (31.3)
Extension of CoR liability to other parties					N=386
To a substantial extent	23 (22.2)	10 (9.6)	64 (61.5)	7 (6.7)	104 (26.9)
To some extent	47 (27.2)	24 (13.9)	96 (55.5)	6 (3.4)	173 (44.9)
No change	39 (35.8)	12 (11.0)	49 (44.9)	9 (8.3)	109 (28.2)
Awareness of driver fatigue*					N=400
Increase	81 (25.7)	36 (11.4)	182 (57.8)	16 (5.1)	315 (78.8)
No change	28 (41.2)	8 (11.8)	28 (41.2)	4 (5.9)	68 (17)
Decrease	2 (11.8)	4 (23.5)	8 (47.1)	3 (17.6)	17 (4.2)

Industry awareness of driver fatigue					N=400
Increase	101 (28.4)	43 (12.1)	192 (54.1)	19 (5.4)	355 (88.8)
No change	10 (22.2)	5 (11.1)	26 (57.8)	4 (8.9)	45 (11.2)
Decrease	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Understanding of FM schemes*					N=400
Very well	59 (29.5)	13 (6.5)	124 (62.0)	4 (2.0)	200 (50.0)
Fairly well	41(25.8)	25 (15.7)	82 (51.6)	11(6.9)	159 (39.8)
Slightly well	11(26.8)	10 (24.4)	12 (29.3)	8 (19.5)	41 (10.2)
Company size*					N=399
Small (4 or fewer trucks)	30 (31.6)	19 (20.0)	38 (40.0)	8 (8.4)	95 (23.8)
Medium (5-29 trucks)	62 (31.3)	24 (12.2)	105 (53.0)	7 (3.5)	198 (49.6)
Large (30 or more tucks)	19 (17.9)	5 (4.7)	74 (69.8)	8 (7.6)	106 (26.6)
Number of trips of more than 100 km*					N=400
All trips	26 (38.8)	6 (9.0)	34 (50.7)	1 (1.5)	67 (16.7)
Most of the trips	44 (26.2)	14 (8.3)	97 (57.7)	13 (7.8)	168 (42.0)
Some of the trips	41(24.8)	28 (17.0)	87 (52.7)	9 (5.5)	165 (41.3)

*Significantly correlated to employment type at the 95% confidence level

Table 5.4 Descriptive statistics by payment method

Variable	Time-based rate	Performance-based rate	Mixed rate	Other rate	
Familiarity with CoR	(%)	(%)	(%)	(%)	N=400 (%)
Very familiar	148 (48.8)	22 (7.3)	110 (36.3)	23 (7.6)	303 (75.8)
Have heard about it	41 (49.4)	4 (4.8)	25 (30.1)	13 (15.7)	83 (20.7)
Have not heard about it	9 (64.3)	1 (7.1)	3 (21.5)	1 (7.1)	14 (3.5)
Extension of CoR liability to the company					N=386
To a substantial extent	48 (42.5)	9 (8.0)	44 (38.9)	12 (10.6)	113 (29.3)
To some extent	79 (51.9)	10 (6.6)	53 (34.9)	10 (6.6)	152 (39.4)
No change	62 (51.2)	7 (5.8)	38 (31.4)	14 (11.6)	121 (31.3)
Extension of CoR liability to other parties					N=386
To a substantial extent	46 (44.2)	9 (8.6)	40 (38.4)	9 (8.6)	104 (26.9)
To some extent	86 (49.7)	11 (6.4)	61 (35.3)	15 (8.6)	173 (44.8)
No change	57 (52.3)	6 (5.5)	34 (31.2)	12 (11.0)	109 (28.3)
Awareness of driver fatigue*					N=400
Increase	147 (46.7)	22 (6.9)	120 (38.1)	26 (8.3)	315 (78.8)
No change	41 (60.3)	5 (7.4)	15 (22.1)	7 (10.2)	68 (17)
Decrease	10 (58.9)	0 (0.0)	3 (17.6)	4 (23.5)	17 (4.2)

Industry awareness of driver fatigue					N=400
Increase	173 (48.7)	25 (7.0)	127 (35.8)	30 (8.5)	355 (88.8)
No change	25 (55.6)	2 (4.4)	11 (24.4)	7 (15.6)	45 (11.2)
Decrease	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Understanding of FM schemes*					N=400
Very well	99 (49.5)	15 (7.5)	77 (38.5)	9 (4.5)	200 (50)
Fairly well	81 (50.9)	10 (6.3)	51 (32.1)	17 (10.7)	159 (39.8)
Slightly well	18 (43.9)	2 (4.9)	10 (24.4)	11 (26.8)	41 (10.2)
Company size*					N=399
Small (4 or fewer trucks)	60 (63.2)	7 (7.3)	13 (13.7)	15 (15.8)	95 (23.8)
Medium (5-29 trucks)	99 (50.0)	15 (7.6)	74 (37.4)	10 (5.0)	198 (49.6)
Large (30 or more tucks)	38 (35.8)	5 (4.7)	51 (48.1)	12 (11.4)	106 (26.6)
Number of trips of more than 100 km*					N=400
All trips	32 (47.7)	7 (10.4)	26 (38.8)	2 (3.0)	67 (16.8)
Most of the trips	66 (39.3)	13 (7.7)	70 (41.7)	19 (11.3)	168 (42.0)
Some of the trips	100 (60.6)	7 (4.2)	42 (25.5)	16 (9.7)	165 (41.2)

*Significantly correlated to payment method at the 95% confidence level

Using the cut-off P-value of 0.2, five of the six variables related to the CoR legislation were correlated to employment type, while only two of them were correlated to payment methods. In the presence of multicollinearity, the estimates from an MLR are likely to be inaccurate (Camminatiello & Lucadamo, 2010). Thus, the correlation between the selected explanatory variables was assessed using Cramer's V statistics in Table 5.5.

Table 5.5 Cramer's V statistics among the independent variables

Variable	1	2	3	4	5	6	7
1. Familiarity with CoR	1						
2. CoR liability to the company	0.24*	1					
3. CoR liability to other parties	0.19*	0.44*	1				
4. Awareness of driver fatigue	0.09	0.08	0.11	1			
5. Understanding of FM schemes	0.34*	0.12*	0.11*	0.08	1		
6. Company size	0.17*	0.11*	0.09	0.13*	0.23*	1	
7. Trips of more than 100 km	0.08	0.06	0.05	0.05	0.15*	0.08	1

*Variables significantly correlated at the 95% confidence level

As already explained in Study 1c, the V statistic varies between 0 and 1, with 0 implying the absence of association and 1 referring to a perfect association. A V less than 0.30 indicates a weak to negligible association, a V between 0.30 and 0.70 denotes a weak to fairly strong association and a V higher than 0.70 indicates a strong association. The V statistics among the independent variables in Table 5.5 are all less than 0.70, implying the absence of a strong correlation among these variables and hence the absence of multicollinearity in the MLRs. Therefore, all the independent variables were considered in the MLRs.

5.3.2 MLRs for employment type and payment method

Table 5.6 and Table 5.7 show the estimated results of the MLRs for employment type and payment method, respectively. The Wald statistic was 170.52 for the employment type regression and 189.31 for the payment model. Both statistics had associated P-values<0.0001, implying that both models were globally statistically significant at the 99% confidence level.

Table 5.6 Multinomial logistic regression for the employment type

Reference category: Employee driver only	Outsourcing Only	Employee driver and outsourcing	Other driver
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Familiarity with CoR			
Very familiar	1.00	1.00	1.00
Have heard about it×	0.85 (0.45-1.60)	0.86 (0.37-2.01)	3.69 (1.03-13.14)*
CoR liability to company			
To a substantial extent	1.00	1.00	1.00
To some extent	1.06 (0.55-2.05)	2.3 (0.82-6.45)	0.15 (0.03-0.71)*
No change	0.97 (0.48-1.97)	2.15 (0.72-6.44)	0.31 (0.07-1.37)
CoR liability to other parties			
To a substantial extent	1.00	1.00	1.00
To some extent	0.91 (0.46-1.77)	0.50 (0.19-1.35)	0.68 (0.16-2.80)
No change	0.63 (0.30-1.32)	0.32 (0.11- 0.95)**	0.84 (0.20-3.43)
Awareness of driver fatigue			
Increase	1.00	1.00	1.00
No change	0.51 (0.27-0.95)*	0.75 (0.30-1.89)	0.82 (0.20-3.42)
Decrease	2.10 (0.40-1.15)	4.14 (0.66-25.83)	5.43 (0.67-42.98)
Understanding of FM schemes			
Very well	2.68 (1.40-5.14)**	0.24 (0.10-0.59)**	0.07 (0.01-0.31)**
Fairly well	2.63 (1.24-5.58)*	0.60 (0.25- 1.43)	0.38 (0.11-1.31)
Slightly well	1.00	1.00	1.00
Company size			

Small	0.40 (0.20-0.83)*	0.97 (0.36-2.61)	0.16 (0.04-0.65)*
Medium	0.49 (0.28-0.88)*	0.68 (0.28-1.65)	0.12 (0.03-0.41)**
Large	1.00	1.00	1.00
Number of trips of more than 100 km			
All trips	1.00	1.00	1.00
Most of the trips	2.07 (1.10-3.87)*	0.97 (0.38-2.54)	11.63 (2.30-58.72)**
Some of the trips	1.99 (1.05-3.78)*	1.73 (0.72- 4.12)	5.53 (1.19-25.73)*
Log-likelihood		-380.03	
Number of observations		385	

**p<0.01, *p<0.05, ×The category "Have not heard about it" was included in this category because of the small size of the former.

Table 5.7 Multinomial logistic regression for payment method

Reference category: Time-based rate	Performance-based rate	Mixed rate	Other rate
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Awareness of driver fatigue			
Increase	1.00	1.00	1.00
No change×	0.60 (0.21-1.72)	0.50 (0.27-0.94)*	1.25 (0.54-2.89)
Understanding of FM schemes			
Very well	0.40 (0.18-0.91)*	1.31 (0.74-2.30)	0.09 (0.03-0.23)**
Fairly well	0.46 (0.17-1.24)	1.48 (0.76-2.89)	0.29 (0.13-0.71)**
Slightly well	1.00	1.00	1.00
Company size			
Small	0.60 (0.21-1.68)	0.21 (0.10-0.43)**	0.34 (0.13-0.84)*
Medium	0.69 (0.30-1.58)	0.61 (0.37-1.01)	0.18 (0.07-0.44)**
Large	1.00	1.00	1.00
Number of trips of more than 100 km			
All trips	1.00	1.00	1.00
Most of the trips	0.65 (0.27-1.57)	1.53 (0.83-2.83)	3.65 (1.30-10.23)*
Some of the trips	0.22 (0.08-0.58)**	0.64 (0.35-1.19)	1.51 (0.57- 3.99)
Log-likelihood		-407.92	

Number of observations	399

$^{**}p<0.01$, $^{*}p<0.05$, ×The category "Decrease in awareness of driver fatigue" was included in this category because of the small size of the former.

The results showed that not all the levels of awareness and perceptions significantly influence driver employment type and payment methods. Moreover, the different levels of awareness and perceptions have diverse relationships with driver employment type and payment methods.

5.4 DISCUSSION

Study 1 showed that distance-based payments encourage drivers to increase their productivity. Nevertheless, this incentive often modifies driver behaviours in ways that negatively affect safety performance. In contrast, owner drivers have lower odds of crash involvement than employee drivers. However, payment methods could significantly influence the association between driver employment type and safety outcomes with poor safety performance being common among owner drivers than other drivers. The current study examined the relationship between company awareness of CoR legislation and the driver employment types and payment methods. The results from MLRs showed various outcomes for the different independent variables.

The descriptive statistics showed that more than 78% of the participants reported that their company awareness of driver fatigue increased over the last 5 years. However, only 50% of them reported that they understood FM schemes very well. This is likely to support the claim that CoR legislation, despite the safety improvement it has been associated with in the HV industry, still has some limitations which offer opportunities to improve the laws and increase compliance (Edwards, 2014; NTC, 2015). Not all the actors to whom the CoR legislation applies understand it (Beesley, 2016). Thus, there is a need to promote the advantages of the

CoR legislation to persuade companies of its importance and the benefits they could obtain from it. Moreover, there is no specification of the actions or inactions that parties should undertake or not undertake to abide by the law. Most of the prosecutions have been on drivers and operators who have to meet unrealistic deadlines imposed by customers (IBISWorld, 2014; Transport Workers' Union of Australia, 2015). Nevertheless, very few customers have been prosecuted to date under CoR legislation, limiting its effectiveness (Mooren, 2016). In this study, more than 70% of the participants reported a high level of familiarity with CoR legislation. However, less than 30% of them reported that they believed that the CoR had extended liability to their companies or other parties in the supply chain.

Moreover, as reported by the National Transport Commission (NTC, 2019), the Heavy Vehicle National Law which incorporates the CoR legislation has several limitations, among which its inconsistency across the different states. This compromises the objective of the reform because drivers experience compliance stress from one state to another. The law focuses more on administrative issues than safety outcomes; for instance, companies are required to provide proof of compliance with FM schemes. In 2019, a driver received three penalties notifications for work diary breaches, even though he did not pose any safety risk (NTC, 2019). The law is applied in one-size-fits-all approach; there is no distinction between the types of operators. Furthermore, the CoR legislation, though encouraging companies to adopt safety-promoting policies, does not directly address the subcontracting and driver payment issues. The RSRT was intended to address these issues by setting minimum pay rates and pay rates that cover driving and non-driving tasks.

The estimates of the MLRs showed that companies which had heard about CoR legislation were more inclined to use unspecified drivers than employee drivers.

However, companies for which the CoR legislation had extended liability to some extent to them were less likely to do so. This could imply that simply hearing about the CoR legislation may not be a sufficient criterion to influence their actual behaviours regarding driver employment type. Further knowledge about their perception of this legislation may alter their behaviour.

Companies for which there was no change in the extension of CoR liability to other parties had lower odds of simultaneously using employee drivers and either or both subcontractor drivers and owner drivers than employee drivers only. Companies whose awareness of driver fatigue did not change had lower odds of paying mixed rates than time-based rates. Thus, it can be suggested that companies whose perceptions of driver fatigue and the extension of CoR liability to other parties did not change were more likely to use employee drivers and pay time-based rates which literature reports to be the most associated with better safety outcomes.

Companies which understood fatigue FM schemes fairly or very well had higher odds of solely outsourcing than using employee drivers only. Conversely, companies which understood FM schemes very well had lower odds of using either other drivers only or third-party drivers together with employee drivers, rather than employee drivers only. An improved understanding of FM schemes appears to encourage companies to outsource the driving task. The driving task is often subcontracted to small companies (NTARC, 2017) which are more likely to be in a critical financial situation (Quinlan & Wright, 2008) and thus more likely to also have a poor safety record. Moreover, they mostly carry freight outside of the control of the subcontracting companies (Miller, et al., 2018). Fatigue management schemes are designed to ensure a safe subcontracting of the driving task, as they require each actor in the transport chain, including drivers, to comply with FM regulations. Thus, a good understanding of FM schemes is more likely to be associated with the use of third-party drivers.

Companies which understood FM schemes very well had lower odds of paying performance-based rates or other rates than time-based rates, and those who indicated understanding them fairly well were also less likely to pay other rates. Thus, a better understanding of FM schemes is likely to motivate the adoption of policies such as the payment of time-based rates, which encourage safe on-road behaviours. Performance-based rates that connect earnings to the amount of work performed (number of trips completed, number of kilometres driven, etc.) encourage drivers to speed, use stimulants, and work longer hours than legally authorised, all of which lead to an increased likelihood of fatigued driving and hence crash risk (O'Neill & Thornthwaite, 2016; Thompson & Stevenson, 2014; Williamson & Friswell, 2013). Thus, economic imperatives encourage non-compliance with FM regulations (Jones, 2013; NTC, 2014). Fatigue management schemes provide HV operators with instructions to avoid actions that encourage extended driving and require companies to show evidence of their compliance. A good understanding of the fatigue regulations is accordingly likely to be associated with a decrease in payments that relate earnings to performance.

Small and medium-sized companies had lower odds of using third-party drivers than employee drivers. These companies also had lower odds of paying unspecified rates than time-based rates, while small companies had lower odds of paying mixed rates than time-based rates. These companies are accordingly more likely to use employee drivers and pay time-based rates. Small and medium-sized companies, particularly small companies, may not have the economic, human and technological resources to monitor the on-road behaviour of contractors and accordingly reduce the probability that their products be damaged (Cantor, 2014; Knipling, Nelson, Bergoffen, & Burks, 2011; Legg et al., 2009; Legg, Olsen, Laird, & Hasle, 2015; Peignier, Leroux, de Marcellis-Warin, & Trépanier, 2011; Rodríguez, et al., 2004). Thus, they are incentivised to use employee drivers only and adopt payment policies such as time-based rates that are likely to increase driver compliance with company safety objectives (Rodríguez, et al., 2004).

Companies having some or most of their trips longer than 100 km had higher odds of using subcontractor drivers and/or owner drivers, and other drivers than employee drivers. Thus, the longer distances companies have to travel, the more likely they would use third-party drivers, as longer trips are more likely to be associated with an increased safety risk. Consequently, operators, particularly larger companies, often use owner drivers to avoid vehicle maintenance responsibilities and/or the acquisition of appropriate equipment to enhance the quality of service and reduce safety issues (Cantor, et al., 2016). Nevertheless, having some of the trips longer than 100 km was associated with lower odds of paying performance-based rates than time-based rates, while having most of the trips longer 100 km was related to higher odds of paying unspecified rates than time-based rates.

5.4.1 Study limitations

This study has some limitations. It used self-reported data, which are likely to include errors. Participants may overestimate their understanding of fatigue management schemes to show awareness of safety regulations. It took 45 minutes to complete the survey, and the variables related to the CoR were covered at the end of the survey. Participants may have been preoccupied with finishing the survey rather than giving their actual perceptions.

5.5 CHAPTER SUMMARY

Chapter 4 has shown that HV driver employment type and payment methods influence crash involvement (Study 1a), affect driver use of cruise control (Study 1b) and payment methods can help explain the relationship between employment type and fatigue-related behaviours (Study 1c). The purpose of Study 2 was to examine the associations between HV companies' awareness of the CoR legislation with driver employment type and payment methods.

The findings showed that companies' perceptions of the extent to which the CoR has extended liability to them and other parties in the transport logistics and supply chain were not significant predictors of driver employment type. A similar result was found for company familiarity with CoR legislation. However, an improved understanding by companies of FM schemes was more likely to be associated with lower odds of paying performance-based rates than time-based rates. Thus, it could accordingly be inferred that a better understanding of FM schemes could potentially be associated with an improvement in safety outcomes because of its likelihood of discouraging payments that connect earnings to performance. Education should be an essential part to increase compliance with CoR laws. It should consist of targeting all the parties in the transport logistics and supply chain and informing them of their duties and responsibilities in order to avoid or reduce law breaches.

The results also showed that companies which understood FM schemes very well had a higher likelihood of using subcontractor drivers and/or owner drivers. This could be due to the reduced fatigued driving that is likely to be associated with FM schemes because they encourage both companies and drivers to be active in fatigue management (NTC, 2006a). The result also showed that small companies were more likely to use employee drivers and pay time-based rates. Small companies are unlikely to possess the economic and technological resources to monitor driver on-road behaviours. Therefore, they use employee drivers and pay time-based rates which are likely to encourage driver compliance with safety regulations (Rodríguez, et al., 2004).

The next chapter presents Study 3 which examines the association of HV company financial performance with safety performance as well as other elements such as driver employment type, payment methods and CoR legislation, which are channels through which the financial situation could affect safety outcomes.

Chapter 6: Study 3-The relationships between company financial performance and safety performance

6.1 INTRODUCTION

The safety policies of HV companies and enforcement of government legislation combine to influence safety outcomes in the HV industry. The legislation is enforced to ensure that truck operators adopt safety-promoting behaviours or to punish unsafe behaviours. Concerning companies, the quality of drivers and equipment is vital for better safety performance (Knipling, 2011b). Driver payment method is an important factor that influences driver safety performance.

Study 1 showed that paying drivers based on the distance driven may directly or indirectly increase crash risk. Study 1a showed that owner drivers are less likely to be involved in crashes than employee drivers, while distance-based payments are associated with poor safety performance such as higher crash involvement (Study 1a) or higher levels of undesired fatigue-related behaviours (Study 1c). Distance-based payments may indirectly influence crash involvement by moderating driver use of cruise control (Study 1b). Study 2 showed that the CoR legislation is associated with a lower likelihood of companies paying drivers based on performance. This suggests that the CoR legislation could be associated with safety improvements in the HV industry. Nevertheless, even if HV companies adopt payment methods that are conducive to safety, the working conditions may still be poor if companies do not have enough financial resources to operate new equipment or adequately maintain the existing equipment (Beard, 1992; Chow, 1989). The financial performance of HV companies accordingly appears as a potential influencing factor of safety performance in the HV industry (Rodríguez, et al., 2004). In spite of legislation and law enforcement, safety in times of financial instability is likely to be a secondary issue (Boustras & Guldenmund, 2018) because organisations may reduce the investments devoted to factors such as employee training; acquisition of new equipment and the maintenance of existing equipment (Anyfantis, Boustras, & Karageorgiou, 2018). It is essential to empirically explore the relationship between financial performance and safety performance to inform company managers of the benefits or losses they could obtain or undergo by adequately or inadequately investing in safety. The findings of the research may also be useful for governmental regulators and policymakers because financial performance outcomes could serve as benchmarks to evaluate the safety performance of HV companies. Thus, this study addresses Research Question 5 (Is there a bidirectional link between company financial performance and HV crash involvement?) and Research Question 6 (Is HV company financial performance associated with other factors influencing crash involvement?). The bidirectional link is meant to examine the reciprocal causality between financial performance and safety performance. According to Wooden (1989), good financial performers are likely to have good safety performance because of improved working conditions which may attract skilled drivers. Conversely, poor safety performance may increase company insurance premiums and damage its reputation which may result in poor financial performance.

6.2 METHODS

6.2.1 Participant recruitment

The participants were representatives of Australian heavy trucking operators. These representatives were company managers or administrative staff members who have sufficient understanding of the financial and safety performance of the company, as well as how drivers are paid and managed (the use of company drivers versus the use of contractors).

A multi-stage approach to recruitment was adopted in response to difficulties encountered in obtaining sufficient participants for this study. Several attempts were made to recruit participants through companies' contact details in the Yellow Pages. This approach was later supplemented by assistance from the Australian Trucking Association (ATA). The participant information sheet, recruitment email, and the survey questionnaire are provided in Appendix C (C1, C2, C3, respectively).

6.2.1.1 Recruitment from Yellow Pages

The Yellow Pages website displays either or both telephone numbers and email addresses of truck companies, grouped into different categories. The companies for the current survey were found in the categories *Heavy Vehicle Transport*, *Transport,* and *Transport and forwarding agents*. These categories were selected following Mooren, et al. (2014) and the National Transport Commission (NTC, 2012b), who selected some or all of their participants from these categories in surveys of Australian HV companies.

An online survey was emailed to participants. Data collection was initially scheduled between February 1, 2019 and May 31, 2019. In the ethics application, the research team mentioned that companies would be contacted through their emails collected on the Yellow Pages. Thus, all companies that were identified in the category of *Heavy Vehicle Transport* to have their email addresses on their websites were selected. A set of 450 addresses were collected, and the survey was then sent to these emails in the first week of February 2019. The questionnaire was expected to be completed by any office-based employee in the company having the appropriate knowledge to complete the survey. Thus, the recruitment email contained the following message:

> The questionnaire is designed to be completed by company managers or any administrative staff members who have a sufficient understanding of the financial and safety performance of the company, as well as how drivers are paid and managed (the use of company drivers versus the use of contractors). It does not ask for any specific financial details. If you do not have sufficient knowledge of these matters, please consider forwarding this email to a relevant member of your company.

This option of collecting emails and sending the survey was not fruitful because out of the 450 emails sent there were only two completions at the end of February 2019. Thus, an ethics variation was submitted and approved on March 20, 2019 to request permission to call companies to obtain the emails of those who might be willing to participate in the survey and send reminders to participants three weeks after the initial contact.

Companies in the category *Heavy Vehicle Transport* having only telephone numbers on their websites were the target of the next step. A set of 529 telephone numbers were collected and called. Two English native speakers who had been appropriately trained to collect this data made the calls. The calls were made during weekdays between 10:00 AM and 4:00 PM based on the availability of the callers. The survey was emailed on the same day as the phone calls. After some initial trials, the following message was finalised and read on the telephone during the calls:

> Hi, my name is ———. I am calling on behalf of a PhD student at the Queensland University of Technology. We are conducting a 20-minute online survey about truck safety in Australia. I am wondering if your company might be willing to participate and give me an email to which we will send the questionnaire. Participants will be offered the chance to enter a prize draw to receive $100 Myer Gift cards.

Participants were reminded at the beginning of the recruitment email that their emails were obtained some time ago from a call:

> Hello, and thanks for having given us your email when our team recently called you.

This option enabled to increase the sample size to 15 completions by May 31, 2019. Due to the low response rate, an ethics variation to extend the data collection period from May 31, 2019 to July 31, 2019 was submitted and approved on May 28, 2019.

Following this second approval, the search for companies on Yellow Pages was extended to the categories *Transport* and *Transport and forwarding agents.* A total of 1,370 telephone numbers were collected from these categories and called, resulting in an increase in sample size to a total of 42 completions.

The research team deemed that this number was too small to provide meaningful results for quantitative analysis. Thus, a third ethics variation was submitted and approved on August 29, 2019. It aimed to extend the data collection period from July 31, 2019 to October 31, 2019 and to request permission to use a snowball technique. Following this third and last approval, 150 new email addresses were obtained from Yellow Pages in the *Heavy Vehicle Transport* category. The telephone numbers of the 450 companies whose emails were initially collected from the *Heavy Vehicle Transport* category were also collected and called. In sum, 2,499 calls were made to companies obtained from Yellow Pages.

6.2.1.2 Recruitment from TruckSafe members

Following the approval to use the snowball technique, the research team contacted the Safety, Health and Wellbeing Director of the ATA to forward the survey to the member companies. The ATA represents 50,000 businesses and

200,000 persons in the national trucking industry (ATA, 2018). It is committed to ensuring a safer operating environment for the trucking industry (ATA, 2016).

The Director forwarded the survey to 200 TruckSafe member companies on September 9, 2019. TruckSafe is a voluntary industry accreditation scheme implemented by the ATA aimed at enhancing the safety and expertise of the trucking operators. The compliance with TruckSafe regulations implies that operators have the documentation showing that they have safer workplaces and well-maintained vehicles driven by healthy and trained drivers (ATA, 2019).

6.2.1.3 Survey participants, rules and response rate

Of the 2,499 telephone numbers obtained from Yellow Pages, 559 companies agreed to participate in the survey and provided their emails. A sample of 200 TruckSafe member companies was contacted through the ATA. Thus, the survey was emailed to 759 companies using the QUT Key Survey Software. This software enables participants to click through the survey several times, skip questions, and review their answers before submission. There were 327 click-throughs, but it is not possible to know how many people clicked through, since the same participant could view the survey several times. Twenty-two (22) participants began the survey and did not submit it. Nine (9) of these participants did not fill in any questions, while the remaining 13 filled between 1 and 5 questions. These 22 participants were accordingly not considered in the analysis.

A total of 69 participants submitted their answers and were considered in the analysis, corresponding to a response rate of 9%. The surveys of the participants obtained from Yellow Pages or contacted by the ATA were conducted concurrently, making it impossible to dissociate response rates.

The participants were advised that the survey is anonymous and participation is voluntary, and they could stop the survey at any time by closing their browser without comment or penalty. Nevertheless, partially completed surveys could still be used in the analysis. After completion of the survey, each participant was offered the option to enter a prize draw to receive one $100 Coles/Myer Gift card. Twelve gift cards were allocated to the whole survey with 4 cards to the first batch, 3 cards to the second and 5 cards to the last batch.

6.2.2 Questionnaire

The questionnaire was composed of 53 questions, more than half of which could be skipped conditional on the answers to preceding questions. The questionnaire was split into eight sections asking about company information over the past 12 months or the 12 months before then. The sections were entitled Participant profile, Company profile, Vehicle characteristics, Driver payment policy, Financial performance, Safety performance, Perception by the other members of the company, and Company awareness of the CoR legislation. The content of most of the questionnaire was adapted from the questionnaire of the National Transport Commission (NTC, 2012b).

6.2.2.1 Participant profile

The questionnaire of the National Transport Commission was designed to be answered by the logistics, operations, or freight managers of the companies. The current survey was designed to be answered by any office-based employee who has adequate knowledge of the financial and safety performance of the company, as well as how it pays and manages drivers. Thus, the person filling the survey was asked to indicate his/her profile among a set of company positions: Owner/Director, Finance Manager, General management, Office staff or other.

6.2.2.2 Company profile

The company profile section contained 5 questions related to the operating area of the company, the number of HVs used in an average week, the types of commodities carried in the past 12 months and any potential major changes (change of ownership, significant expansion, major acquisition of vehicle, bankruptcy) that occurred in the company in the last 5 years. Regarding the operating area, NTC (2012b) asked companies to indicate the state in which they are based. The current survey asked them to indicate their operating area (local, regional, state-wide, interstate or other). The research team believed that the operating area, more than the location, could affect the financial and safety performance of the company.

6.2.2.3 Vehicle characteristics

The information concerning vehicle characteristics was formulated in 6 questions related to truck type, the average age of the company vehicle fleet, the average age of company vehicles at purchase in the past 12 months and, if applicable, the frequency at which the company scheduled vehicles for maintenance or inspection. The last question listed some technologies and asked the company to report the percentage of its vehicles equipped with each of these technologies.

6.2.2.4 Driver payment policy

The driver payment policies were described in 27 questions. Not all questions would apply to all companies. These questions were framed based on the type of driver (employee drivers, owner drivers and subcontractor drivers) and the distance driven (short distance, at most 200 km versus long distance, more than 200 km). The questions concerned whether the company selected each type of driver for each type of distances. When applicable, participants were asked to report the number of drivers, select all the types of payment methods they paid these drivers and indicate whether drivers were paid for non-driving tasks such as loading/unloading and queuing/waiting. Drivers could be paid based on the amount of time worked or on the performance as described in NTC (2012b) and used in Study 2. The last three questions of this section, designed by the research team, asked participants to assess on a five-point Likert scale (very poor, poor, neither poor nor good, good, very good) the skill levels of the drivers their company selected in the past 12 months, select the type(s) of payment methods they think is/are conducive to road safety, and report the average rate (per hour, per trip or per kilometre) their company paid drivers.

6.2.2.5 Financial performance

This section contained two five-point Likert scale questions designed by the research team. The first question asked the participants to rate the financial performance (very poor, poor, neither poor nor good, good, very good) in the past 12 months and the 12 months before then. The second question asked the participants to rate the financial performance (much less, less, about the same, more, much more) of their company to that of their competitors in the past 12 months and the 12 months before then.

6.2.2.6 Safety performance

The safety performance of the company was framed in 4 questions designed by the research team. Two of these questions were five-point Likert scale questions. As in the case of financial performance, the first question asked participants to rate the safety performance (very poor, poor, neither poor nor good, good, very good) of their company in the past 12 months and the 12 months before then. The second Likert scale question asked participants to rate the level (very low, low, neither low nor high, high, very high) of crash-related insurance costs of their company in the past 12 months and the 12 months before then. The last two questions asked about the number of policed-attended crashes in which the company was involved and, if known, the number of these crashes in which the company was at-fault.

6.2.2.7 Perception by the other members of the company

This section contained two five-point Likert scale questions. They asked participants to report the perception by the other members of the company concerning its financial performance (very poor, poor, neither poor nor good, good, very good) and safety performance (very poor, poor, neither poor nor good, good, very good) in the past 12 months and the 12 months before then.

6.2.2.8 Company awareness of the chain of responsibility legislation

This section had 6 questions designed by the research team. The first question was a four-point Likert scale question asking participants to rate the level of awareness (no opinion, have not heard about it, have heard something about it, very familiar) of the CoR legislation of their company. The second question was a five-point Likert scale question asking participants to rate the awareness (very poor, poor, neither poor nor good, good, very good) of driver fatigue of their company. The remaining four questions asked companies about the potential changes in terms of driver employment type and payment methods that the introduction of the CoR legislation has been associated with. Some of these four questions would not apply to companies and could be skipped, depending on the answer to the previous question.

6.2.3 Data

Some of the variables were recoded for the study. Similar to Study 2, participants were asked to select all categories that apply for employment type and payment method. Thus, in Study 3, employment type and payment method were recoded. Two four-category variables were created for companies' use of drivers for short and long-distance trips, respectively: employee driver only, outsourcing only (subcontractor driver and/or owner drivers), employee drivers and outsourcing, and not applicable (for companies which did not use drivers). Likewise, for each type of trip, the payment method was classified as a time-based rate (hour, day, week and single time pay plus overtime), performance-based rate (trip rate, distance-based rate, tonnage rate), mixed rate (time-based and performance-based), not applicable (for companies which did not undertake such kinds of trips) and the payment for the non-driving tasks was divided into all types of drivers were paid, some of the drivers were paid, and no payment for driving tasks.

Technology adoption was represented by nine technologies, each of which was defined by a three-point Likert scale variable: none, some, and all vehicles. A score was created for technology adoption and tested reliable (Cronbach alpha=0.82). This score was an additive index obtained by summing all the nine Likert scale variables representing technology adoption. The obtained index is an ordered series of integers, where lower numbers indicate low levels of the measured variable (here the percentage of vehicles equipped with the technology) and high numbers refer to high levels of the measured variable (Kohler & Kreuter, 2005). The index for technology adoption was composed of an ordered series of sixteen integers reduced to three categories: Low, medium and high, where low indicates a low percentage of vehicles equipped with technology, medium is medium percentage of vehicles equipped with technology, and high is a high percentage of vehicles equipped with technology. Low was composed of the first five numbers of the series, medium was composed of the next five number, and high was composed of the last six numbers.

6.2.4 Analytical method

RQ5 examining the bidirectional relationship between financial performance and safety performance is accordingly composed of two parts. The first part of RQ5 examines the influence of financial performance (ordinal variable) on safety performance, represented by crash involvement (binary variable) or perception of safety performance (ordinal variable). When designing the experiment, it was planned to use binary logistic regression (binary dependent variable), ordered probit, or mixed logit (ordinal dependent variable) for this analysis. The second part of RQ5, examining the influence of safety performance on financial performance, and RQ6 examining the associations of financial performance with other factors influencing crash involvement (categorical variables) were expected to be examined using ordered probit or mixed logit regressions controlling for other confounding factors.

Given the small sample size, the suitability of the planned analyses was reconsidered. Based on the work of Peduzzi, Concato, Kemper, Holford, and Feinstein (1996), the minimum sample size N for logistic regressions is $N = \frac{10k}{p}$ where k is the number of parameters and p the smallest of the proportions of 0s and 1s in the dependent variable; 22.7% of 1's in the present case. The required sample size is accordingly $N = 44k$. Thus, the sample size of 69 for this study is inadequate to obtain a meaningful model mainly using ordered probit or mixed logit models.

Correspondence analysis (CA) was used instead for the second part of RQ5 and RQ6. It is a data exploration technique which can effectively examine the relationships between and among categorical variables irrespective of the sample size (Kudlats, et al., 2014).

6.2.4.1 Regression model

The influence of financial performance on crash involvement (RQ5) was examined using logistic regression to control for the effects of other variables. Previous such research used the lagged financial performance, on the grounds that the benefits of safety investments may not be immediate (Corsi, et al., 1988). The effects of financial performance through safety investments may be associated with better safety performance. Nevertheless, it may take some time with the effects of safety investment of a year appearing the following year (Britto, et al., 2010; Corsi, et al., 1988; Miller & Saldanha, 2016; Pritchard, 2010).

Crash involvement in the *current* year as the dependent variable was represented by a binary variable equalling 1 if the company was involved in an at-fault crash and 0 otherwise. The total crash involvement was used in previous studies; however, at-fault crash involvement is more likely to represent the safety efforts of companies than total crash involvement (Beard, 1992; Savage, 1999).

Due to the small sample size of the current study, only two of the potential explanatory variables (the number of trucks used in an average week in the past 12 months and financial performance in the 12 months before then) provided a statistically significant model. At-fault crash involvement had 3 missing values which were included in the regression using the multiple imputations method. Thus, the logistic regression was calibrated using the multiple imputations by chained equations (White, et al., 2011) in Stata 15.0.

6.2.4.2 An illustration of correspondence analysis

Correspondence analysis has already been described in Section 3.3.3.2 of Chapter 3. An illustration of how to interpret the output of CA is presented in what follows applying the simple CA to the relationship between two categorical variables collected in the survey for the current study: financial performance (FP12) and safety performance (SP12) in the past 12 months. Financial performance has four categories: poor, neither poor nor good, good, and very good while safety performance has three categories: poor, good and very good. The departing point of CA is a cross-tabulation shown in Table 6.1 between the two variables. The CA is sensitive to outliers, and they should first be identified and removed (Hair, et al., 2010). The box plots showed that there are no outliers in FP12 and SP12. In addition, the Cramer's V statistic (V=0.17) showed that the correlation between the two variables is negligible (Kraska-Miller, 2013). All the calculations related to the CA analysis were performed in Stata 15.0.

Table 6.1 Contingency table for financial performance and safety performance in the past 12 months

	Financial performance			
N=66	Poor	Neither poor nor good	Good	Very good
	7 (11%)	18 (27%)	30 (45%)	11 (17%)
Safety performance				
Poor	1 (14)	1 (5)	1 (3)	0 (0)
Good	2 (29)	5 (28)	12 (44)	5 (45)
Very good	4 (57)	12 (67)	16 (53)	6 (55)

Table 6.2 shows that two dimensions are needed to plot the two variables because they explain more than 70% of the inertia, which, as explained in Section 3.3.3.2, is the rule of thumb for selecting the number of dimensions (Higgs, 1991). Dimension 1 has the highest Eigenvalue, corresponding to the highest inertia and accordingly accounting for the highest percentage (81.6%) of the variance of the model. Dimension 2 has the next and lowest Eigenvalue accounting for 18.4% of this variance.

Table 6.2 Dimensionality between financial and safety performance in the past 12 months

Dimension	Eigenvalue	Inertia	Chi2	Percent of inertia explained	Cumulative percent of inertia
1	0.209	0.043	2.87	81.6	81.6
2	0.099	0.010	0.65	18.4	100.00
Total	-	0.053	3.52	100	-

Figure 6.1 shows the two-dimensional map of the two variables. The origin of the map represents the centroid (the average profile) of each variable. The closer a point to the origin, the closer it is to the centroid.

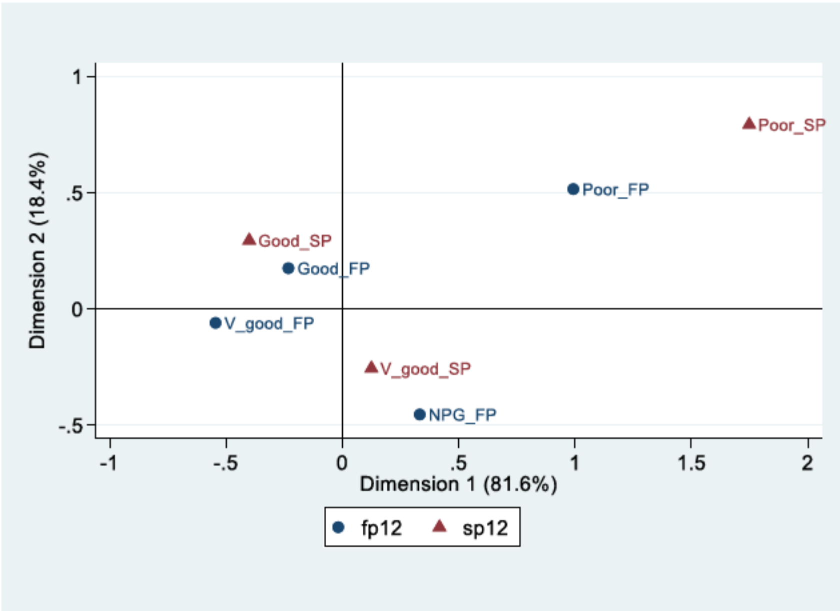


Figure 6.1 Relationship between financial and safety performance in the past 12 months

Table 6.3 contains further information on the map through a statistical description. Coordinates X in Dimension 1 and Y in Dimension 2 represent each response category on the map. The mass of a response category for a variable is the weight (relative frequency) of the category with respect to all categories of the variable (Hair, et al., 2010). The farther away from the centroid a response category is along a specific dimension, the higher its contribution to that dimension. The contribution refers to how well this category loads onto that dimension. The inertia is the variance or dispersion of the category around the centroid. The larger the inertia, the farther is the point from the centroid.

Table 6.3 Decomposition of the inertia between financial and safety performance in the past 12 months

Variable	Mass	Inertia	Dimension 1		Dimension 2	
			X	Contribution	Y	Contribution
FP12						
Poor	0.106	0.461	0.501	0.501	0.284	0.284
Neither poor nor good	0.273	0.223	0.145	0.145	0.569	0.569
Good	0.455	0.121	0.117	0.117	0.140	0.140
Very good	0.167	0.195	0.237	0.237	0.006	0.006
SP12						
Poor	0.045	0.597	0.666	0.666	0.288	0.288
Good	0.379	0.298	0.291	0.291	0.331	0.331
Very good	0.576	0.105	0.043	0.043	0.381	0.381

In the CA map, the relationship between FP12 and SP12 corresponds to the relationship between row points and column points. The lines connecting these points to the origin of the map are accordingly used. Thus, it appears that companies that reported poor financial performance (Poor_FP) also tended to report poor safety performance (Poor_SP). Companies that reported good financial performance (Good_FP) were more likely to report good safety performance (Good_SP). Companies categorised as neither poor nor good financial performers (NPG_FP) tended to report very good safety performance (V_good FP). Companies that reported very good financial performance (V_good FP) were more likely to report good safety performance (Good _SP) than a very good safety performance (V_good_SP).

6.3 RESULTS

6.3.1 Sample characteristics

6.3.1.1 Overall description

The descriptive statistics of the sample are provided in Appendix D. Most of the participants were owner directors (41%), followed by general managers (35%). In the past 5 years, most of the companies (75%) did not undergo any major change in terms of change of ownership, significant expansion, major acquisition of vehicles, or bankruptcy. Interstate operating companies represented 22% of the sample, and regional or state-wide operators represented 17%. In an average week, companies mostly used at most 10 trucks (43%), which were more likely to be B-doubles (68%) and less likely to be rigid trucks (4%).

No company undertook short-distance trips only. Most of the companies (97%, N=67) undertook both short and long-distance trips. The average number of drivers they used was 38 employee drivers (SD = 71.2, N=46), 34 subcontractor drivers (SD= 89.5, N=20), and 6 owner drivers (SD=5.6, N=13) for short-distance trips, and 120 employee drivers (SD= 583.5, N=47), 43 subcontractor drivers (SD= 187.9, N=28), and 8 owner drivers (SD= 9.5, N=18) for long-distance trips. Regarding payment methods, information about average pay rates was mostly missing. However, performance-based payment was the least suggested (28%) as the best payment method to improve road safety.

A large percentage of the participants reported that their companies were mostly aware of driver fatigue (84%). The CoR legislation did not change companies' behaviours in terms of driver employment type for 80% of the companies and in terms of payment policy for 91% of the companies.

Companies mostly had a vehicle fleet that was at least 10 years old on average (72%). Most of their vehicles were equipped with ABS brakes (57%), cruise control (41%) and audible reversing devices (54%), while few companies had all their vehicles equipped with emergency brake assists (17%), forward collision avoidance systems (6%), electronic control stability systems (19%), lane departure warning and prevention systems (7%), or automatic transmissions (16%).

Table 6.4 provides statistics based on financial performance in the past 12 months (here referred to as the *current* year). It shows the relationship between financial performance and variables in the *current* year.

Table 6.4 Descriptive statistics based on financial performance

	Financial performance in the current year			
	Poor	NPG	Good	Very good
Safety performance in the current year	7 (%)	18 (%)	30 (%)	11 (%)
Poor	1 (14)	1 (5)	1 (3)	0 (0)
Good	2 (29)	5 (28)	13 (43)	5 (46)
Very good	4 (57)	12 (67)	16 (54)	6 (54)
Driver employment type				
Short-distance trips	7	18	30	12
Employee drivers only	3 (43)	5 (28)	15 (50)	9 (76)
Outsourcing only	0 (0)	2 (11)	0 (0)	1 (8)
Employee drivers and outsourcing	1 (14)	9 (50)	14 (47)	1 (8)
Not applicable	3 (43)	2 (11)	1 (3)	1 (8)
Long-distance trips	7	18	30	12
Employee drivers only	2 (29)	5 (28)	13 (43)	4 (34)
Outsourcing only	1 (14)	2 (11)	0 (0)	1 (8)
Employee drivers and outsourcing	3 (43)	11 (61)	17 (57)	6 (50)
Not applicable	1 (14)	0 (0)	0 (0)	1 (8)

Driver payment policy				
Short-distance trips	7	18	30	12
Time-based rate	4 (57)	5 (28)	15 (50)	7 (58)
Performance-based rate	0 (0)	0 (0)	3 (10)	2 (17)
Mixed rate	0 (0)	11 (61)	11 (37)	2 (17)
Not applicable	0 (43)	2 (11)	1 (3)	1 (8)
Long-distance trips	7	18	30	12
Time-based rate	3 (43)	5 (28)	9 (30)	3 (25)
Performance-based rate	0 (0)	2 (11)	6 (20)	3 (25)
Mixed rate	3 (43)	11 (61)	15 (50)	5 (42)
Not applicable	1 (14)	0 (0)	0 (0)	1 (8)
Best payment method for safety	7	18	30	12
Hourly rate	3 (43)	7 (39)	11 (37)	2 (17)
Performance-based rate	3 (43)	5 (28)	5 (17)	6 (50)
Mixed rate	1 (14)	6 (33)	14 (47)	4 (33)
Payment for non-driving tasks-short-distance trips	7	18	30	12
All types of drivers	0 (0)	1 (6)	4 (14)	0 (0)
Some	4 (57)	15 (83)	25 (83)	11 (92)
None	3 (43)	2 (11)	1 (3)	1 (8)
Payment for non-driving tasks-long-distance trips	7	18	30	12
All types of driver	0 (0)	1 (6)	4 (13)	0 (0)
Some	6 (86)	17 (94)	26 (87)	11 (92)
None	1 (14)	0 (0)	0 (0)	1 (8)
Vehicle characteristics				
Technology score	7	18	30	12
Low	5 (72)	8 (44)	5 (17)	3 (25)
Medium	1 (14)	7 (39)	17 (57)	7 (58)
High	1 (14)	3 (17)	8 (26)	2 (17)
Average age of vehicle fleet	7	18	30	12
Less than 10 years	5 (71)	13 (72)	24 (80)	12 (58)
10 years or more	2 (29)	5 (28)	6 (20)	5 (42)
Average age of vehicles at purchase	7	18	30	12
New	2 (29)	11 (61)	21 (70)	8 (67)
Not new	2 (29)	5 (28)	8 (27)	1 (8)
No purchase	3 (42)	2 (11)	1 (3)	3 (25)
Schedule vehicles for maintenance or inspection	7	18	30	12
Yes	7 (100)	17 (94)	30 (100)	11 (92)
No	0 (0)	1 (6)	0 (0)	1 (8)
Frequency of vehicle maintenance or inspection	7	18	30	12

On distance driven basis	2 (29)	11 (61)	19 (63)	6 (50)
On time basis	4 (71)	6 (33)	11 (37)	5 (42)
No schedule for maintenance	0 (0.0)	1 (6)	0 (0.0)	1 (8)
CoR legislation and associated policies				
Awareness of CoR legislation	7	18	30	12
Have not heard about it	0 (0)	1 (6)	0 (0)	0 (0)
Have heard something about it	1 (14)	1 (6)	2 (93)	0 (0)
Very familiar	6 (86)	16 (88)	28 (7)	12 (100)
Skill levels of drivers	7	18	30	12
Neither poor nor good	1 (14)	2 (12)	2 (7)	0 (0)
Good	2 (29)	8 (44)	13 (43)	5 (42)
Very good	4 (57)	8 (44)	15 (50)	7 (58)
Load type	7	18	30	12
General or mixed freight	6 (86)	10 (56)	15 (50)	6 (50)
Livestock or refrigerated or dangerous goods	0 (0.0)	1 (5)	6 (20)	2 (17)
Other types of freight	1 (14)	7 (39)	9 (30)	4 (33)

6.3.1.2 Safety performance

Figure 6.2 shows the graphical display of safety performance in the *current* year (SP12) and in the *previous* year (SP24). The corresponding financial performance (FP12) and (FP24) are also shown. NPG refers to neither poor nor good performance. Companies mostly rated their safety performance as very good and their financial performance as good.

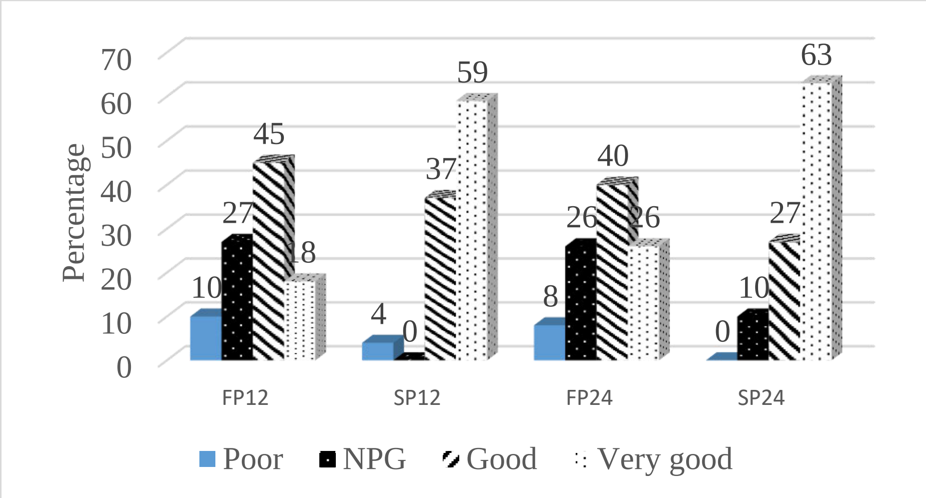


Figure 6.2 Distributions of financial and safety performance

The proportion of companies involved in police-attended crashes was 34% (N=68) in the past 12 months (here referred to as the *current* year) and 39% (N=67) in the 12 months before then (here referred to as the *previous* year). With regard to police-attended at-fault crashes, the proportion of companies involved in these crashes was 23% in the *current* year and 20% (N=65) in the *previous* year. Most of the companies reported the same level of financial performance compared to competitors in the *current* year (56%, N=66) and the *previous* year (55%, N=65). They also mostly reported that the decision makers in their companies would describe company financial performance as good (40% and 38%, N=68) and safety performance as very good (57% and 54%, N=68) during the same periods, respectively. Consistent with their reports of good safety performance, companies mostly reported very low insurance costs (30% and 31%) during the same periods, respectively.

Table 6.5 provides descriptive statistics based on safety performance in the *current* year. It shows the safety performance of the other variables, mostly measuring information in the *current* year.

Table 6.5 Descriptive statistics based on safety performance

	Safety performance in the current year			
	Poor (%)	Good (%)	Very good (%)	
Financial performance in the previous year				64
Poor	1 (20)	2 (40)	2 (40)	5 (7)
Neither poor nor good (NPG)	1 (6)	6 (35)	10 (59)	17 (27)
Good	0 (0)	8 (32)	17 (68)	25 (39)
Very good	1 (6)	9 (53)	7 (41)	17 (27)
Driver employment type				
Short-distance trips				68
Employee drivers only	1 (3)	14 (42)	18 (55)	33 (49)
Outsourcing only	0 (0)	0 (0)	2 (100)	2 (3)
Employee drivers and outsourcing	2 (8)	9 (34)	15 (58)	26 (38)
Not applicable	0 (0)	2 (29)	5 (71)	7 (10)
Long-distance trips				68
Employee drivers only	0 (0)	10 (39)	16 (61)	26 (38)
Outsourcing only	0 (0)	0 (0)	3 (100	3 (4)
Employee drivers and outsourcing	3 (8)	13 (35)	21(57)	37 (55)
Not applicable	0 (0)	2 (100)	0 (0)	2 (3)
Driver payment policy				
Short-distance trips				68
Time-based rate	1 (3)	13 (41)	18 (56)	32 (47)
Performance-based rate	0 (0)	1(20)	4 (80)	5 (8)
Mixed rate	2 (8)	9 (38)	13 (54)	24 (35)
Not applicable	0 (0)	2 (29)	5 (71)	7 (10)
Long-distance trips				68
Time-based rate	0 (0)	9 (45)	11(55)	20 (29)
Performance-based rate	0 (0)	3 (23)	10 (77)	13 (19)
Mixed rate	3 (9)	11 (33)	19 (58)	33 (49)
Not applicable	0 (0)	2 (100.0)	0 (0.0)	2 (3)
Best payment method for safety				68
Hourly rate	2 (8)	11(48)	10 (44)	23 (33)
Performance-based rate	1 (5)	3 (17)	14 (78)	18 (27)
Mixed rate	0 (0)	11(41)	16 (59)	27 (40)
Payment for non-driving tasks-short-distance trips				68
All types of drivers	2 (40)	2 (40)	1 (20)	5 (7)

Some	1 (1)	21(38)	34 (61)	56 (83)
None	0 (0)	2 (29)	5 (71)	7 (10)
Payment for non-driving tasks-long-distance trips				68
All types of drivers	2 (40)	3 (60)	0 (0)	5 (7)
Some	1 (1)	20 (33)	40 (66)	61(90)
None	0 (0)	2 (100)	0 (0)	2 (3)
Vehicle condition				
Technology score				68
Low	0 (0)	8 (36)	14 (64)	22 (32)
Medium	1 (3)	12 (38)	19 (59)	32 (47)
High	2 (13)	5 (37)	7 (50)	14 (21)
Average age of vehicle fleet				68
Less than 10 years	3 (6)	17 (34)	30 (60)	18 (26)
10 years or more	0 (0)	8 (44)	10 (56)	50 (74)
Average age of vehicles at purchase				68
New	3 (6)	17 (39)	24 (55)	44 (65)
Not new	0 (0)	8 (50)	8 (50)	16 (23)
No purchase	0 (0)	0 (0)	8 (100)	8 (12)
Schedule vehicles for maintenance or inspection				68
Yes	3 (4)	24 (36)	40 (60)	67 (98)
No	0 (0)	1 (100)	0 (0)	1 (2)
Frequency of vehicle maintenance or inspection				68
On distance driven basis	2 (4)	11 (28)	27 (68)	40 (59)
On time basis	1 (4)	13 (48)	13 (48)	27 (40)
No schedule for maintenance	0 (0)	1 (100)	0 (0)	1 (1)
CoR legislation and associated policies				
Awareness of CoR legislation				68
Have not heard about it	0 (0)	1 (100)	0 (0)	1(1)
Have heard something about it	1 (25)	2 (50)	1 (25)	4 (6)
Very familiar	2 (3)	22 (35)	39 (62)	63 (93)
Skill levels of drivers				68
Neither poor nor good	1 (20)	2 (40.0)	2 (40)	5 (7)
Good	2 (7)	13 (45)	14 (48)	29 (43)
Very good	0 (0)	10 (29)	24 (71)	34 (50)
Load type				68
General or mixed freight	3 (7)	15 (39)	21 (54)	39 (57)
Livestock or refrigerated or	0 (0)	3 (33)	16 (67)	9 (14)

dangerous goods				
Other types of freight	0 (0)	7 (35)	13 (65)	20 (29)

Part of the previous table connects the safety performance in the *current* year to financial performance in the *previous* year. The direction of causality is considered in Table 6.6, which connects the financial performance in the *current* year to safety performance in the *previous* year. Financial performance is provided for the different safety performance levels.

Table 6.6 Cross-tabulation of financial and safety performance

	Financial performance in the current year				
	Poor	Neither poor nor good	Good	Very good	
Safety performance in the previous year					65 (%)
Neither poor nor good	1 (14)	1 (14)	4 (58)	1 (14)	7 (11)
Good	1 (5)	5 (28)	9 (50)	3 (17)	18 (28)
Very good	5 (12)	12 (30)	16 (40)	7 (18)	40 (61)

6.3.1.3 Sample comparison: Study 2 vs. Study 3

The characteristics of the sample in Study 3 showed that more than half of the participants reported good or very good safety or financial performance. This high level of reported better performance suggests that perhaps the sample was biased due to better-performing companies being more willing to participate in the survey. The potential for bias was examined by comparing the characteristics of the Study 3 sample with that of the larger National Transport Commission survey used in Study 2. Both samples were collected across Australia, however, the sample from the National Transport Commission, is the most likely to be more representative of the general truck company population, due to its greater size. Table 6.7 provides descriptive statistics comparing the chosen variables for both samples.

Most of the companies in both surveys reported operating at most 10 trucks, while fewer of them reported operating more than 50 trucks. B-doubles were reported as the most operated trucks in both samples, followed by semitrailers. Regarding the use of drivers for long-distance trips, the smallest percentage of companies reported using outsourced drivers only, while most reported using both employee and outsourced drivers. In both samples, most of the companies reported being very familiar with CoR legislation, while fewer reported not having heard about the legislation. In both samples, companies reported being less likely to carry livestock or refrigerated or dangerous goods or pay performance-based rates. In sum, the characteristics of the Study 3 sample are generally similar to those of the larger sample collected by the National Transport Commission, suggesting that the Study 3 sample is at least no more biased than the earlier study.

Table 6.7 Sample comparison for Study 2 and Study 3

Variable	Study 2 sample (N=400)	Study 3 sample (N=69)
	N (%)	N (%)
Load type	398	
General or mixed freight	47 (12)	39 (57)
Livestock or refrigerated or dangerous goods	21 (6)	9 (13)
Other types of freight	330 (83)	21 (30)
Number of trucks	208	
10 or fewer	104 (50)	30 (43)
Between 11 and 50	71 (34)	20 (29)
More than 50	24 (11)	19 (28)
Unknown	9 (4)	-
Truck type	208	
Rigid truck	33 (16)	3 (5)
Semitrailer	46 (22)	10 (14)
Road trains	7 (3)	9 (13)
B-doubles	120 (58)	47 (68)
Other	2 (1)	-

Employment type		
Employee drivers only	111 (28)	26 (38)
Outsourcing only	48 (12)	4 (6)
Employee drivers and outsourcing	218 (54)	37 (53)
Other driver	23 (6)	0 (0)
Not applicable		2 (3)
Payment method		
Time-based rate	198 (50)	20 (29)
Performance-based rate	27 (7)	13 (19)
Mixed rate	138 (34)	34 (49)
Other rate	37 (9)	0 (0)
Not applicable	0 (0)	2 (3)
Awareness of CoR legislation		
Have not heard about it	14 (3)	1 (1)
Have heard something about it	83 (21)	4 (6)
Very familiar	303 (76)	64 (93)

6.3.2 Estimates

6.3.2.1 Correlation coefficients

The research questions in this study concern the relationships between financial and safety performance on the one hand and on the other, the relationships between financial performance and other factors that could influence safety outcomes. These factors are related to driver employment type, payment policy and skill levels, market segment, vehicle condition and awareness of the CoR legislation. It is important to ensure that these factors are not highly correlated, because high correlations could make the CA irrelevant. The correlation coefficients (here Cramer's Vs) report the extent of the association between categorical variables while CA reports the extent of the association between the categories of these variables. Thus, Table 6.8 provides the correlation coefficients among the different variables selected for the CA. These variables are related to company financial performance in the *current* year, company safety performance in the *past* year, employment type for drivers driving short-distance trips (< 200 km from the base) and long-distance trips

(≥ 200 km from the base), driver payment policy for driving and non-driving tasks for drivers driving short and long-distance trips, market segment represented by the load type, the skill level of the different drivers that companies used, technology adoption, and company awareness of the CoR legislation. The number of trucks as a variable used in the logistic regression was also included in the correlation matrix.

Correlation coefficients for categorical variables are Cramer's V statistics. The V statistic varies between 0 and 1, with 0 indicating the absence of correlation and 1 implying a perfect correlation. A Cramer's V statistic less than 0.30 indicates a weak to negligible association, a V between 0.30 and 0.70 denotes a weak to fairly strong association, and a V higher than 0.70 indicates a strong association (Kraska-Miller, 2013).

Driver employment type for short-distance trips (empsd) is strongly and significantly correlated with the driver payment method for short-distance trips (paysd) (V= 0.68), payment for non-driving tasks of short-distance trips (ndpsd) (V=0.75), and driver employment type for long-distance trips (empld) (V=0.61). Payment for non-driving tasks of long-distance trips (ndpld) is strongly and significantly correlated with the payment method for drivers driving long-distance trips (payld) (V=0.73). Payment for non-driving tasks of long-distance trips (ndpld) is strongly and significantly correlated with the payment method for drivers driving short-distance trips (paysd) (V=0.73). Thus, employment type for short-distance trip drivers (empsd) and payment for non-driving tasks of short and long-distance trips (ndpsd, ndpld), were not considered in the CA because of their strong correlations with the other variables.

Table 6.8 Matrix of correlation coefficients

	FP12	SP24	EMPSD	EMPLD	PAYSD	PAYLD	NDPSD	NDPLD	APUR	TRUCK	LOAD	CORAW	DQUAL	TECH
FP12	1													
SP24	0.12	1												
EMPSD	0.32*	0.15	1											
EMPLD	0.23	0.25	0.61*	1										
PAYSD	0.32*	0.16	0.68*	0.34*	1									
PAYLD	0.21	0.25	0.34*	0.52*	0.51*	1								
NDPSD	0.30	0.33*	0.75*	0.39*	0.73*	0.39*	1							
NDPLD	0.25	0.41*	0.40*	0.73*	0.40*	0.73*		1						
APUR	0.29	0.22	0.35*	0.26	0.47*	0.22	0.32*	0.17	1					
TRUCK	0.23	0.24	0.33*	0.26	0.29	0.20	0.36*	0.26	0.39*	1				
LOAD	0.20	0.17	0.30	0.14	0.25	0.15	0.17	0.13	0.11	0.18	1			
CORAW	0.16	0.25	0.15	014	0.22	0.08	0.16	0.14	0.27	0.22	0.09	1		
DQUAL	0.13	0.27*	0.24	0.22	0.19	0.25	0.15	0.14	0.11	0.28*	0.10	0.22	1	
TECH	0.33*	0.17	0.29	0.19	0.22	0.21	0.17	0.16	0.23	0.31*	0.18	0.13	0.14	1

*Variables significantly correlated at the 95% confidence level. FP12: Financial performance in the current year, SP24: Safety performance in the previous year, EMPSD: Use of drivers on short distance, EMPLD: Use of drivers on long distance, PAYSD: Payment method for short-distance drivers, PAYLD: Payment method for long-distance trips, NDPSD: Payment for short-distance non-driving tasks, NDPLD: Payment for long-distance non-driving tasks, APUR: Average age of vehicles at purchase, TRUCK: Number of trucks, LOAD: Load type, CORAW: Awareness of the CoR legislation, DQUAL: Skill level of drivers, TECH: Technology adoption score.

Better financial performance in the *previous* year is expected to be positively associated with better safety performance in the *current* year. Both types of performance are expected to be positively associated with having a high level of awareness of CoR legislation, paying time-based rates and non-driving tasks, using good skilled drivers, purchasing newer vehicles and adopting technology. Nevertheless, the associations of financial performance and safety performance with employment type can be positive or negative. As discussed in Chapter 2, research about safety performance based on employment type is not conclusive.

6.3.2.2 Logistic regression

As shown in Table 6.9, two logistic regressions were estimated with company police-attended at-fault crash involvement in the *current* year as the dependent variable. Model 1 presents the results of the regression containing financial performance in the *previous* year when controlling for the number of trucks. Model 2 presents the results of the regression containing safety performance in the *previous* year when controlling for the number of trucks. Past safety performance may provide companies with lessons to improve future safety performance. The at-fault crash involvement equals 1 if the company was involved in police-attended crash and 0 otherwise. Research has reported at-fault crash involvement as being more representative of company safety investments than the total number of crashes (Beard, 1992). The F-tests for the overall models provided a statistic of 3.14 for Model 1 and 4.87 for Model 2 with associated P-values<0.01, suggesting that the models are globally significant at the 99% confidence level.

All the other financial performance levels had odds of crash involvement significantly less than 1 compared to companies having reported poor financial performance. Likewise, all the other safety performance levels had odds of crash involvement significantly less than 1 compared to companies categorised as neither poor nor good safety performers. In Model 1, compared to companies having at most 10 trucks, companies which had more than 50 trucks (OR: 16.66, CI: 1.73-160.50, p=0.02) had odds of crash involvement significantly less than 1.

Table 6.9 Estimates from logistic regression of current year at-fault crash involvement

	Model 1			Model 2		
Variable	OR	P-value	95% CI	OR	P-value	95% CI
Financial performance in the previous year						
Poor	1.00	-	-	-	-	-
Neither poor nor good	0.04*	0.01	0.01-0.42	-	-	-
Good	0.01**	<0.001	0.001-0.14	-	-	-
Very good	0.09*	0.04	0.01-0.88	-	-	-
Safety performance in the previous year						
Neither poor nor good	-	-	-	1.00	-	-
Good	-	-	-	0.19*	0.02	0.04-0.81
Very good	-	-	-	0.08**	<0.001	0.03-0.28
Number of trucks used in an average week in the current year						
10 or fewer	1.00	-	-	1.00	-	-
Between 11 and 50	8.43	0.07	0.79-89.79	2.74	0.17	0.64-11.64
More than 50	16.66*	0.02	1.73-160.50	3.73	0.05	0.95-14.70

**p<0.01, *p<0.05

6.3.2.3 Correspondence analysis

The simple CA between financial performance, safety performance and the selected factors influencing crash involvement is presented in two dimensions in Figure 6.3 to Figure 6.11. The CA shows the relationship between the response categories of financial performance and those of the selected variables. As shown from the analysis of correlation coefficients, the variables that did not show high correlation and were accordingly retained for the CA analysis are safety performance in the *previous* year, long-distance employment type, short-distance payment method, long-distance payment method, driver skill levels, load type, vehicle age at purchase, technology score, and awareness of the CoR legislation. CA is sensitive to outliers (Kudlats, et al., 2014), but the box plots of the different variables did not show any outliers. Each of the graphs in the CA was drawn in a two-dimensional space.

As previously explained, CA is used to explore the associations among row or column response categories of variables or between the row and column response categories of variables (Hair, et al., 2010). For analyses exploring associations between row and column categories, as is the case for the present study, the relationship is examined using the angle formed by the lines linking each row point to each column point from the origin of the correspondence map. The sharper the angle, the stronger is the association between these points (Higgs, 1991; Tim, 2019a, 2019b). The closer the angle to 90 degrees, the less associated are the variables and the closer the angle to 180 degrees, the more negatively correlated the variables (Tim, 2019a, 2019b).

Figure 6.3 presents the relationship between financial performance (fp12) in the *current* year and safety performance (sp24) in the *previous* year. The statistics about the two dimensions and the decomposition of the inertia between the two variables are provided in Tables E.1 and E.2, respectively in Appendix E. FP12, as shown in the descriptive statistics, has four categories: poor financial performance (Poor_FP), neither poor nor good financial performance (NPG_FP), good financial performance (Good_FP), and very good financial performance (V_Good_FP). Safety performance has three categories: neither poor nor good safety performance (NPG_SP), good safety performance (Good_SP), and very good safety performance (V_Good_SP). The point cloud on the map shows that companies that reported a very good financial performance in the *current* year were the most likely to report a very good safety performance in the *previous* year. It is also likely that there is a negative correlation between reporting poor financial performance in the *current* year and reporting good safety performance in the *previous* year on the one hand; and between the category neither poor nor good financial performance in the *current* year and the category neither poor nor good safety performance in the *previous* year on the other hand.

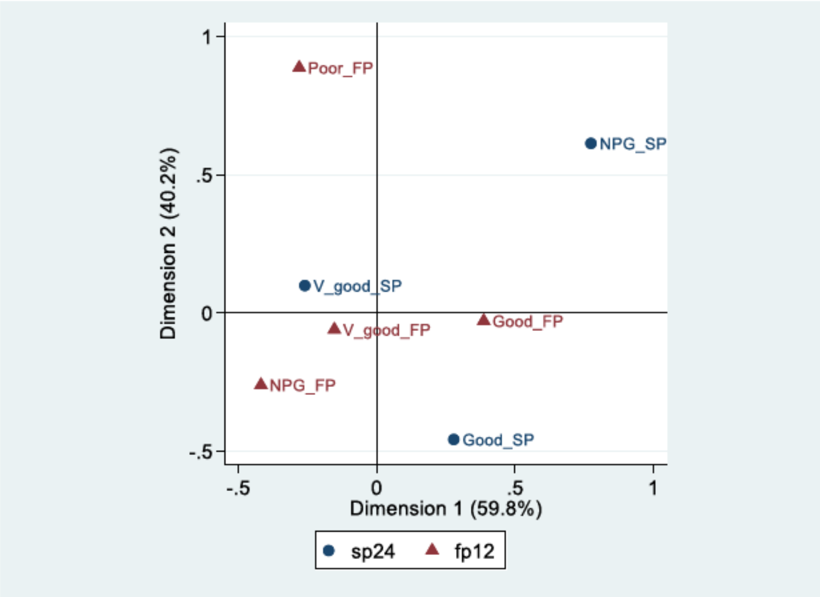


Figure 6.3 Relationship between financial performance in the current year and safety performance in the previous year

Figure 6.4 presents the relationship between FP12 and how companies employ drivers for long-distance trips (emplld) in the *current* year. The statistics about the two dimensions and the decomposition of the inertia between the two variables are provided in Tables E.3 and E.4, respectively, in Appendix E. For long-distance trips, companies can select employee drivers only (ED), outsourcing only (Outs) or a combination of both (ED + outs). The NO is for companies which did not undertake long-distance trips. The map suggests that companies that reported good financial performance tend to use employee drivers only. Companies categorised as neither poor nor good financial performers tend to use both employee drivers and third-party drivers.

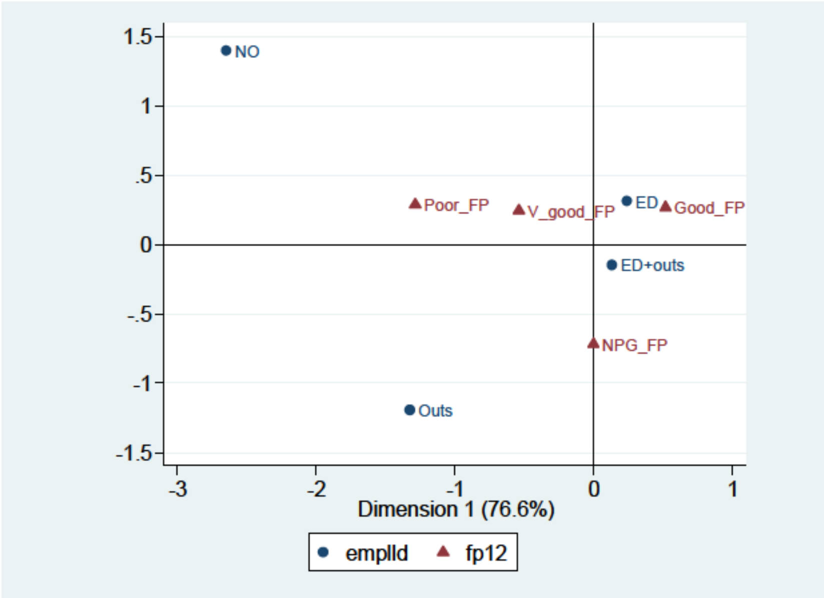


Figure 6.4 Relationship between financial performance and employment type for long-distance trip driver

Companies that reported very good financial performance are more likely to use employee drivers only while companies that reported poor financial performance are more likely to use outsourced drivers only than any other type of drivers.

Figure 6.5 shows the relationship between FP12 and payment method for short-distance trip drivers. The statistics about the two dimensions and the decomposition of the inertia between the two variables are provided in Tables E.5 and E.6, respectively in Appendix E. The payment method is divided into time-based (flat) rates (Flat_r), performance-based rates (Perf_r), mixed rates (Mixed_r) and NA for companies which did not undertake short-distance trips. Time-based rates in the survey were defined based on the amount of time worked measured in hours, days, or weeks. Performance-based rates were defined based on the amount of worked performed measured by the numbers of trips completed between a given origin and destination, the distance driven, or the tonnage carried. Mixed rates were composed of any combination of time-based and performance-based rates. The figure shows that companies that reported very good financial performance tend to pay either time-based or performance-based rates, while companies that reported good financial performance tend to pay performance-based rates. Companies categorised as neither poor nor good financial performers tend to pay mixed rates.

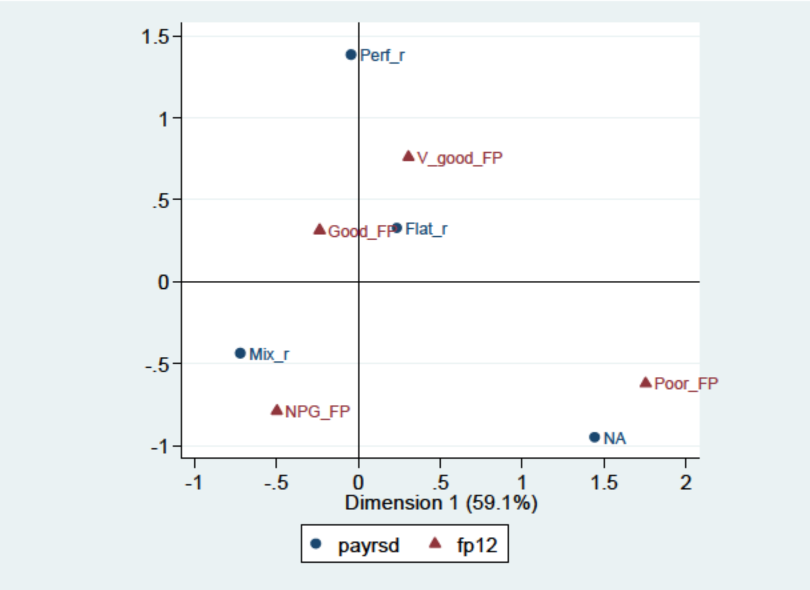


Figure 6.5 Relationship between financial performance and payment method for short-distance trip drivers

Figure 6.6 shows the connection between FP12 and driver payment method for long-distance drivers (payrld) in the *current* year. The statistics about the two dimensions and the decomposition of the inertia between the two variables are provided in Tables E.7 and E.8, respectively, in Appendix E. The figure shows that companies that reported poor financial performance tend to pay time-based rates while those that reported good or very good financial performance tend to pay performance-based rates. As in the case of short-distance trips, companies categorised as neither poor nor good financial performers tend to pay mixed rates.

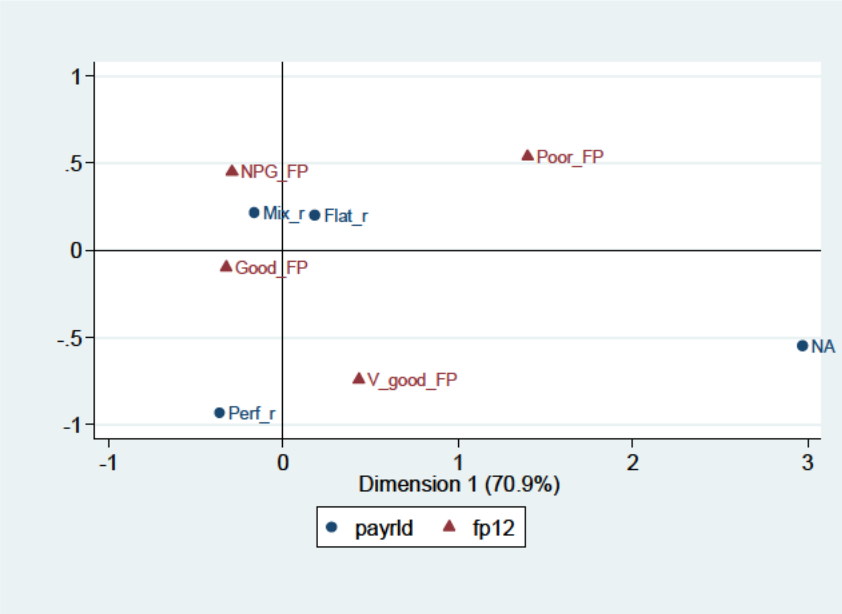


Figure 6.6 Relationship between financial performance and payment method for long-distance trip drivers

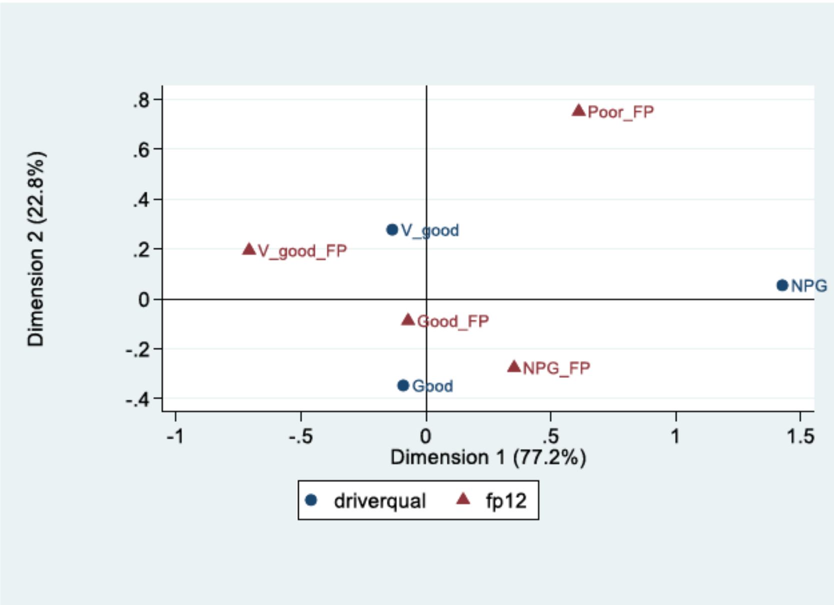


Figure 6.7 Relationship between financial performance and the skill level of drivers

Figure 6.7 shows the relationship between FP12 and the skill level of all the drivers (driverqual) that companies used in the *current* year. The statistics about the two dimensions and the decomposition of the inertia between the two variables are provided in Tables E.9 and E.10, respectively, in Appendix E. The skill level of drivers is divided into neither poor nor good (NPG), good (Good) and very good (V_good). The map shows that companies that reported very good financial performance tend to use very good drivers. Likewise, companies that reported good financial performance tend to use good drivers.

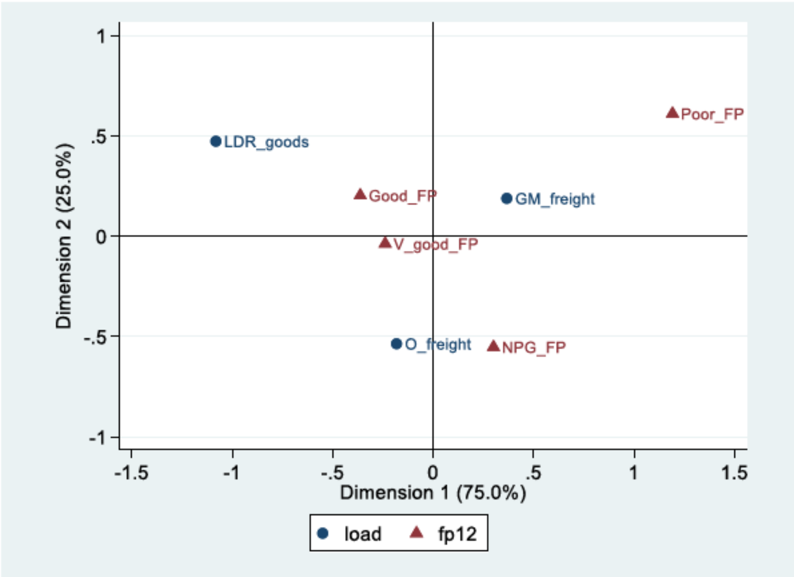


Figure 6.8 Relationship between financial performance and load type

Figure 6.8 shows the connection between FP12 and the market segment represented by load type (load). The statistics about the two dimensions and the decomposition of the inertia between the two variables are provided in Tables E.11 and E.12, respectively, in Appendix E. Load type is divided into livestock, dangerous or refrigerated goods (LDR_goods), general or mixed freight (GM_freight) and other types of freight (O_freight). Companies that reported poor financial performance tend to carry general or mixed freight, while those that reported good or very good financial performance tend to carry livestock, dangerous or refrigerated goods. Livestock, dangerous and refrigerated goods are specialised goods, subject to additional regulatory requirements (mainly livestock and dangerous goods). Poor companies may accordingly not possess adequate technology to carry these goods.

Companies categorised as neither poor nor good financial performers tend to carry other types of freight.

Figure 6.9 displays the connection between FP12 and the average age of vehicles at purchase (agepurchase) in the *current* year. The statistics about the two dimensions and the decomposition of the inertia between the two variables are provided in Tables E.13 and E.14, respectively in Appendix E. The average age of vehicles at purchase is divided into new vehicle (New_V), vehicle not new (Not_new_V) and no purchase (No_purchase). The results show that companies that reported good and very good financial performance tend to buy new vehicles. Companies categorised as neither poor nor good financial performers tend to buy vehicles that are not new. Companies that reported very good financial performance are unlikely to buy vehicles that are not new. Likewise, companies that reported poor financial performance are unlikely to buy new vehicles.

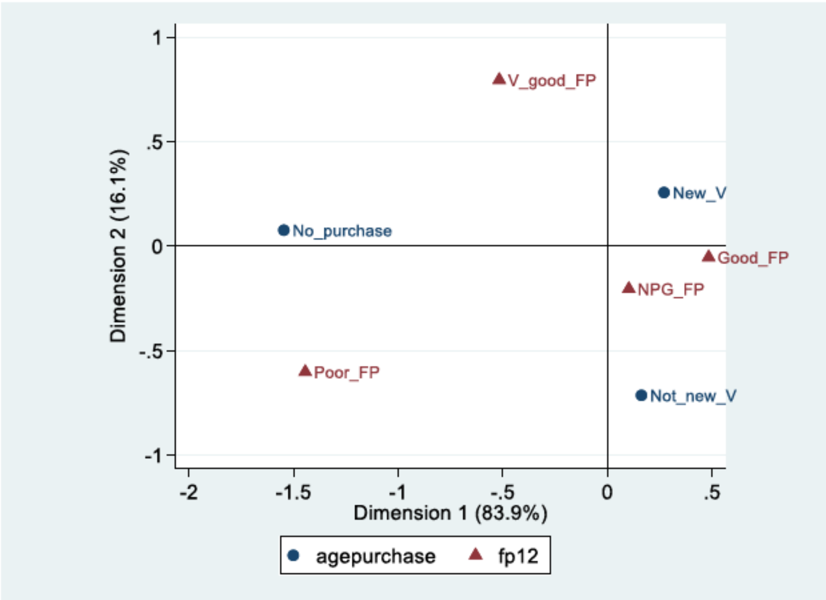


Figure 6.9 Relationship between financial performance and vehicles average age at purchase

Figure 6.10 shows the association between FP12 and the score for technology adoption (techindex) representing the percentage of vehicles equipped with technologies that the companies used in the *current* year. The statistics about the two dimensions and the decomposition of the inertia between the two variables are provided in Tables E.15 and E.16, respectively, in Appendix E. As previously explained, Low indicates lower levels of percentages, Medium indicates to medium levels of percentages and High indicates higher levels of percentages. The map shows that companies categorised as poor and neither poor nor good financial performers tend to have a low score. Companies that reported good financial performance tend to have a high score while those that reported very good financial performance tend to have a medium score.

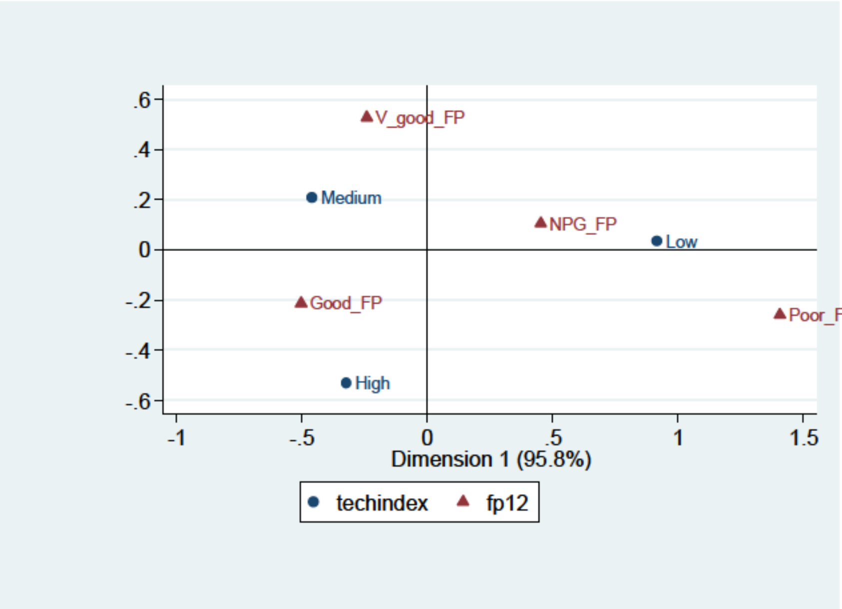


Figure 6.10 Relationship between financial performance and technology adoption

Figure 6.11 shows the connection between FP12 and company awareness of the CoR legislation (corawar). The statistics about the two dimensions and the decomposition of the inertia between the two variables are provided in Tables E.17 and E.18, respectively, in Appendix E. The awareness of the CoR legislation is divided into those who have not heard about it (N_H), those who have heard something about it (H) and those who are very familiar with the legislation

(V_familiar). The map shows that the strongest association is between reporting very good financial performance and a high level of familiarity with the CoR legislation. Companies that reported poor financial performance tend to have heard something about the CoR legislation.

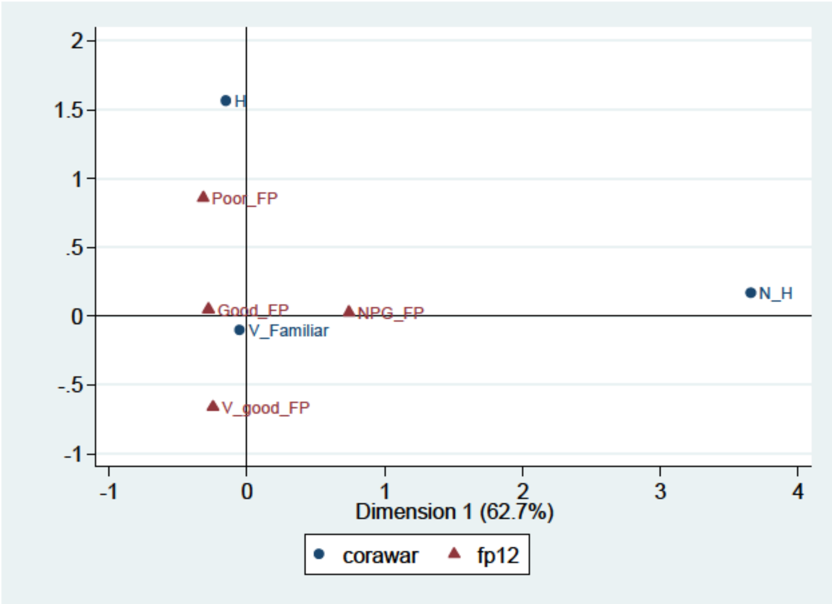


Figure 6.11 Relationship between financial performance and awareness of CoR legislation

Table 6.10 summarises the CA findings. The + signs indicate the categories that tend to be positively associated while the – signs refer to categories that tend to be negatively associated. While Cramer's V coefficients provide the association between categorical variables, the CA goes further to provide the association between and among the response categories of these categorical variables. The negative association between the neither poor nor good safety and financial performance is unexpected. This unexpected association could be due to the sensitivity of CA results to cell sizes. Response categories having low cross-tabulation statistical values are likely to be farther on both sides of the origin of the map leading to a negative association (as already explained in how to interpret CA results) between these categories (Di Franco, 2016). Table 6.6 showed that the cross-tabulation statistical values between these pairs of response categories is 1. That is why the CA is exploratory and regression models remain useful to provide more weight to CA findings.

Table 6.10 Summary of the findings from correspondence analysis

	Financial performance in the current year			
	Poor	Neither poor nor good	Good	Very good
Safety performance in the previous year				
Neither poor nor good		–		
Good	–			
Very good				+
Long-distance trip drivers in the current year				
Employee drivers only			+	+
Outsourcing only	+			
Employee drivers and outsourcing		+		
Payment method for short-distance trip drivers in the current year				
Time-based rate				
Performance-based rate			+	+
Mixed rate		+		
Payment method for long-distance drivers in the current year				
Time-based rate	+			
Performance-based rate			+	+
Mixed rate		+		
Skill levels of drivers in the current year				
Neither poor nor good				
Good			+	
Very good				+
Load type in the current year				
General or mixed freight	+			
Livestock or refrigerated or dangerous goods			+	+
Other types of freight		+		
Average age of vehicle at purchase in the current year				
New	–		+	+
Not new				–
No purchase				
Technology score in the current year				
Low	+	+		
Middle				+
High			+	
Awareness of CoR legislation				
Have not heard about it				
Have heard something about it				
Very familiar				+

6.4 DISCUSSION

This study examined the last two research questions of the research program:

RQ5. Is there a bidirectional link between company financial performance and HV crash involvement?

RQ6. Is HV company financial performance associated with other factors influencing crash involvement?

These questions were motivated by claims that HV companies in the search for profit tend to reduce safety investments (Anyfantis, et al., 2018), drawing researchers' interest to the link between financial performance and safety in several industries (e.g. HV, aviation and maritime sectors). Nevertheless, despite this interest, the nature of the relationship has not been established. The current study examined the nexus between HV financial performance and safety performance using Australian data. It made a step further to explore the bidirectional association between safety and financial performance. Moreover, it assessed the relationship between financial performance and some other factors that may influence safety outcomes. These particular factors are driver employment type, driver payment method, driver skill level, market segment, the average age of vehicles at purchase, technology adoption, and awareness of the CoR legislation.

The interplay between these variables is likely to influence safety performance. As shown in the literature review, driver employment type is likely to be associated with payment methods which may affect driver quality. Payments that are not conducive to safety may deter drivers from applying to a company. The load type, mainly dangerous goods, may need skilled drivers with good vehicles adequately equipped with technology. Awareness of the CoR legislation, as shown in Study 2, is likely to be associated with safety conducive actions such as time-based payments. The combination of good financial performance and the associated response categories of the selected variables is expected to be conducive to safety.

The influence of safety performance on financial performance and the relationships between financial performance and other factors influencing crash involvement could be examined using ordinal or mixed logit regressions because of the ordinal nature of the dependent variable financial performance. However, due to the limited sample size, it was not possible to obtain statistically significant models. Thus, a CA was used to explore these links.

6.4.1 Causal connections between financial performance and safety performance

Poor financial performance may adversely affect the capability of HV companies to adequately invest in safety. Likewise, poor safety performance may damage company reputation, result in the loss of some customers and could adversely affect company financial performance.

Safety performance was represented by at-fault crash involvement and company managers' perception of safety performance in the *current* year. At-fault crashes represent safety performance better than the total number of crashes. Likewise, perception of safety performance provides a better indication of safety performance than other single variables such as maintenance expenditure.

Estimates from a logistic regression controlling for the number of trucks showed a significant connection between at-fault crash involvement in the *current* year and company financial performance in the *previous* year. Companies that rated their financial performance as not poor in the *previous* year had lower odds of at-fault crash involvement in the *current* year compared to those who rated their performance as poor. Then, the CA showed that companies that reported a very good safety performance in the *previous* year were more likely to report very good financial performance in the *current* year. Likewise, companies that reported a good safety performance in the *previous* year were less likely to report poor financial performance in the *current* year. In sum, the financial performance of the *previous* year influences positively the safety performance of the *current* year and the safety performance of the *previous* year influences positively the financial performance of the *current* year. These positive relationships between financial performance and safety performance suggest a bidirectional association between them.

6.4.1.1 Effects of financial performance on safety performance

The analysis of the causal association between financial performance and safety performance showed that *past* financial performance positively influences *current* safety performance. A comprehensive safety program would likely include driver recruitment and driver training, incentives for better safety performance, driver on-road monitoring, acquisition of new equipment and maintenance of the existing equipment, and general safety information. Nevertheless, a critical financial situation may limit the capability of a company to implement an adequate safety program (O'Neill & Thornthwaite, 2016). Thus, a financially unstable company may be tempted to decrease safety expenditures to avoid bankruptcy and operate older equipment, save on driver training and vehicle maintenance. Operating older or improperly maintained vehicles have been associated with declining morale for drivers (Das, Pagell, Behm, & Veltri, 2008); they are more likely to be frustrated, angered and careless of their job (Das, et al., 2008; Ouellet, 2010). These negative feelings, combined with the high risk of mechanical failures, are likely to increase the likelihood of crashes. Financially weak companies are also unlikely to face unexpected breakdowns and personnel shortage or sort out customers whose requirements are consistent with company safety policies (O'Neill & Thornthwaite, 2016). Conversely, financially healthy companies may design training programs to enhance driver skills (Chow, 1989) as well as investing in newer and safer equipment to attract and keep skilled and high-performing personnel who could improve safety outcomes (Britto, et al., 2010).

6.4.1.2 Effects of safety performance on financial performance

The analysis of the causal association between financial performance and safety performance showed that *past* safety performance positively influences *current* financial performance. Companies with poor safety performance could lose corporate goodwill and have difficulties in retaining existing business partners and workers and/or attracting new ones (Cantor, 2008; Das, et al., 2008; Miller & Saldanha, 2016). It is accordingly in the interest of companies to invest in safety promotion to acquire and maintain a reputation for providing safe operations to increase their market shares. Hazardous working conditions may exacerbate the company climate and dampen employees' morale and enthusiasm. This is likely to increase employee turnover and generate additional costs related to the recruitment of new workers and the company may not find adequate workers to replace the resigning ones (Fernández-Muñiz, et al., 2009; Wooden, 1989). Crashes can delay the delivery process, resulting in economic losses and a decline in the perception of business partners regarding the company. This is likely to reduce company competitiveness through the loss of part of its market share (Fernández, Montes, & Vázquez, 2000).

In sum, a better safety performance may generate benefits in the form of good quality services that attract more customers, motivated workers, fewer lawsuits or lower insurance premiums, lower salaries (assuming that employees require a compensating differential for risky workplaces), increased productivity, a good reputation, and hence better financial performance (Chun, Argandoña, Choirat, & Siegel, 2019; Cohn & Wardlaw, 2016; Kabir, Watson, & Somaratna, 2018; Rodríguez, et al., 2004). As expressed in Carslake, Cureton, and Potter (2012, p5):

> A good place to look for the success of a business is in its safety practices. If safety is well managed, then the rest of the company is probably pretty tidy. If safety is a mess, then it is likely that the other key functions are also falling apart.

6.4.2 Relationships between financial performance and other safety-related factors

The findings also showed that financial performance, in addition to affecting safety performance, is likely to influence companies' attitude towards the adoption of other safety measures. Companies that reported very good financial performance tended to be very familiar with the CoR legislation. They were more likely to select employee drivers for long-distance trips, have very good skilled drivers, and pay both short and long-distance trip drivers time-based or performance-based rates. They also tended to buy new vehicles, have a medium level percentage of their vehicles equipped with technology and specialise in the transport of livestock, refrigerated or dangerous goods. Companies that reported a good financial performance had an almost similar profile with very good financial performers, except that they tended to have good skilled drivers, a higher percentage of their vehicles equipped with technology, and not show awareness of the CoR legislation.

Companies that reported poor financial performance were more likely to use third-party drivers only, pay time-based rates only for long-distance drivers, and carry general or mixed freight in vehicles unlikely to be new or equipped with technology. Companies categorised as neither poor nor good financial performers also tended to have a low percentage of their vehicles equipped with technology, but presented a profile that was different from that of those who reported themselves as financially poor performers. They tended to use both employee drivers and third-party drivers to carry other types of freight and pay mixed rates.

One explanation of the findings could be that companies in good financial health have the necessary resources to design adequate safety policies for their drivers and create safer operating conditions, increasing the likelihood of using employee drivers. Financially poor performers tended to outsource the driving task. As shown in Study 1a, owner drivers as outsourced drivers are safer than employee drivers. Owner drivers accordingly appear as an alternative for financially poor companies to reduce safety expenditures and avoid bankruptcy (Chow, 1989). The outsourcing of the driving task provides several other advantages to subcontracting companies in terms of reducing the complexities related to drivers' management in the supply chain, increasing access to adequate technology and decreasing exposure to safety hazards (Belcourt, 2006; Cantor, et al., 2016). The payment of time-based rates by poor companies, as discussed for small companies in Study 2, appears to be a means for them to encourage driver compliance with safety regulations (Rodríguez, et al., 2004; Williamson & Friswell, 2013) and ensure that the cargo is carried properly. Performance-based payments by financially strong companies may be related to the larger financial resources that they have available to invest in safety technology and monitor the safety behaviours of drivers (Cantor, 2014).

Since performance-based payment is more likely to be associated with safety violations, good or very good financial performers paying these types of rates are more likely to recruit drivers of good or very good skills, respectively in order to reduce crash risk. With regard to load types, the transport of dangerous goods is complex and may pose serious safety issues (Uddin & Huynh, 2018). Thus, companies react to such freight-specific risk by using better equipment to carry hazardous materials (Beard, 1992), which are more likely to be acquired by financially healthy companies. Newer vehicles are more likely to have new technology and to incorporate newer elements that are less vulnerable to failure. Financially strong companies are likely to have the resources to purchase these vehicles, while financially distressed companies are the least likely to do so because of difficulties obtaining loans at a reasonable cost without putting the business at risk (Chow, 1989). Lenders or equipment suppliers may be less willing to grant long-term credit to these distressed companies because of their likely inability to face interest burdens.

This study implies that HV company managers have to be aware that there should not be a trade-off between economic performance and safety performance. The two outcomes should instead be considered as complementary (Miller & Saldanha, 2016). Managers with adequate business knowledge are more likely to be able to deal better with financial issues in their companies (Alqatawni, 2016); and therefore, heavy vehicle company managers should consider investing in business education, in order to ensure they have the kind of knowledge and skills necessary both to reduce the chance of business bankruptcy and improve safety in the industry.

The study also provides safety regulators with information about HV companies' attitudes, based on their financial performance, in terms of the choice of market segment, the quality of their drivers, driver payment method, vehicle purchase, technology adoption and awareness of the CoR legislation.

6.4.3 Study limitations, strengths and future research

6.4.3.1 Sample size and representativeness of the sample

A primary limitation of this study is the small sample size and the representativeness of the sample. Further research using larger samples could provide more insight into the effects of financial performance on road safety outcomes in the HV industry. Part of the data was collected on Yellow Pages that host a greater number of Australian trucking operators all over the countries. Still, the findings from the study cannot be representative of the general population of HV companies nor generalisable to other industries or countries. Even if they may be indicative of what could happen in other areas, examining other data of larger sample sizes in a longitudinal framework, or with objective measures, could also be useful to provide further highlights on the connection between financial performance and safety practices in the HV industry. A longitudinal framework is suggested because the data were cross-sectional in nature, though part of the questionnaire asked participant perceptions of financial performance and safety performance for the previous year and the year before then. Collecting information for the previous years at the same time may result in more highly correlated responses than if the information was collected a year apart.

In spite of these limitations, the data from the current study showed that HVs were at-fault in almost 20% of the crashes, as is the general trend in Australia (BITRE, 2016). Moroever, most of the participants (93%) reported high levels of company familiarity with the CoR legislation, which is similar to the lastest survey data (76%) by NTC (2012b) used in Study 2. The data from the current study also showed that companies are largely aware of driver fatigue (84%), also as in the NTC survey (79%). Moreover, both data sets have several similarities in terms of the types of loads carried, the number of trucks operated, truck type, the types of drivers that companies used for long-distance trips, and the associated payment methods. Most of the participating companies in both surveys reported operating at most 10 trucks that were mostly B-doubles, while fewer of them reported operating more than 50 trucks. They mostly reported using both employee and outsourced drivers for long-distance trips and being less likely to carry livestock or refrigerated or dangerous goods and pay performance-based rates.

6.4.3.2 Low response rate

The relatively low response rate to the survey of 9% is also another important limitation of the study. Low rates are common in self-administered questionnaires in the Australian HV industry (Mooren, et al., 2014; Williamson & Friswell, 2013). Thus, it is important to review how HV companies are surveyed in the country. The NTC (2012b) surveys were conducted by telephone interviews with telephone numbers collected on Yellow Pages and/or other appropriate documentation. Nevertheless, the NTC only reports the number of companies which completed surveys. Despite the incentives to all participants in NTC surveys, response rate may still be low.

Mooren, et al. (2014) conducted an independent survey of 404 Australian HV companies identified from Yellow Pages and obtained a response rate of almost 17% (67 responses). The differences in response rates among surveys could be due to the approach adopted in conducting these surveys. Mooren et al. initially opted to contact companies through insurance brokers who were previously contacted by the insurance companies. However, the contacted insurance brokers were not all cooperative in inviting their clients, resulting in a low response rate of 9% (17 completions) over 199 companies initially contacted. Thus, this option was abandoned for companies listed on the Yellow Pages website. The telephone numbers of the companies were obtained on their websites, and the researchers called them to explain the purpose of the research and invited a representative of the companies to participate. Companies willing to participate were posted paper copies of the questionnaire and the consent form, asking them to mention whether they would like to complete the questionnaire as an online survey, a telephone survey at a mutually defined time, or the paper survey, which could be sent back by mail or scanned and sent by email. This flexibility in completing the survey was aimed to increase the participation rate. Each participant was awarded a gift voucher of $75.

While all participants in previous surveys were compensated for the time spent in completing the questionnaire, the current survey used a prize draw instead because of limited student funding. Nevertheless, the amount $100 for the gift card was directed to increase the participation rate.

Some of the companies called for the current survey provided their phone number and promised to look at the questionnaire before deciding whether to complete it or not. A collaboration with truck associations like the Australian Trucking Association is likely to provide an opportunity to have companies visualise the questionnaire and provide feedback to improve it before conducting the survey. The collaboration with the ATA within the framework of the current research was initiated somewhat late in the data collection process, following the unexpected low response rate from the companies obtained from the Yellow Pages. This made it difficult to initiate this kind of consultation approach, given the limited amount of time in the PhD timeline to conduct the research.

6.4.3.3 Sampling and response biases

The study used perceptions of mainly owner directors (41%) and general managers (34.8%) to evaluate the safety and financial performance of companies. This might have generated a bias resulting from the best safety performers being more inclined to complete the survey. Moreover, perceptions are self-reported data, which may contain some errors and potential sampling bias. Participants were asked to rate their safety and financial performance for the past 24 months. There is a likelihood of misreporting such events, as it may be difficult to remember past facts accurately. Nevertheless, owner directors and general managers are generally the most informed about the policies and practices of companies (Fernández-Muñiz, et al., 2009), which, combined with the anonymous nature of the survey, may reduce the bias in the answers. Still, prospective studies could consider the perceptions of employees in order to provide a broader view of companies' safety and financial practices.

6.4.3.4 Correspondence analysis

Correspondence analysis is a graphic-based exploratory approach; statistical models remain useful to test the relationships (Garson, 2012; Greenacre, 1993; Hair, et al., 2010). The interpretation of the graphs is somewhat subjective and may differ from one researcher to another (Sourial, et al., 2010). Moreover, CA is sensitive to cell sizes. Low frequency categories are likely to have larger variances positioning them farther from the origin of the map (Di Franco, 2016; Husson & Josse, 2014). Nevertheless, the graphs provide salient connections between the response categories that cannot be easily spotted from pairwise statistical tests or visual inspection of contingency tables (Sourial, et al., 2010). Correspondence analysis does not require any assumption about the distribution of the variables. It can be used to explore both linear and nonlinear relationships between variables, making it more flexible than regression-based methods (Rodriguez-Sabate, Morales, Sanchez, & Rodriguez, 2017). More importantly, the sample size is not a critical issue when using CA (Kudlats, et al., 2014).

The literature showed that at-fault crashes are more likely to reflect safety efforts than total crash involvement. It would have accordingly been interesting to examine how at-fault crash involvement in the *current year* relates to the perception of financial performance and other safety-related factors. This would require turning at-fault crash involvement into a categorical variable (at least 3 categories), because CA only handles categorical variables. The number of dimensions to retain in a CA between two variables should account for at least 70% of the variance of the model (Higgs, 1991). Nevertheless, the greatest number of dimensions that can be used to plot variables in CA is calculated by subtracting one from the smallest number of rows or columns (Hair, et al., 2010). This rule excludes the use of binary variables in CA because CA maps are plotted in at least two dimensions (Greenacre, 1993; Kudlats, et al., 2014); CA between two binary variables would mean a zero-dimension map and CA between a binary variable and a categorical variable would mean a one-dimension map.

The at-fault-crash involvement in the *current* year, with 3 missing values, was divided into three categories: 1- no at-fault crash; 2- one at-fault crash and 3- two or more at-fault crashes. The frequencies of these categories were respectively 51, 11 and 4. Due to the 4, the cross-tabulation of at-fault crash involvement with other safety-related factors may produce low statistical values. Low cross-tabulation frequencies between two categories are likely to result in unexpected associations between these categories (Di Franco, 2016). Thus, the CA was not performed to assess the associations of at-fault-crash involvement with the perception of financial performance and other safety-related factors.

Despite these limitations, this study has undertaken a critical step towards an improved understanding of the relationship between company financial performance and safety performance in the HV industry. Past studies linking financial and safety performance used diverse measurements for these variables, which have some benefits and shortcomings. For instance, in terms of safety performance, maintenance expenditures, although they reflect safety efforts, can be misleading because they are likely to be associated with the fleet age (Corsi, et al., 1988; Raghavan & Rhoades, 2005). The number of crashes, though of most concern for customers, may not reflect safety efforts because the company may not be at-fault (Beard, 1992). Concerning financial performance, although research has reported cash flow-based measurements to be more reliable that other financial performance outcomes (Miller & Saldanha, 2016), the use of a single metric may not be sufficient to provide a comprehensive view of the financial condition of a company (Chow, 1989). The use of perceptions of performance in this study is likely to provide a more global indication of the safety and financial conditions of participating companies.

6.5 CHAPTER SUMMARY

The objective of Study 3 was twofold. Firstly, it sought to examine whether there is a bidirectional relationship between safety and financial performance. Secondly, it examined the associations between the financial performance and other factors influencing crash involvement.

The findings showed that there is a bidirectional relationship between safety performance, suggesting that the *past* financial performance significantly influences *current* safety performance and, conversely, that *past* safety performance influences *current* financial performance. The findings suggested diverse relationships between financial performance and the other selected factors influencing crash involvement. For instance, good safety performers are more likely to have good drivers, buy new vehicles, carry livestock, refrigerated or dangerous freight, select employee drivers, and pay drivers based on performance. They are also very familiar with the CoR legislation.

The next chapter provides a summary of the findings of this research.

Chapter 7: Discussion

7.1 INTRODUCTION

This research program contained three quantitative studies aimed to provide a better understanding of company financial influences on safety performance within the Australian HV industry. The findings of the individual studies have been discussed in the previous chapters. This chapter draws out the implications of these findings for the research questions that were formulated to examine the different relationships hypothesised from the conceptual framework. It starts with the research background for the studies before synthesising the major findings and identifying policy implications. Then, the research limitations and strengths are discussed before suggesting some directions for future research. The last section summarises the chapter.

7.2 RESEARCH BACKGROUND AND DESIGN

The literature review showed that the financial pressure on the HV industry could influence HV driver safety performance through payment methods and the safety performance of HV companies either directly or indirectly by affecting their safety investments, and how they employ and pay drivers. The literature review identified several gaps related to this main hypothesis. Existing studies only examined the direct link between financial performance and safety performance with mixed findings and no such studies were conducted in Australia. Moreover, analyses of the causal direction between financial performance and safety performance are missing; if financial performance influences safety performance, safety performance may also influence financial performance. Regarding indirect links, no study has examined the associations of financial performance with driver employment type, payment methods and other factors influencing crash involvement. Moreover, no study has examined the associations of driver employment type and payment methods with driver safety performance.

A conceptual framework (shown in Figure 2.6) was designed based on the research gaps, to which was added another Australian gap related to the CoR legislation. No study has examined the associations of driver employment type and payment methods with the CoR legislation. This legislation aims to ensure that the actors in the transport logistic and supply chain do not adopt practices that encourage fatigued driving.

Six research questions were formulated to examine the different research gaps and relationships included in the conceptual framework. Table 7.1 provides the description of each study, including the sample, the research questions and the modelling method. The research questions fell into two research objectives. The first research objective examined the safety impact of driver employment type and payment methods and their associations with CoR legislation. The second research objective examined the direct and indirect associations of HV company financial performance with safety performance. Research questions RQ1 to RQ4 were examined under the first research objective, while RQ6 and RQ7 were examined under the second research objective.

Table 7.1 Overview of the research program

Study and sample		Research question and statistical method
Study 1	Study 1a	RQ1: Are HV driver employment type and payment methods associated with crash involvement? *Statistical method*: Logistic regression
Existing case-control data on 1038 Australian long-distance HV drivers	Study 1b	RQ2: Are HV driver employment type and payment methods related to driver use of cruise control? *Statistical method*: Logistic regression
	Study 1c	RQ3: Do HV driver payment methods mediate the relationship between driver employment type and fatigue-related behaviours? *Statistical method*: Likelihood ratio-based tests
Study 2 Existing data on 400 Australian HV companies		RQ4: What is the relationship between HV company awareness of CoR legislation and the driver employment types and payment methods? *Statistical method*: Multinomial logistic regression
Study 3 Primary data on 69 Australian HV companies		RQ5: Is there a bidirectional link between financial performance and crash involvement for HV companies? *Statistical method*: Logistic regression and correspondence analysis RQ6: Is HV company financial performance associated with other factors influencing crash involvement? *Statistical method*: Correspondence analysis

7.3 RESEARCH FINDINGS

The conceptual framework hypothesised that how drivers are employed and paid influences their crash involvement, their level of fatigue-related behaviours, and their use of cruise control. Secondly, it hypothesised that company awareness of the CoR legislation could influence how companies employ and pay drivers. The last hypothesis stated that financial performance could influence company awareness of

CoR legislation, how they employ and pay drivers as well as other factors influencing crash involvement. This section summarises the findings related to the six research questions formulated to examine the different hypotheses within the conceptual framework.

7.3.1 Findings related to RQ1

The first research question was:

Are HV driver employment type and payment methods associated with crash involvement?

This research question concerned the first hypothesis of the conceptual framework and was addressed in Study 1a.

Study 1a, a multivariate analysis, showed that owner drivers are less likely to be involved in crashes (OR=0.5) than employee drivers. This result is consistent with the findings of Dammen (2005) and Cantor (2014) but inconsistent with Hunter and Mangum (1995) and Monaco and Williams (2000) who found no statistically significant association between crash involvement and employment type. Researchers who found similar results with the current study reported that owner drivers, as self-employed persons, need to cover their own costs. These drivers are aware that a crash may necessitate the repair of vehicles with significant cost repercussions and time delays (Nickerson & Silverman, 2003). Moreover, the time spent repairing the damaged equipment is considered as a loss of business opportunities (Cantor, et al., 2013). Furthermore, employee and subcontractor drivers may have poorer safety performance than owner drivers as a result of the employing company operating old equipment or paying performance-based rates (Cantor, 2016). Conversely, findings that are inconsistent with the current study reported that the nonsignificant relationship between employment type and crash involvement may reflect the variety of employment-related factors that have opposing influences on crash involvement. Owner drivers may be more vulnerable to crashes because of the motivation to drive faster and longer due to the financial pressure to cover their costs. The lower crash involvement of owner drivers compared to employee drivers may also be due to the payment method. Owner drivers were paid distance-based rates less than employee drivers.

Regarding payment methods, Study 1a showed that drivers paid on a trip or time basis are less likely to be involved in crashes than those paid distance-based rates. This result is consistent with past research showing that distance-based rates are the most associated with driver poor safety performance (O’Neill & Thornthwaite, 2016; Quinlan & Wright, 2008). Drivers paid time-based rates are safer than those paid distance-based rates because time-based rates tend to motivate longer driving, while distance-based rates motivate longer and faster driving (Quinlan & Wright, 2008). Trip and distance-based rates are both performance-based payments. Nevertheless, the better safety performance of drivers paid trip rates may be related to the uncertainty in earnings (Hensher, et al., 1991). Trip and distance-based rates are both associated with the number of kilometres travelled. Nevertheless, distance-based rates are likely to be associated with greater uncertainty in driver earnings than trip-based rates. An underlying reason for this higher uncertainty in earnings could be that trip-related earnings appear to be more predictable than earnings associated with distance-based payments, because trips are defined between specified origins and destinations. Thompson and Stevenson (2014) found that trip rates were associated with lower crash involvement than distance-based rates. Study 1a used some of the data that these authors used. While they did not explain this result, it might be that trip rates were relatively higher than distance-based rates.

Given that driver employment type and payment methods were directly associated with crash involvement, the next research question examined whether employment type and payment methods could indirectly influence crash involvement through the use of cruise control (CC).

7.3.2 Findings related to RQ2

The literature review showed that speeding may help explain the relationship between payment methods and crash involvements with distance-based payments being more associated with speeding than time-based payments. Different relationships between use of CC and payment methods can be hypothesised. Distance-based rates may discourage the use of CC, or they may encourage its use because the CC is designed to reduce the driving workload and improve driving performance. Regarding employment type, employee drivers may be more likely to use CC than owner drivers because of company regulations. On the other hand, vehicle ownership may encourage owner drivers to use CC in order to protect their assets from crash involvement. Thus, the second research question was:

> *Are HV driver employment type and payment methods related to driver use of cruise control?*

This research question also concerned the first hypothesis of the conceptual framework and was addressed in Study 1b. Only the data from control drivers were used in Study 1b because it is unknown whether case drivers were using CC at the time of the crash. Case drivers were drivers involved in a police-attended crash during the data collection period in which they were not seriously injured. Control drivers were drivers who self-reported not having been involved in a police-attended crash during the past 12 months.

Study 1b, a multivariate analysis, showed that drivers paid trip rates are less likely (OR=0.24) to use CC than those paid distance-based rates. This is consistent with research that suggests that distance-based payments, by tying earnings to the number of kilometres travelled, encourage risky behaviours (Mooren, et al., 2015; NTC, 2008; O'Neill & Thornthwaite, 2016). It suggests that drivers may consider CC as a means to reduce their workload, improve their driving performance, and enable them to drive longer distances. They may also see CC as more important to ensure they are never below speed limits unnecessarily.

Study 1b also showed that subcontractor drivers are more likely (OR=3.26) to use CC, but when paid distance-based rates, they are less likely (OR=0.09) to use it. Distance-based rates can encourage speeding, and CC may interfere with drivers' speeding behaviours, thus discouraging the use of CC. The next question examined whether payment method could indirectly affect crash involvement by influencing fatigue-related behaviours based on employment type.

7.3.3 Findings related to RQ3

The third research question was:

Do HV driver payment methods mediate the relationship between driver employment type and fatigue-related behaviours?

This research question similar to previous research questions concerned the first hypothesis of the conceptual framework. It was addressed in Study 1c. Only data from control drivers were used in Study 1c because the inclusion of the case drivers would overestimate the prevalence of unsafe behaviours.

Study 1c showed that payment methods may help explain the relationship between employment type and three fatigue-related behaviours: stimulant intake, drowsy driving, and rest breaks. All types of drivers could be vulnerable to fatigued driving as the results of performance-based payments (Mooren, et al., 2015). Nevertheless, the difference in how earnings are calculated for the different types of drivers is likely to lead to differences in safety performance (Kudo & Belzer, 2019b). Owner drivers may have the poorest performance because of the greater financial strain they may face compared to employee and subcontractor drivers (Miller, et al., 2018; Miller & Saldanha, 2016). Additionally, owner drivers may have more power to decide on the number of stops and lengths of rest breaks compared to the other drivers. Thus, they may be less likely to comply with rest break regulations than other drivers.

In sum, Study 1 showed that distance-based payments are directly associated with a higher crash involvement and could indirectly be associated with crash reduction (increase use of CC) or crash increase (moderator, lower use of CC). They can also help differentiate the different types of drivers in terms of fatigue-related behaviours. Owner drivers are less likely to involved in crashes than employee drivers, but they are likely to undergo higher levels of fatigue-related behaviours than employee drivers, due to performance-based payments. Thus, driver employment type and payment methods have safety implications for companies. They are critical factors that may affect the likelihood of speeding, fatigued driving and crash involvement. This necessitates legislation to prevent or reduce the adverse effects of these factors.

7.3.4 Findings related to RQ4

The fourth research question was:

What is the relationship between HV company awareness of CoR legislation and the driver employment types and payment methods?

This research question concerned the second hypothesis of the conceptual framework and was addressed in Study 2. The CoR legislation aims to ensure that the actors in the transport logistics and supply chain adopt practices that do not encourage fatigued driving.

Study 2 showed that merely hearing about the CoR legislation might not be enough to influence how companies employ drivers. Companies that reported no change in their perceptions of driver fatigue and the extent of CoR liability to other parties in the transport logistics and supply chain are more likely to use employee drivers and pay time-based rates. Study 2 also showed that companies with a better understanding of fatigue management schemes are more likely to outsource the driving task and pay time-based rates to drivers. As explained by NTARC (2017), the outsourcing of the driving task is generally performed by larger companies which subcontract the driving task to smaller companies. Nevertheless, small companies may not possess the economic, human and technological resources to monitor driver safety behaviours (Quinlan & Wright, 2008; Rodríguez, et al., 2004). Time-based payments could encourage safety compliance. Importantly, fatigue management schemes are aimed to ensure a safer subcontracting system by requiring all the actors in the transport logistics and supply chain, including drivers, to comply with fatigue management regulations. Thus, a good understanding of fatigue schemes is likely to encourage outsourcing of the driving task.

This finding implies that the CoR legislation, through fatigue management schemes, is likely to enhance road safety performance because of its likelihood of discouraging payments that connect earnings to performance. A better safety performance could suggest high compliance with speed and fatigue management regulations.

However, even if HV companies comply with fatigue management regulations, their safety performance may still be poor if they are not financially healthy enough to operate new equipment or adequately maintain the existing equipment. Financial performance accordingly appears as a critical factor that could influence the safety performance of HV companies.

7.3.5 Findings related to RQ5

The fifth research question was:

Is there a bidirectional link between company financial performance and HV crash involvement?

This research question concerned the last hypothesis of the conceptual framework and was addressed in Study 3. The analysis consisted of examining the influence of financial performance on safety performance and the influence of safety performance on financial performance.

The results showed a positive association between financial performance in the *previous* year and at-fault crash involvement in the *current* year. This is consistent with research claiming that financially healthy companies are likely to have safety-promoting practices. They may recruit skilled and experienced drivers and possess vehicles equipped with technology to track driver on-road safety behaviours. The situation is likely to be different for poor financial performers (O'Neill & Thornthwaite, 2016). They may operate older equipment, which not only decreases driver morale, but also increases worker turnover and deters experienced workers from joining the company (Autry & Daugherty, 2003), implying that safety performance may also influence financial performance. The direction of the causality in Study 3 showed a positive association between the safety performance in the *previous* year and the financial performance in the *current* year.

Thus, the findings of Study 3 suggest a bidirectional relationship between financial performance and safety performance. This is consistent with research claiming that good safety performance is a critical factor to increase competitive advantage (Fernández-Muñiz, et al., 2009). A better safety performance attracts more business partners, reduces insurance premiums and hence increases company reputation (Cantor, 2008; Das, et al., 2008; Miller & Saldanha, 2016). The next question examined the connection between financial performance and other safety influencing factors.

7.3.6 Findings related to RQ6

The sixth research question was:

Is HV company financial performance associated with other factors influencing crash involvement?

This research question, similar to RQ5, concerned the last hypothesis of the conceptual framework and was addressed in Study 3.

Study 3 showed that companies that reported good or very good financial performance tend to use employee drivers for long-distance trips but not for short trips, use drivers of at least good skills, buy new vehicles or use vehicles mostly equipped with technology, carry livestock, refrigerated or dangerous goods, and pay time or performance-based rates to drivers, irrespective of distance. Companies that rated their financial performance as very good showed a high level of familiarity with the CoR legislation. Conversely, companies that reported poor financial performance are more likely to use outsourced drivers than any other type of drivers, pay time-based rates to long-distance drivers, and carry general or mixed freight. However, they are unlikely to buy new vehicles or use vehicles equipped with technology. With regard to companies that rated their financial performance as neither poor nor good, they are unlikely to have vehicles equipped with technology. They are likely to use both employee drivers and outsourced drivers, pay mixed rates and transport other types of freight.

The use of employee drivers by good safety performing companies may be explained by their capacities to highly invest in safety programs, such as driver training, acquisition of new vehicles, and the adoption of technologies. The adopted technologies in the survey comprised ABS brakes, cruise control or similar, fatigue management devices, emergency brake assistance, forward collision avoidance systems, electronic stability control systems, lane departure warning and prevention systems, automatic transmission systems and audible reversing devices. These technologies enable these companies to improve driver safety performance through fatigue management and crash avoidance. That could also be the reason why they tend to carry specialised freight and pay drivers based on the amount of work performed. Payments based on the amount of work performed are more likely to be associated with fatigued driving and crash involvement. Safety technology appears as a countermeasure to the adverse effects of payments based on the amount of work performed.

The use of outsourced drivers by financially weak companies may be motivated by the desire to reduce safety investments and avoid bankruptcy (Chow, 1989). It may also allow them to access adequate technology and reduce exposure to safety risk and the complexities associated with driver management (Cantor, et al., 2016). These companies pay time-based rates to increase the likelihood of compliance with safety regulations by outsourced drivers (Rodríguez, et al., 2004).

7.3.7 Consistency of the findings

This section examines the extent to which the findings of the different research questions fit together. The examination of RQ1, RQ2 and RQ3 showed that time-based rates are associated with a better safety performance than distance-based rates, and outsourced drivers (owner drivers) are safer than employee drivers. The results from RQ4 are consistent with those from the previous research questions. The examination of RQ4 showed that a better understanding of fatigue management schemes is more likely to be associated with outsourcing of the driving task and paying time-based rates to drivers. The examination of RQ6 showed that self-reported good financial performers tend to pay time-based rates and be very familiar with CoR legislation; these factors are safety-promoting policies, as shown in the analysis of RQ1 and RQ4, respectively.

In sum, the research program showed that time-based rates and owner drivers are associated with safer driving than distance-based rates and employee drivers, respectively. Thus, companies with good safety performance or a better understanding of fatigue regulations are more likely to pay time-based rates and employ owner drivers.

7.4 RESEARCH IMPLICATIONS

This research program offered an opportunity to develop a better understanding of company financial influences on safety performance in the HV industry. The research has highlighted some policy gaps that, if addressed, may contribute to the safety improvement in the industry.

7.4.1 Implications for driver remuneration policy

Study 1 showed that drivers paid distance-based rates have poor safety performance than those paid time-based or trip rates. Both trip and distance-based rates are associated with the distance driven. However, the lower crash involvement associated with trip rates compared to distance-based rates might be related to pay level; trip rates may have been relatively higher than distance-based rates. Distance-based rates decrease drivers' likelihood of using CC, which could result in inadequate following distances. The adverse effects of distance-based payments raise the issue of driver payment regulating policies.

The Federal Labor Government established the Road Safety Remuneration Tribunal (RSRT) in July 2012 to regulate drivers' remuneration policy. It aimed at setting minimum pay rates for drivers throughout the country (Rawling, et al., 2017). Nevertheless, it was abolished in 2016 on the grounds that it made owner drivers less competitive and forced some of them out of the business. Some researchers have suggested that the RSRT or a similar tribunal again be put on the political agenda (Litchfield, 2017). Nevertheless, before the establishment of the RSRT, New South Wales implemented a price regulatory scheme similar to the RSRT, but there has not been evidence that this jurisdiction had better safety performance than other jurisdictions. Moreover, no country has used price regulation to improve road safety (Deighton-Smith, 2019). Thus, the CoR legislation remains a critical alternative due to the vital safety improvements it has been associated with. This legislation may be reinforced with a Safety Rating Scheme, as discussed later.

7.4.2 Implication for company managers

Study 3 showed that better financial performance is associated with safety-promoting policies. Financial knowledge accordingly appears to be a critical factor to improve safety management in the HV industry. Heavy vehicle company managers should consider taking such kind of training to avoid financial distresses, which may adversely affect the amount of resources devoted to safety investments. The government or industry organisations may provide free or low-cost training opportunities.

7.4.3 Implications for fatigue management

Study 2 showed that the understanding of safety regulations appears to be a critical factor in compliance with safety regulations. Safety regulations, particularly those related to fatigue management, encourage the adoption of safety-conducive payment policies. That may be the reason why a better understanding of fatigue management schemes is associated with paying time-based rates. Education appears as a must to increase the knowledge of freight stakeholders about their respective duties formulated in the different legislations. A better understanding of the safety regulations may surely ensure a safer outsourcing system and enable carriers at the different levels of the supply chain to have stable financial health.

7.4.4 Implications for legislative improvements

Study 3 showed that companies that reported better financial status are more likely to implement safety-promoting policies. In some countries, such as the UK, truck companies are required to demonstrate their financial capability to adequately maintain vehicles before they can be granted the right to operate. They must show that they have £8,000 (almost AUD $ 15,263) for the first truck and £4450 (AUD $ 8,490) for each additional truck they want to use (UK Traffic Commissioner, 2018). Likewise, in the United States, truck companies are required to show adequate financial responsibility before being granted a business license (Mooren, Grzebieta, Williamson, & Olivier, 2012).

Conversely, in Australia, companies are not required to show financial aptitude to maintain vehicles before starting operations. The National Heavy Vehicle Accreditation Scheme only requires them to show that they have a maintenance system (Jones, 2015; Mooren, et al., 2012). Financiers are not included in the CoR legislation. Banks that lend to companies to buy trucks are not required to ensure that the costs to maintain vehicles are imputed in the loan. The Australian Technical Working Group on Roadworthiness has suggested that financiers be included in the CoR regulations; the rationale being that the purchase should go beyond interest payments to incorporate truck maintenance (Jones, 2015). It would accordingly be important to examine the inclusion of financial performance into the HV regulatory frameworks such as the CoR legislation.

7.4.5 Implications for improvements of data collection in the Australian HV industry

Study 3 showed again that low response rates for surveys are common in the HV industry. It may be useful to reconsider introducing the Safety Rating Scheme initiated in 2013 by the Transport Workers' Union of Australia (Transport Workers' Union of Australia, 2015). This scheme consisted of rating the safety performance of HV companies based on the assessment of annually collected data and making the outcomes, as in the United States, readily accessible to the public. Nevertheless, the Safety Rating Scheme has not been as successful as expected, mainly because of the incompleteness of the information collected (Jones, 2015). An online database about safety performance beyond providing researchers and freight stakeholders with data may also encourage carriers to comply with safety regulations, because poor safety performers would be less likely to have business opportunities. All US studies connecting financial and safety performance used quantitative measures for these performances. The availability of quantitative measures in Australia is not aiming to avoid conducting surveys, but they could serve as baselines for the findings based on survey-obtained subjective measures.

7.5 RESEARCH LIMITATIONS, STRENGTHS AND FUTURE RESEARCH

The strengths, limitations and opportunity for future research identified in the research program have already been highlighted in the sections related to each study. This section only provides a brief overview.

7.5.1 Limitations

A limitation across all the studies of the research program is the use of self-reported data that, as already explained, may contain some errors and sampling biases. However, the anonymous nature of the different surveys is likely to increase the accuracy of the responses (Bailey & Wundersitz, 2019). The different samples do also not represent all truck drivers. Study 1 did not include HV drivers involved in fatal crashes or those who were severely injured in crashes. Moreover, the survey might have omitted control drivers not using truck stops for their meals. Nevertheless, this omission was likely to be minimised because the survey was spread over different times, days, weeks and months to capture various travel patterns. Some of the participants in Study 2 and Study 3 were selected from the Yellow Pages website, which may host only some of the HV companies in Australia. Nevertheless, data from both studies showed several similarities in terms of loads carried, the number of trucks operated, truck type, the type of drivers companies used for long-distance trips and the associated payment methods, and company awareness of CoR legislation. This agreement between the two surveys conducted at different periods supports the representativeness of Study 3 responses.

Data for Study 1 were collected between November 2008 and November 2011 and those for Study 2 were collected in April and May 2012. While these data are somewhat old, the issues analysed in the two studies are still critical to safety improvement in the HV industry. The relationship between employment type and safety performance has not been empirically established since then. Moreover, it is less explored in Australia than, for instance, in the United States. Factors that affect driver use of CC in the HV industry are less explored, despite the appearance of emerging technologies such as adaptive CC and the increased number of HV-related fatal crashes due to speeding. The examination of the associations of CoR legislation with driver employment type and payment methods is critical for assessing the effectiveness of this legislation, given the safety implications of employment type and payment methods. Nevertheless, this issue has not been examined.

The small sample of Study 3 is another limitation of the research. The data were collected over a period of nine months (February to October 2019), after several modifications to the recruitment method and extensions of the data collection period. Nevertheless, low response rates are common in self-administered surveys in the Australian HV industry (Mooren, et al., 2014; Williamson & Friswell, 2013).

Regression models were unable to be used to examine the causal direction between financial performance and safety performance because of the small sample size. Instead, an exploratory method, correspondence analysis, was used. Correspondence analysis can provide meaningful results irrespective of the sample size (Kudlats, et al., 2014). Nevertheless, the method is sensitive to cell sizes making low-frequency cells to be far from the origin of the map. The interpretation of the results is also somewhat subjective and may differ among researchers. In contrast, correspondence analysis does not require assumptions on variables. It can be used to examine both linear and nonlinear associations, making it more flexible than regression-based methods (Rodriguez-Sabate, et al., 2017).

The survey for Study 3 was cross-sectional in nature, though part of the questionnaire asked information from previous years. Collecting information for the previous years at the same time may have resulted in stronger correlations than if the information was collected a year apart. A longitudinal framework would be preferred that could examine several lags of financial performance, safety performance and at-fault crash involvement.

7.5.2 Strengths

Carriers can employ their employee drivers or outsource the driving task. The literature review showed that it is unclear whether outsourced drivers have better safety performance than employee drivers. Unlike previous research, Study 1 included payment methods in the analysis of safety performance based on driver employment type, because of their major impact on safety performance.

Mere familiarity with the legislation is not enough for the CoR regulatory framework to ensure a safer freight carrying industry. Each stakeholder in a freight transport task should be confident that the other actors in the transport chain will fulfil their duties as required by law. Thus, the different stakeholders should understand the law and how it applies to all the parties in the transport logistics and supply chain. Hence, Study 2 included variables such as awareness of driver fatigue, understanding of fatigue management schemes, and extension of CoR liability to other parties. These variables are all included in the concept of the CoR legislation.

Study 3 sought to make a major contribution to empirical research on the link between financial performance and safety performance in the freight transport industry. It is not only the first of the kind within the Australian context, but it improved upon existing studies to examine the association between financial performance and some other factors that may influence safety performance. Driver employment type, payment methods, and the CoR legislation are among these factors. The research began with an exploration of the association of employment type and payment methods with safety performance and the effectiveness of the CoR legislation as a safety-promoting regulatory framework that could reduce the adverse effects of the subcontracting of the driving task and payment methods on safety. Moreover, it also examined the bidirectional connection between safety performance and financial performance.

Study 3 used at-fault crash involvement and the perception of safety performance to represent safety outcomes and perceptions of financial performance to represent the financial health of companies. At-fault crashes are better measurements for safety outcomes because they represent company safety efforts. The use of perceptions of performance is likely to provide a more global indication of the safety and financial conditions of participating companies. Previous research connecting financial performance to safety performance used various measurements for these variables, which have some advantages and disadvantages. For instance, in terms of safety performance, maintenance expenditures, while reflecting safety efforts, can be misleading because they may be related to fleet age (Corsi, et al., 1988; Raghavan & Rhoades, 2005). Crash involvement, though of most concern for customers, may not reflect safety efforts because the company may not be at-fault (Beard, 1992). Concerning financial performance, the use of a single metric may not be enough to provide a comprehensive view of the financial condition of a company (Chow, 1989).

The perceptions of safety and financial performance were self-reported and thus may contain some errors. Nevertheless, these errors were likely to be minimised because of the anonymous nature of the survey, and because most of the participants were owner directors and general managers. The people in these positions are generally the most informed about the policies and practices of companies (Fernández-Muñiz, et al., 2009).

7.5.3 Future research

Study 1a used crash involvement to represent safety performance. Future research could use at-fault crash involvement or safety behaviours because they are more likely to reflect company safety efforts. More important than payment methods, pay level is a critical factor that affects driver safety performance, as has been found in studies using US data. Nevertheless, these kinds of studies are yet to be conducted in Australia.

Study 1b used a binary indicator of the use of CC. Prospective studies may use an estimate of the percentage of the trip on which the driver is using CC. This could provide further weight to the use of CC as an outcome variable. Moreover, the data used in the study are somewhat old because there has been the emergence of many safety technologies since then. Future research could use more recent data on the use of new technologies such as adaptive cruise control to explore the associations of employment type, payment methods, and other variables with HV driver use of these technologies.

Study 1b also showed that trip rates are less likely to be associated with speeding than distance-based rates. However, no difference, in terms of using CC, was expected between these rates because they all encourage speeding by tying earnings to the distance driven. Prospective research could examine why drivers paid trip rates are less likely to use CC than those paid distance-based rates.

Lastly, the correspondence analysis in Study 3 is exploratory in nature. Analyses using statistical models would provide further weight to the findings from Study 3. Such statistical models include modelling techniques such as logit, binomial or multinomial models.

7.6 CHAPTER SUMMARY

This chapter briefly described the different studies in this program of research and the associated research questions. It then summarised the outcomes of the research and made some policy recommendations, then reported some of the limitations and strengths of the research before suggesting directions for future research.

Chapter 8: Conclusions

This research program examined financial influences on safety performance in the Australian heavy vehicle industry. The findings showed that driver employment type and payment methods influence driver safety performance and potentially other occupational health safety issues such as injuries, diseases, and mental health. Paying drivers based on the amount of time worked or the number of trips completed between a given origin and destination is associated with safer driving than payments based on the distance driven. Distance-based payments appear to decrease driver use of cruise control and mediate the relationship between employment type and fatigue-related behaviours. The CoR legislation, through the heavy vehicle company’s understanding of fatigue management schemes, is associated with better safety performance because it discourages performance-based payments. Good financial performers are likely to implement safety-promoting policies that may reduce or prevent the adverse effects of how companies employ and pay drivers. Likewise, good safety performers are likely to have good financial performance through an increase in the number of customers.

The results of this research demonstrate some of the complex inter-relationships of factors affecting safety in the heavy vehicle industry. As mentioned in the policy implications, the Australian Technical Working Group on Roadworthiness has suggested the consideration of financiers in the CoR legislation. The results of the current research provide support for this suggestion.

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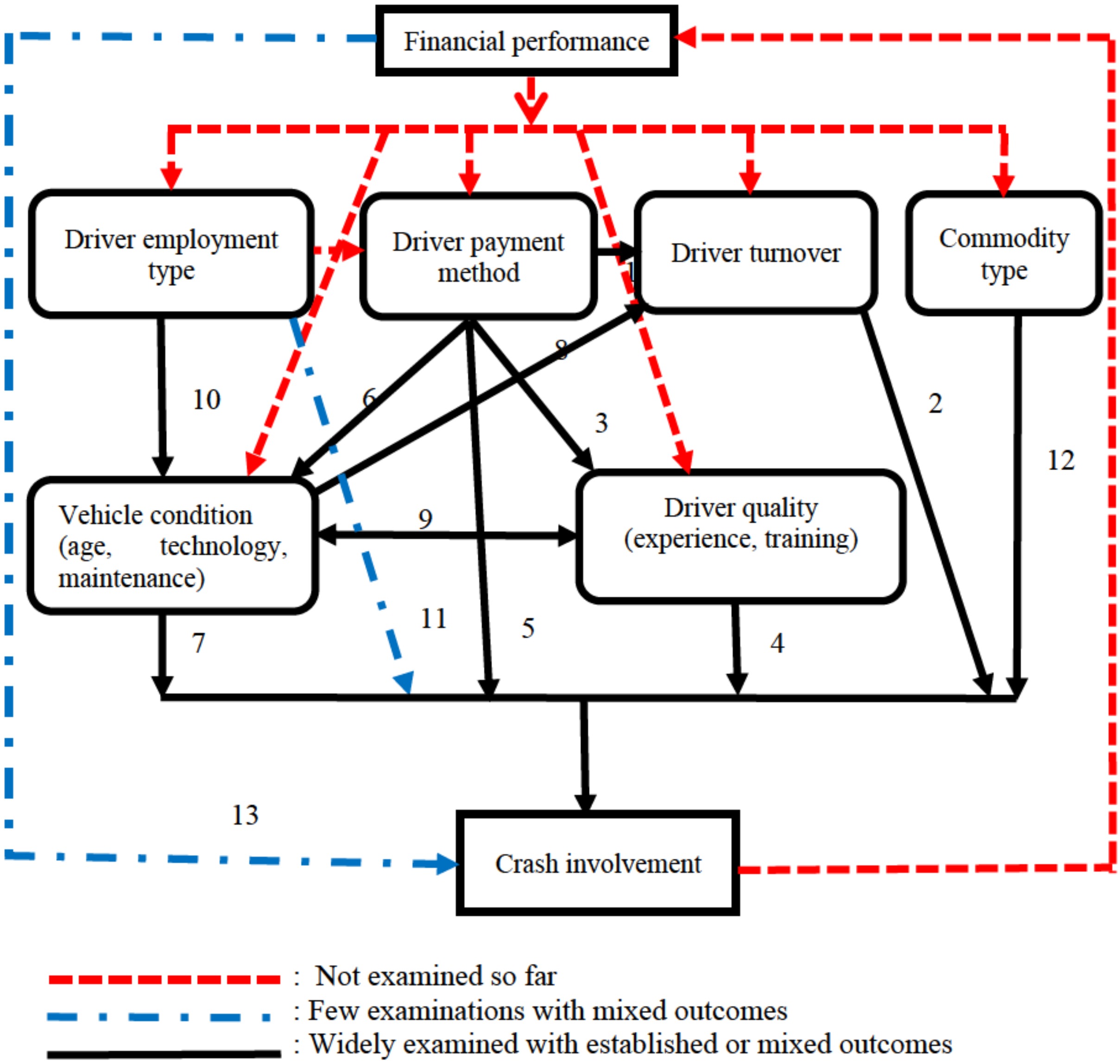
Appendices

APPENDIX A: ANNOTATED FRAMEWORK OF FINANCIAL INFLUENCES ON CRASH INVOLVEMENT



IDs (1 to 13) are put on the different arrows on the graphs. Table A.1 lists the different studies that examined these links.

Table A.1: Studies of the different links of the conceptual framework

ID	Relationship	Studies
1	Driver payment and turnover	Garver, et al. (2008); Gupta, et al. (1996); Harrison and Pierce (2009); Humphreys (2016); Johnson, et al. (2011); Keller and Ozment (1999b); Keller (2002); Min and Emam (2003); Min and Lambert (2002); Munasinghe (2000); Richard, et al. (1995); Rodríguez, et al. (2004); Rodriguez, et al. (2006); Sersland and Nataraajan (2015); Shaw, et al. (1998); Taylor, Garver, and Williams (2010); Williams, et al. (2011)
2	Driver turnover and crash involvement	Cantor, et al. (2011); Cantor, et al. (2013); Faulkiner and Belzer (2019); Min and Lambert (2002); Staplin and Gish (2005); Suzuki, et al. (2009)
3	Driver payment and driver quality	Faulkiner (2015); Faulkiner and Belzer (2019); Gupta and Shaw (2014); Pritchard (2010); Zhang, Yau, Zhang, and Li (2016)
4	Driver quality and crash involvement	Bruning (1989); Chow (1989); Faulkiner and Belzer (2019); Zhang, et al. (2016)
5	Driver payment and crash involvement	See Table 2.3
6	Driver payment and vehicle condition	Belzer (2012); Belzer, et al. (2002); Cantor, et al. (2013); Corsi, et al. (1988); Mooren (2016); Viscelli (2016)
7	Vehicle condition and crash involvement	Al-Bulushi, et al. (2015); Assemi and Hickman (2016); Blower, et al. (2010); Bruning (1989); Corsi and Fanara (1988); Corsi, et al. (1988); Miller, Saldanha, Rungtusanatham, and Knemeyer (2017); Min and Lambert (2002); Mooren, et al. (2014); Pritchard (2010); Werner, et al. (2016)
8	Vehicle condition and driver turnover	Autry and Daugherty (2003); Das, et al. (2008); Garver, et al. (2008); Humphreys (2016); Min and Emam (2003); Ouellet (2010)
9	Driver quality and vehicle condition	Faulkiner (2015); Faulkiner and Belzer (2019); Zhang, et al. (2016)
10	Employment type and vehicle condition	Cantor (2016); Cantor, et al. (2013); Miller, et al. (2018); Monaco and Redmon (2012); Nickerson and Silverman (2003)

11	Employment type and crash involvement	See Table 2.2
12	Commodity type and crash risk	Beard (1992); Cantor, et al. (2010); Corsi (2004); Corsi and Fanara (1988); Corsi, et al. (1988)
13	Financial performance and crash involvement	See Table 2.1

APPENDIX B: DETAILED DESCRIPTION OF STUDY 2 PAYMENT METHODS

Outcome variable	N= 400 (%)
Time-based rates	198 (49.5)
Hourly rate	98 (24.5)
Daily rate	8 (2.0)
Weekly rate	20 (5.0)
Hourly and daily rates	32 (8.0)
Hourly and weekly rates	20 (5.0)
Hourly, daily and weekly rates	16 (4.0)
Daily and weekly rates	4 (1.0)
Performance-based rates	27 (6.7)
Distance-based rate	15 (3.8)
Load-based rate	10 (2.5)
Distance-based and load-based rates	2 (0.5)
Mixed rates	138 (34.5)
Hourly and distance-based rates	40 (10.0)
Hourly and load-based rates	23 (5.8)
Daily and distance-based rates	8 (2.0)
Daily and load-based rates	6 (1.5)
Weekly and distance-based rates	8 (2.0)
Weekly and load-based rates	5 (1.3)
Weekly, distance and load-rates	3 (0.8)
Hourly, daily and distance-based rates	14 (3.5)
Hourly, daily and load-based rates	9 (2.3)
Hourly, daily, weekly and distance-based rates	7 (1.8)
Hourly, daily, weekly and load-based rates	2 (0.5)
Hourly, daily, weekly, distance and load-rates	2 (0.5)
Daily, weekly and distance-based rates	3 (0.8)
Daily, weekly and load-based rates	4 (1.0)
Daily, weekly, distance and load-rates	2 (0.5)
Daily, distance and load-rates	2 (0.5)
Other rates	37 (9.3)

APPENDIX C: SURVEY MATERIALS FOR STUDY 3

C1. Participants Information Sheet

PARTICIPANT INFORMATION FOR QUT RESEARCH PROJECT

Relationship between financial performance and road safety outcomes in the Australian trucking industry

QUT Ethics Approval Number 1800000996

RESEARCH TEAM

Principal Researcher:	Wonmongo Lacina Soro*	PhD student
Associate Researchers:	Professor Narelle Haworth*	Principal Supervisor
	Dr Jason Edwards*	Associate Supervisor
	Dr Ashim Debnath+	External Supervisor
	Dr Darren Wishart×	External Supervisor

***Centre for Accident Research and Road Safety–Queensland (CARRS-Q)**
Faculty of Health, Queensland University of Technology (QUT)
+ Deakin University
× Griffith University

DESCRIPTION

This research project is being undertaken as part of a PhD study for Wonmongo Lacina Soro.

While the number of crashes involving heavy trucks has been decreasing in Australia, the current number of fatalities of both industry members and the public is still significant. Researchers have suggested that the financial performance of a truck company is likely to have a major contribution to its safety performance. This suggestion has not yet been sufficiently tested. The purpose of this research project is to evaluate how Australian heavy vehicle companies' financial performance affects their safety performance and some factors that are likely to influence this relationship.

You are invited to participate in this research project because you are a manager in the Australian trucking industry, or an administrative staff member (with sufficient knowledge of your company's financial and safety performance, and the management of drivers in your company)

PARTICIPATION

Your participation will involve completing an anonymous online survey that will take approximately 20 minutes of your time.

Questions will concern information over the past two (2) years. They will mainly be related to:

1. The drivers' employment status (the use of company drivers versus the use of contractors) and payment methods of your company;
2. Your perception of the financial and safety performance, and awareness of the chain of responsibility legislation of your company; and
3. The number of crashes and at-fault crashes of your company.

Regarding the financial and safety performance, you will be asked to rank the performance on scales showing different levels of performance based on your perception of whether the company performed well or not.

Your participation in this research project is entirely voluntary.

If you agree to participate you do not have to complete any question(s) you are uncomfortable answering. Your decision to participate or not participate will in no way impact upon your current or future relationship with QUT or your company. If you do agree to participate you can stop the survey at any time by closing your browser without comment or penalty. However, due to the anonymous nature of the study, if you discontinue participation after starting the survey it will not be possible to identify and remove your responses from the study. Partially completed surveys may still be used in the analysis. At the end of the survey, you will be able to review your responses before submitting and save a copy of your responses after submitting the survey.

EXPECTED BENEFITS

It is expected that this research project will not directly benefit you. However, it may be of significant benefit to the trucking industry. This research may help inform trucking companies about the safety effects that a poor financial management of their business can produce. It will also inform companies about the financial loss they can undergo should they have a poor road safety management. The findings could also be useful to safety regulators in terms of regulation and policy design. For instance, they can design policies directed to financially support truck companies in situations of financial distress in order to prevent undesired safety outcomes.

To recognise your contribution should you choose to participate, the research team is offering you the chance to enter a prize draw to receive one of five $100 Coles/Myer Gift cards after completing the survey. So, once you submit the survey, you will be asked whether you would like to be considered for the draw. If you answer YES, you will be invited to provide your names and mail address. It will not be possible to match your contact details with the answers since the survey will be submitted long before.

Please note the opening date for entries is 05/ 11/2019 and the closing date is 08/ 11/2019.
The Terms and Conditions of the prize draw are attached at:
http://www.orei.qut.edu.au/human/guidance/prize.jsp

RISKS

There may be some inconveniences and minimal risks associated with your participation in this survey. Not only will it take part of your time, but some questions also ask about crash involvement, your perception of the financial performance, and other issues (e.g. drivers' management and payment) of your company. This may create a discomfort as for instance talking about past crashes may remind the frustration and loss undergone by your company, yourself or an acquaintance as the result of these crashes. The research team suggests that you should consider your personal situation before deciding to participate. When completing the online survey, you are free to skip any question you do not wish to answer or feel uncomfortable with.

In case you experience discomfort as the result of your participation in this survey, QUT offers limited free psychology or counselling services (face-to-face only). Should you wish to access this service please call the Clinic Receptionist on **07 3138 0999** (Monday–Friday only 9am–5pm), QUT Psychology and Counselling Clinic, 44 Musk Avenue, Kelvin Grove, and indicate that you are a research participant. Alternatively, Lifeline provides access to online, phone or face-to-face support, call **13 11 14** for 24-hour telephone crisis support. For people aged up to 25, you can also call the Kids Helpline on **1800 551 800**.

It should be noted that if you do agree to participate you can withdraw from participation at any time during the project without comment or penalty.

PRIVACY AND CONFIDENTIALITY

You will submit the survey before being asked if you would like to be considered for the draw. Thus, if you agree, it will not be possible to match your contact information with the answers you provided in the survey. Accordingly, all your responses will be anonymous and treated confidentially unless required by law.

Any data collected as part of this research project will be stored securely as per QUT's Management of research data policy. Moreover, your contact information will not be used for any other purpose but the draw or contacting you to ensure that you received the gift card in case you happen to be selected to get one. The contacts will be destroyed after achieving this purpose.

Please note that the non-identifiable data from this research project may be used as comparative data in future projects or stored on an open access database for secondary analysis. As it will not be possible to match your survey answers with your contact details, the data will remain in a de-identified format for any use in the future.

CONSENT TO PARTICIPATE

Submitting the completed online survey is accepted as an indication of your consent to participate in this research project.

QUESTIONS / FURTHER INFORMATION ABOUT THE RESEARCH PROJECT

If you have any questions or require further information please contact one of the listed researchers.

Wonmongo Lacina Soro	w.soro@hdr.qut.edu.au	07 3138 7718
Narelle Haworth	n.haworth@qut.edu.au	07 3138 8417

CONCERNS / COMPLAINTS REGARDING THE CONDUCT OF THE RESEARCH PROJECT

QUT is committed to research integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the research project you may contact the QUT Research Ethics Advisory Team on 07 3138 5123 or email humanethics@qut.edu.au. The QUT Research Ethics Advisory Team is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.

THANK YOU FOR HELPING WITH THIS RESEARCH PROJECT.

C2. Recruitment email

Hello,

Thanks for having given us your email when our team recently called you. My name is Wonmongo Lacina Soro. I am a PhD student at the Centre for Accident Research and Road Safety–Queensland (CARRS-Q), Queensland University of Technology (QUT). My research examines the relationship between financial performance and road safety outcomes in the Australian trucking industry.

I am looking for office-based employees from Australian truck companies that carry freight in trucks of more than 4.5 tonnes or have it carried in similar trucks to complete an anonymous 20-minute online questionnaire. The questionnaire is designed to be completed by company managers or any administrative staff members who have a sufficient understanding of the financial and safety performance of the company, as well as how drivers are paid and managed (the use of company drivers versus the use of contractors). It does not ask for any specific financial details. If you do not have sufficient knowledge of these matters, please consider forwarding this email to a relevant member of your company.

The questions in the survey will ask you information about your company in the past two (2) years. This information concerns truck features, the type of loads, drivers' employment status and payment methods, the total number of crashes and at-fault crashes. You will also be asked about your perception of the company's financial and safety performance, awareness of the chain of responsibility legislation.

There may be some inconveniences and minimal risks associated with your participation in this survey. Not only will it take part of your time, but some questions also ask about crash involvement, your perception of the financial performance, and other issues (e.g. drivers' management and payment) of your company. The research team suggests that you should consider your personal situation and whether answering such questions would result in discomfort, before deciding whether to participate. When completing the online survey, you are free to skip any question you do not wish to answer or feel uncomfortable with.

It should be noted that if you do agree to participate, you can stop the survey at any time by closing your browser without comment or penalty. However, due to the anonymous nature of the study, if you discontinue participation after starting the survey, it will not be possible to identify and remove your responses from the study. Partially completed surveys may still be used in the analysis. After completion of the survey, you will be offered the chance to enter a prize draw to receive one of five $100 Coles/Myer Gift cards between November 5, 2019 and November 8, 2019.

Please note that unidentifiable data, including partially or full completed surveys that you provide in this study, may also be used in other future studies whenever necessary.

Further details on the study and how to participate can be found by clicking on the following link:
https://survey.qut.edu.au/f/192800/5c59/

If you are interested in participating or have any questions, please contact me via email.

Please note that this study has been approved by the QUT Human Research Ethics Committee (approval number 1800000996).

Many thanks for your consideration of this request.

Wonmongo Lacina Soro
PhD Student
w.soro@hdr.qut.edu.au

Professor Narelle Haworth
Supervisor
n.haworth@qut.edu.au

Dr Jason Edwards
Associate Supervisor
jason.edwards@qut.edu.au
Centre for Accident Research and Road Safety–Queensland (CARRS-Q)
Faculty of Health, Queensland University of Technology

Dr Ashim Debnath
External Supervisor
ashim.debnath@deakin.edu.au
Deakin University

Dr Darren Wishart
External Supervisor
d.wishart@griffith.edu.au
Griffith University

C3. Survey questionnaire

PARTICIPANT PROFILE

1. Which of the categories below best describes your position in the company?

- Owner/Director
- Finance Manager
- General Management
- Office Staff
- Other (Please specify)

COMPANY PROFILE

2. In the past 12 months, what areas did your company operate across? (You may tick more than one option)

- Local
- Regional
- State-wide
- Interstate
- Other (Please specify)
- Don't know

3. In the past 12 months, how many trucks of more than 4.5 tonnes did your company use in an average week?

- 1 Fewer than 5 trucks
- 2 Between 6 and 10
- 3 Between 11 and 50
- 4 More than 50

4. In the past 12 months, what were the main types of loads that your company transported? (You may tick more than one option)

- Livestock
- Refrigerated or temperature controlled
- Dangerous goods
- Farm produce
- Machinery
- Building materials
- Groceries
- Manufactured goods
- Cars
- Express freight
- General/ mixed freight
- Other (Please specify)

5. Has there been any major change in your company during the past 5 years?

- No ***Go to 7***
- Yes ***Go to 6***
- Don't know ***Go to 7***

6. What change was it? (You may tick more than one option)

- Change of ownership
- Significant expansion

- Major acquisition of vehicles
- Bankruptcy
- Other (Please specify)

VEHICLE CHARACTERISTICS

7. In the past 12 months, what types of trucks did your company use in an average week? (You may tick more than one option)
    - Rigid trucks
    - Semi-trailers
    - Road trains
    - B-doubles or triples
    - Other (Please specify)
8. In the past 12 months, what was the average age of your company vehicle fleet?
9. What was the average age of the vehicles that your company purchased in the past 12 months?
10. In the past 12 months, did your company schedule vehicles for maintenance or inspection?
    - No ***Go to 12***
    - Yes ***Go to 11***
    - Don't' know ***Got to 12***
11. How often was it, per unit of time?
12. In the past 12 months, approximately, what percentage of your vehicles were equipped with
    - ABS brakes
    - Cruise control or similar
    - Fatigue management devices
    - Emergency brake assist
    - Forward collision avoidance system
    - Electronic stability control system
    - Lane departure warning and prevention system
    - Automatic transmission
    - Audible reversing device
    - Other (specify)

DRIVER PAYMENT POLICY

Now, we would like to know about the types of drivers your company uses (employees, drivers working for subcontracting companies and independent owner drivers)

13. In the past 12 months, did your company use employee drivers on short distance trips (distance ≤ 200 kilometres)?
    - No ***Go to 17***
    - Yes ***Go to 14***
    - Don't' know ***Go to 17***
14. Approximately, how many in an average week?
15. How did you usually pay them? (You may tick more than one option)
    - Hourly rate

- Daily rate
- Weekly rate
- Single pay plus over time
- Trip rate
- Distance based-rate
- Tonnage based-rate
- Don't know
- Other (specify)

16. Did you pay them for the non-driving tasks such as loading/unloading and queuing/waiting?

- No
- Yes
- Varies
- Don't know

17. In the past 12 months, did your company use employee drivers on long-distance trips (distance >200 kilometres)?

- No ***Go to 21***
- Yes ***Go to 18***
- Don't know ***Go to 21***

18. Approximately, how many in an average week?
19. How did you usually pay them? (You may tick more than one option)

- Hourly rate
- Daily rate
- Weekly rate
- Single pay plus over time
- Trip rate
- Distance based-rate
- Tonnage based-rate
- Don't know
- Other (specify)

20. Did you pay them for the non-driving tasks such as loading/unloading and queuing/waiting?

- No
- Yes
- Varies
- Don't know

21. In the past 12 months, did your company use subcontractor drivers on short distance trips (distance $\leq$ 200 kilometres)?

- No ***Go to 25***
- Yes ***Go to 22***
- Don't know ***Go to 25***

22. Approximately, how many in an average week?
23. How did you usually pay them? (You may tick more than one option)

- Hourly rate
- Daily rate
- Weekly rate

- Single pay plus over time
- Trip rate
- Distance based-rate
- Tonnage based-rate
- Don't know
- Other (specify)

24. Did you pay them for the non-driving tasks such as loading/unloading and queuing/waiting?

- No
- Yes
- Varies
- Don't know

25. In the past 12 months, did your company use subcontractor drivers on long distance trips (distance>200 kilometres)?

- No ***Go to 29***
- Yes ***Go to 26***
- Don't know ***Go to 29***

26. Approximately, how many in an average week?
27. How did you usually pay them? (You may tick more than one option)

- Hourly rate
- Daily rate
- Weekly rate
- Single pay plus over time
- Trip rate
- Distance based-rate
- Tonnage based-rate
- Don't know
- Other (specify)

28. Did you pay them for the non-driving tasks such as loading/unloading and queuing/waiting?

- No
- Yes
- Varies
- Don't know

29. In the past 12 months, did your company use independent owner drivers on short distance trips (distance ≤ 200 kilometres)?

- No ***Go to 33***
- Yes ***Go to 30***
- Don't know ***Go to 33***

30. Approximately, how many in an average week?
31. How did you usually pay them? (You may tick more than one option)

- Hourly rate
- Daily rate
- Weekly rate
- Single pay plus over time
- Trip rate

- Distance based-rate
- Tonnage based-rate
- Don’t know
- Other (specify)

32. Did you pay them for the non-driving tasks such as loading/unloading and queuing/waiting?

- No
- Yes
- Varies
- Don’t know

33. In the past 12 months, did your company use independent owner drivers on long distance trips (distance > 200 kilometres)?

- No ***Go to 37***
- Yes ***Go to 34***
- Don’t know ***Go to 37***

34. Approximately, how many in an average week?
35. How did you usually pay them? (You may tick more than one option)

- Hourly rate
- Daily rate
- Weekly rate
- Single pay plus over time
- Trip rate
- Distance based-rate
- Tonnage based-rate
- Don’t know
- Other (specify)

36. Did you pay them for the non-driving tasks such as loading/unloading and queuing/waiting?

- No
- Yes
- Varies
- Don’t know

37. In the past 12 months, how would you describe the skill level of the drivers your company used (including employees, subcontractors and independent owner drivers)?

- Very poor
- Poor
- Neither poor nor good
- Good
- Very good

38. Irrespective of your payment methods, which payment method do you think is best for road safety? (You may tick more than one option)

- Hourly rate
- Daily rate
- Weekly rate
- Single pay plus over time
- Trip rate

- Distance based-rate
- Tonnage based-rate
- Other (specify)

Please remember, responses to this survey will be confidential. Even if you provide contact details for the prize draw, that information will not be able to be linked to your responses.

39. In the past 12 months, how much was the average rate that the company paid to drivers?

Per hour	Per trip	Per kilometre

FINANCIAL PERFORMANCE

This section asks questions about the past 12 months and also about the previous 12 months (i.e from 12 months to 24 months ago).

40. How would you describe the financial performance of your company?

	Very poor	Poor	Neither poor nor good	Good	Very good
In the past 12 months					
In the 12 months before then					

41. How profitable was your company compared to your competitors?

	Much less	Less	About the same	More	Much more
In the past 12 months					
In the 12 months before then					

SAFETY RECORDS

This section asks questions about the past 12 months and also about the previous 12 months (i.e from 12 months to 24 months ago)

42. How would you describe the safety performance of your company?

	Very poor	Poor	Neither poor nor good	Good	Very good
In the past 12 months					
In the 12 months before then					

43. Do you think the total crash-related insurance costs of your company was?

	Very low	Low	Neither low nor high	High	Very high
In the past 12 months					
In the 12 months before then					

44. Approximately, in how many police-attended crashes was your company involved?

In the past 12 months		
In the 12 months before then		

45. If known, approximately in how many police-attended crashes was your company at-fault?

In the past 12 months		
In the 12 months before then		

PERCEPTION BY THE OTHER MEMBERS OF THE COMPANY

46. On average, how do you think the decision makers in your company would describe its financial performance?

	Very poor	Poor	Neither poor nor good	Good	Very good
In the past 12 months					
In the 12 months before then					

47. On average, how do you think the decision makers in your company would describe its safety performance?

	Very poor	Poor	Neither poor nor good	Good	Very good
In the past 12 months					
In the 12 months before then					

COMPANY AWARENESS OF THE CHAIN OF RESPONSIBILITY LEGISLATION

48. How would you describe your company awareness of the chain of responsibility legislation and requirements?

- No opinion
- Have not heard about it
- Have heard something about it
- Very familiar

49. How would you describe your company awareness of driver fatigue?

- Very poor
- Poor
- Neither poor nor good
- Good
- Very good

50. Did the introduction of the chain of responsibility legislation lead your company to change how it uses drivers?

- No ***Go to 52***
- Yes ***Go to 51***
- No opinion ***Go to 52***

51. How?

- We shifted to more employee drivers
- We shifted to more owner drivers or subcontractors
- Other (Please specify)

52. Did the introduction of the chain of responsibility legislation lead your company to change how it pays drivers?

- No ***Go to prize draw***
- Yes ***Go to 53***
- No opinion ***Go to prize draw***

53. How?

- We shifted to more time-based rates
- We shifted to more productivity-based rates
- Other (Please specify)

PRIZE DRAW

Would you like to be considered for the prize draw?

- No
- Yes

Provide your contact details

- Name:
- Email:

You are almost done. Please click SUBMIT to finish!

APPENDIX D: DESCRIPTIVE STATISTICS OF STUDY 3 SAMPLE

	N=69	%
Financial performance		
Financial performance in the current year		
Poor	7	10
Neither poor nor good	18	26
Good	30	44
Very good	12	17
Missing values	2	3
Financial performance in the previous year		
Poor	5	7
Neither poor nor good	17	25
Good	26	38
Very good	17	25
Missing values	4	5
Company profitability compared to competitors in the current year		
Less	8	12
About the same	37	54
More	21	30
Missing values	3	4
Company profitability compared to competitors in the previous year		
Less	8	12
About the same	36	52
More	21	30
Missing values	4	6
Financial performance viewed by company decision makers in the current year		
Neither poor nor good	27	39
Good	27	39
Very good	14	21
Missing values	1	1
Financial performance viewed by company decision makers in the previous year		
Neither poor nor good	28	41
Good	26	38
Very good	14	20
Missing values	1	1
Safety performance		
Safety performance in the current year		
Poor	3	5
Good	25	36

Very good	40	58
Missing values	1	1
Safety performance in the previous year		
Neither poor nor good	7	10
Good	18	26
Very good	42	61
Missing values	2	3
Police-attended crash involvement in the current year		
Yes	23	33
No	45	65
Missing values	1	2
Police-attended at-fault crash involvement in the current year		
Yes	15	22
No	51	74
Missing values	3	4
Police-attended crash involvement in the previous year		
Yes	26	38
No	41	59
Missing values	2	3
Police-attended at-fault crash involvement in the previous year		
Yes	14	20
No	52	75
Missing values	3	5
Safety performance viewed by company decision makers in the current year		
Neither poor nor good	5	7
Good	24	35
Very good	39	57
Missing values	1	1
Safety performance viewed by company decision makers in the previous year		
Neither poor nor good	7	10
Good	24	35
Very good	37	54
Missing values	1	1
Crash-related insurance costs in the current year		
Very low	20	29
Low	12	18
Neither low nor high	16	23
Very high	18	26
Missing values	3	4
Crash-related insurance costs in		

the current year		
Very low	20	29
Low	13	20
Neither low nor high	15	22
Very high	17	25
Missing values	3	4
Driver employment type		
Use of drivers		
Short-distance trips only	0	0
Long-distance trips only	2	3
Both types of trips	65	94
Missing values	2	3
Short-distance trips		
Employee drivers only	33	48
Outsourcing only	3	4
Employee drivers and outsourcing	26	38
Not applicable	7	10
Long-distance trips		
Employee drivers only	26	38
Outsourcing only	4	6
Employee drivers and outsourcing	37	53
Not applicable	2	3
Driver payment policy		
Short-distance trips		
Time-based rate	32	47
Performance-based rate	5	7
Mixed rate	25	36
Not applicable	7	10
Long-distance trips		
Time-based rate	20	29
Performance-based rate	13	19
Mixed rate	34	49
Not applicable	2	3
Best payment method for safety		
Hourly rate	23	33
Performance-based rate	19	27
Mixed rate	27	39
Payment for non-driving tasks-short-distance trips		
All types of drivers	5	7
Some	57	83
None	7	10
Payment for non-driving tasks-long-distance trips		
All types of driver	5	7
Some	62	90
None	2	3

Vehicle characteristics		
Truck type		
Rigid truck	3	5
Semitrailer	10	14
Road trains	9	13
B-doubles	47	68
Number of trucks		
10 or fewer	30	43
Between 11 and 50	20	29
More than 50	19	28
Average age of vehicle fleet		
Less than 10 years	50	28
10 years or more	19	72
Average age of vehicles at purchase		
New	44	64
Not new	16	23
No purchase	9	13
Schedule vehicles for maintenance or inspection		
Yes	67	97
No	2	3
Frequency of vehicle maintenance or inspection		
On distance driven basis	40	58
On time basis	27	39
No schedule for maintenance	2	3
Technology adoption		
Percentage of vehicles equipped with ABS brakes		
All vehicles	39	57
Some	18	26
None	12	17
Percentage of vehicles equipped with cruise controls or similar		
All vehicles	28	40
Some	26	38
None	15	22
Percentage of vehicles equipped with fatigue management devices		
All vehicles	13	19
Some	7	10
None	49	71
Percentage of vehicles equipped with emergency brake assists		
All vehicles	12	18
Some	21	30
None	36	52
Percentage of vehicles equipped		

with forwarding collision avoidance systems		
All vehicles	4	6
Some	14	20
None	51	74
Percentage of vehicles equipped with electronic stability control systems		
All vehicles	13	19
Some	23	33
None	33	48
Percentage of vehicles equipped with lane departure warning and prevention systems		
All vehicles	5	7
Some	15	21
None	49	71
Percentage of vehicles equipped with an automatic transmission system		
All vehicles	11	16
Some	27	39
None	31	45
Percentage of vehicles equipped with an audible reversing device		
All vehicles	37	54
Some	12	17
None	20	29
CoR legislation and associated policies		
Awareness of CoR legislation		
Have not heard about it	1	1
Have heard something about it	4	6
Very familiar	64	93
Change in drivers use due to the CoR legislation		
Yes	14	20
No	55	80
Change in drivers payment policy due to CoR legislation		
Yes	6	9
No	63	91
Awareness of driver fatigue		
Yes	57	84
No	11	16
Skill levels of drivers		
Neither poor nor good	5	7
Good	29	42
Very good	35	51

Load type		
General or mixed freight	39	57
Livestock or refrigerated or dangerous goods	9	13
Other types of freight	21	30
Other characteristics		
Participant profile		
Owner director	28	40
General manager	24	35
Office staff or other	17	25
Operating area		
Regional or State wide	12	17
Interstate	15	22
Other	42	61
Major change in the past 5 years		
Yes	17	25
No	52	75

APPENDIX E: DIMENSIONALITY AND DECOMPOSITION OF INERTIA

Table E.1: Dimensionality between financial performance and safety performance

Dimension	Eigenvalue	Inertia	Chi2	Percent of inertia explained	Cumulative percent of inertia
1	0.128	0.016	1.06	59.83	59.83
2	0.105	0.011	0.71	40.17	100.00
Total	-	0.027	1.77	100.00	-

Table E.2: Decomposition of the inertia between financial performance and safety performance

Variable	Mass	Inertia	Dimension 1		Dimension 2	
			X	Contribution	Y	Contribution
FP12						
Poor	0.108	0.365	-0.281	0.066	0.887	0.810
Neither poor nor good	0.277	0.300	-0.419	0.381	-0.261	0.180
Good	0.446	0.313	0.386	0.521	-0.029	0.004
Very good	0.169	0.021	-0.154	0.031	-0.060	0.006
SP24						
Neither poor nor good	0.108	0.458	0.774	0.505	0.613	0.387
Good	0.277	0.323	0.278	0.168	-0.458	0.555
Very good	0.615	0.219	-0.260	0.327	0.099	0.057

Table E.3: Dimensionality between financial performance and employment type for long-distance trip drivers

Dimension	Eigenvalue	Inertia	Chi2	Percent of inertia explained	Cumulative percent of inertia
1	0.345	0.119	7.96	76.61	76.61
2	0.190	0.036	2.42	23.34	99.95
3	0.008	0.00007	0.00	0.05	100.00
Total	-	0.155	10.39	100	-

Table E.4: Decomposition of the inertia between financial performance and employment type for long-distance trip drivers

Variable	Mass	Inertia	Dimension 1		Dimension 2	
			X	Contribution	Y	Contribution
FP12						
Poor	0.104	0.395	-1.286	0.502	0.287	0.045
Neither poor nor good	0.269	0.171	-0.002	0.000	-0.719	0.731
Good	0.448	0.305	0.517	0.347	0.267	0.168
Very good	0.179	0.129	-0.539	0.151	0.245	0.056
emplld						
Employee driver only	0.358	0.089	0.240	0.060	0.312	0.183
Outsourcing only	0.060	0.338	-1.327	0.305	-1.192	0.446
Employee driver and outsourcing	0.552	0.036	0.131	0.028	-0.149	0.064
Not applicable	0.030	0.537	-2.648	0.608	1.397	0.306

Table E.5: Dimensionality between financial performance and payment method for short-distance trips drivers

Dimension	Eigenvalue	Inertia	Chi2	Percent of inertia explained	Cumulative percent of inertia
1	0.430	0.185	12.39	59.07	59.07
2	0.355	0.126	8.46	40.32	99.39
3	0.043	0.002	0.13	0.61	100
Total	-	0.313	20.97	100	-

Table E.6: Decomposition of the inertia between financial performance and payment method for short-distance trips drivers

Variable	Mass	Inertia	Dimension 1		Dimension 2	
			X	Contribution	Y	Contribution
FP12						
Poor	0.104	0.489	1.756	0.749	-0.621	0.113
Neither poor nor good	0.269	0.281	-0.496	0.154	-0.789	0.470
Good	0.448	0.086	-0.235	0.058	0.314	0.124
Very good	0.179	0.144	0.307	0.039	0.761	0.292
payrsd						
Time-based rate	0.463	0.094	0.238	0.061	0.327	0.140
Performance-based rate	0.075	0.166	-0.042	0.000	1.387	0.404
Mixed rate	0.358	0.332	-0.720	0.432	-0.434	0.190
Not applicable	0.104	0.408	1.445	0.507	-0.951	0.266

Table E.7: Dimensionality between financial performance and payment method for long-distance trips drivers

Dimension	Eigenvalue	Inertia	Chi2	Percent of inertia explained	Cumulative percent of inertia
1	0.309	0.095	6.38	70.94	70.94
2	0.187	0.035	2.34	26.02	96.95
3	0.064	0.004	0.27	3.05	100.00
Total	-	0.134	8.99	100.00	-

Table E.8: Decomposition of the inertia between financial performance and payment method for long-distance trips drivers

Variable	Mass	Inertia	Dimension 1		Dimension 2	
			X	Contribution	Y	Contribution
FP12						
Poor	0.104	0.515	1.400	0.663	0.537	0.161
Neither poor nor good	0.269	0.139	-0.292	0.074	0.449	0.290
Good	0.448	0.126	-0.325	0.153	-0.098	0.023
Very good	0.179	0.220	0.434	0.109	-0.741	0.526
payrld						
Time-based rate	0.299	0.058	0.181	0.032	0.200	0.064
Performance-based rate	0.164	0.248	-0.363	0.070	-0.931	0.762
Mixed rate	0.507	0.074	-0.164	0.044	0.216	0.126
Not applicable	0.030	0.620	2.971	0.854	-0.545	0.047

Table E.9: Dimensionality between financial performance and the skill level of drivers

Dimension	Eigenvalue	Inertia	Chi2	Percent of inertia explained	Cumulative percent of inertia
1	0.165	0.027	1.82	77.16	77.16
2	0.090	0.008	0.54	22.84	100.00
Total	-	0.035	2.36	100.00	-

Table E.10: Decomposition of the inertia between financial performance and the skill level of drivers

Variable	Mass	Inertia	Dimension 1		Dimension 2	
			X	Contribution	Y	Contribution
FP12						
Poor	0.104	0.334	0.612	0.238	0.751	0.658
Neither poor nor good	0.269	0.209	0.353	0.203	-0.276	0.228
Good	0.448	0.019	-0.071	0.014	-0.088	0.038
Very good	0.179	0.438	-0.708	0.545	0.195	0.076
driverqual						
Neither poor nor good	0.075	0.713	1.427	0.923	0.054	0.002
Good	0.418	0.144	-0.091	0.021	-0.347	0.561
Very good	0.507	0.143	-0.135	0.056	0.278	0.437

Table E.11: Dimensionality between financial performance and load type

Dimension	Eigenvalue	Inertia	Chi2	Percent of inertia explained	Cumulative percent of inertia
1	0.242	0.058	3.92	75.00	75.00
2	0.140	0.019	1.31	25.00	100.00
Total	-	0.077	5.22	100.00	-

Table E.12: Decomposition of the inertia between financial performance and load type

Variable	Mass	Inertia	Dimension 1		Dimension 2	
			X	Contribution	Y	Contribution
FP12						
Poor	0.104	0.530	1.192	0.614	0.611	0.279
Neither poor nor good	0.269	0.222	0.301	0.100	-0.552	0.586
Good	0.448	0.216	-0.363	0.244	0.204	0.133
Very good	0.179	0.032	-0.239	0.042	-0.037	0.002
Load						
General or mixed freight	0.552	0.265	0.367	0.307	0.189	0.141
Livestock, dangerous or refrigerated goods	0.134	0.541	-1.082	0.650	0.473	0.216
Other goods	0.313	0.193	-0.182	0.043	-0.535	0.644

Table E.13: Dimensionality between financial performance and vehicles average age at purchase

Dimension	Eigenvalue	Inertia	Chi2	Percent of inertia explained	Cumulative percent of inertia
1	0.374	0.139	9.35	83.91	83.91
2	0.164	0.026	1.79	16.09	100.00
Total	-	0.165	11.14	100.00	-

Table E.14: Decomposition of the inertia between financial performance and vehicles average age at purchase

Variable	Mass	Inertia	Dimension 1		Dimension 2	
			X	Contribution	Y	Contribution
FP12						
Poor	0.104	0.527	-1.445	0.584	-0.602	0.232
Neither poor nor good	0.269	0.017	0.102	0.007	-0.205	0.069
Good	0.448	0.236	0.483	0.280 |	-0.054	0.008
Very good	0.179	0.219	-0.518	0.129	0.794	0.691
Agepurchase						
New	0.627	0.143	0.270	0.122	0.256	0.251
Not new	0.239	0.134	0.162	0.017	-0.714	0.744
No purchase	0.134	0.723	-1.547	0.861	0.076	0.005

Table E.15: Dimensionality between financial performance and technology adoption

Dimension	Eigenvalue	Inertia	Chi2	Percent of inertia explained	Cumulative percent of inertia
1	0.385	0.149	9.96	95.84	95.84
2	0.080	0.006	0.43	4.16	100.00
Total	-	0.155	10.39	100.00	-

Table E.16: Decomposition of the inertia between financial performance and technology adoption

Variable	Mass	Inertia	Dimension 1		Dimension 2	
			X	Contribution	Y	Contribution
FP12						
Poor	0.104	0.518	1.407	0.536	-0.260	0.088
Neither poor nor good	0.269	0.138	0.452	0.143	0.106	0.037
Good	0.448	0.292	-0.503	0.294	-0.214	0.255
Very good	0.179	0.052	-0.241	0.027	0.527	0.620
Techindex						
Low	0.313	0.654	0.916	0.682	0.035	0.005
Medium	0.478	0.262	-0.460	0.262	0.209	0.261
High	0.209	0.085	-0.323	0.057	-0.531	0.734

Table E.17: Dimensionality between financial performance and awareness of CoR legislation

Dimension	Eigenvalue	Inertia	Chi2	Percent of inertia explained	Cumulative percent of inertia
1	0.203	0.041	2.77	62.67	62.67
2	0.157	0.024	1.65	37.33	100.00
Total	-	0.065	4.41	100.00	-

Table E.18: Decomposition of the inertia between financial performance and awareness of CoR legislation

Variable	Mass	Inertia	Dimension 1		Dimension 2	
			X	Contribution	Y	Contribution
FP12						
Poor	0.104	0.215	-0.313	0.050	0.860	0.492
Neither poor nor good	0.269	0.458	0.743	0.730	0.026	0.001
Good	0.448	0.107	-0.276	0.167	0.048	0.007
Very good	0.179	0.219	-0.243	0.052	-0.662	0.500
Corawar						
Have not heard about it	0.015	0.617	3.657	0.982	0.169	0.003
Have heard about it	0.060	0.353	-0.149	0.007	1.566	0.934
Very familiar	0.925	0.031	-0.049	0.011	-0.104	0.064