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Eco driving as a road safety measure: Before and after study of three companies

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ABSTRACT

This study reports the results of a natural before and after study of economic driving and use of fleet management system recording driving style as a road safety measure. The study includes three companies studied on three occasions, in: 1) 2013, 2) 2018 and 3) 2020. Surveys in all the companies were conducted in 2013 and 2018, and interviews were conducted at all three time points. Two of the companies (Company B and C) started working actively with fleet management system as a measure for economic driving between measurement time points 1 and 2. The third company had such a measure in place before time point 1 (Company A). Company A is therefore used as a “control company”. The study indicates that measures for economic driving in general and fleet management systems in particular have a good effect on road safety and economy. This applies to fleet management systems focusing on aspects of economic and safe driving. The accident risk in Company B and C decreased significantly in the post-measurement in 2018, and the safety culture improved. The interview data supports the conclusion of lower accident risk. The discussion indicates that these results cannot be explained by referring to other safety measures during the period, changes in framework conditions, demographic changes in the samples, or a decrease in the risk of property damage accidents with heavy goods vehicles during the study period. However, it is concluded that implementing safety management systems have better effect on road safety than fleet management systems, because Company A, which has the former, has a higher level of road safety than the other two companies.

1. Introduction

1.1. Background

Truck transport is the dominant means of goods transport in Norway (Hovi, Caspersen and Wangsness 2014) and worldwide (Rodrigue 2020). However, truck transport has several negative effects in our society. Accidents with heavy goods vehicles (HGVs) represent an important societal challenge. These are generally serious accidents with high proportions of killed and severely injured people, because of the weight of the heavy vehicles. In the EU, about 4000 people were killed in road accidents involving HGVs in 2016, making up about 16 % of all road fatalities (ERSO, 2018). In the US, 4761 people were killed in accidents involving large trucks in 2017, and 72 % of these were other road users (NHTSA, 2019). In Norway, 20 % of the people who were severely injured or killed in traffic in the period 2007–2016 could be attributed to accidents involving HGVs (Nævestad et al 2022). Most of the people who were severely injured or killed were other road users.

Nævestad et al. (2022) estimates that up to 48 % of deaths/serious injuries in accidents involving heavy goods vehicles can be avoided if more companies introduce safety management measures. This corresponds to an average of 66 people killed and seriously injured on average per year in the period 2007–2016. Despite the potential, existing research shows that Norwegian transport companies have only to a limited extent introduced measures to increase road safety (Nævestad et al 2015). This is probably related to the size of the companies and the fact that the results of the measures, for example for safety and economy, are not well known (Nævestad,

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Blom et al. 2020).

Previous studies of economic driving, fleet management systems and energy management systems in goods transport companies on roads find that such measures have an effect on both fuel consumption/economy and road safety (Nævestad, Milch og et al. 2020, Nævestad and Milch 2020). In a study of 14 goods transport companies that have introduced measures aimed at economic driving and energy management over a one-year period, Nævestad and Milch (2020) find that the companies that implemented most measures have the greatest reduction (10 %) in fuel consumption. They also found that the same companies have a 33 % lower accident risk in regional and long-haul transport than a Reference sample of drivers from supposed average companies. Although there are few studies of this, these suggested relationships also find support in previous studies from other countries. Studies of economic driving and fleet management use with heavy vehicles often find reductions in fuel consumptions between 5-10% (Nævestad et al 2020a). Although there are relatively few studies which also examine reductions in accident risk, Toledo and Shiftan (2016) find that fleet management systems with feedback to drivers lead to a 3–10 % reduction in fuel consumption and an 8 % reduction in safety–critical incidents. In addition, there are studies that find up to a 35–40 % reduction in accidents due to economic driving (Haworth and Symmons 2001). In contrast, Af Wåhlberg (2007) find a 2% reduction in fuel consumption and no effect on accident risk, concluding, however, that with such a low effect on fuel consumption of the studied intervention, it would be difficult to see effects on accident risk.

The highest effects of fleet management system use and economic driving on accident risk are comparable to, or better than those seen for several organisational road safety measures (Nævestad et al. 2022). It can therefore be asked whether economic driving (and use of fleet management system) is also an effective road safety measure. In addition, it may be asked whether economic driving can be more efficient than traditional road safety measures in truck transport, because it has clear economic advantages, which probably means that it is easier to motivate transport companies to implement it.

There are several reasons to assume a relationship between economic driving and road safety. Economic driving is often defensive, predictive and slow driving, which is often related to increased road safety (Dekhordi et al. 2019). Economic driving, for example, involves drivers maintaining smooth acceleration/deceleration, smooth and low speed and "flow", reaching maximum possible rollout (i.e. rolling without touching the gas pedal), avoiding hard braking, driving at the highest possible gear, anticipating pending traffic conditions and avoiding idling (cf. Huang et al. 2018; Dekhordi et al. 2019).

However, the knowledge we have about the road safety effects of company-level economic driving and organised use of fleet management systems is associated with some uncertainty, due to methodological weaknesses in the existing studies of this. The most important methodological challenge is related to the design of the studies. Most of the studies are cross-sectional studies, which mainly use data from one measurement time point, or from short experiment periods (Af Wåhlberg 2007; Symmons et al. 2008; Toledo & Shiftan 2016; Nævestad and Milch 2020). None of the studies are systematic before and after studies of companies, with experimental and control groups. They also do not control for corporate safety measures during the experiment periods, before and after measures for economic driving have been implemented.

The ideal research design in such evaluations is to do before and after measurements with experiment groups and control groups. With such a design, one can first control for general development over time, for example, improved road safety, which applies to all transport companies. In addition, it provides better control over causality. Nævestad and Milch (2020), for example, find that companies that have in place many measures for economic driving also have many measures for road safety, but they cannot conclude which comes first, or which, if either, is the reason for the other. With before and after measurements, one can control for the companies' work on road safety before introducing measures for economic driving. This makes it easier to identify the isolated effect of economic driving on road safety. Additionally, with such a design, one can measure and control for other key factors influencing road safety among occupational drivers, e.g. driver demographics (e.g. gender, age), drivers' perceived level of time pressure and stress, working hours, fatigue and other work related variables, as these are key variable influencing the accident risk of professional drivers (Davey et al. 2006; Öz et al. 2013; Nævestad et al 2015; Useche et al 2019; Llamazares et al 2021).

1.2. *The aims of the study*

The main objective of the study is to study the effects of economic driving in general and the implementation of fleet management systems specifically on road safety and fuel consumption in three goods transport companies over a period of four years. The study has four aims:

1) Which measures have the companies introduced for economic driving and fleet management system use in the period 2013–2018?
2) What are the effects on fuel consumption during the period?
3) What are the effects on road safety, measured as accident risk and safety culture during the period?
4) How can we explain any observed effects on road safety during the period?

1.3. *Previous research*

1.3.1. *Measures for economic driving*

This section presents previous research relevant to the first aim. This study refers to economic driving at both the driver and company level. At the company level, economic driving is about implementing organisational measures to facilitate economic driving at the driver level. The study focuses on five such measures.

The use of fleet management technology, also referred to as "in vehicle data recorder" (IVDR), is the most basic element of companies' work on economic driving (Diaz-Ramirez, 2015; Ayyildiz et al., 2017; Sanguinetti et al. 2020). This is a system mounted in the vehicles, which records a number of aspects of the drivers' driving style. The systems used in HGVs measure a number of characteristics of driving style, which are combined into five or six main aspects, for which the fleet management systems provide feedback (e.g. idling, anticipatory driving, braking, roll-out, cruise control use and speed) (Nævestad, Blom et al. 2020, Walnum and Simonsen 2015). The system gives scores for the various main aspects, and the scores for the main aspects are combined into a general score that the drivers get based on their driving (for example: E-A, 1–100). The composition of the scores is based on algorithms, which weight different aspects. First, these aspects measure an economic driving style. A fleet management system expert interviewed in Nævestad and Hagman (2020) said that the vehicle supplier states that an improvement from mark E to A on average involves an 11 % reduction in fuel consumption. Second, the fleet management system also measures a safe driving style. Experts interviewed by Nævestad and Hagman (2020) mentioned that indicators of safe driving (speed, anticipatory driving) count the most when the algorithms in the fleet management systems weigh different driving style aspects to calculate driver marks/scores. Drivers can see their own scores after each trip (or day, week, etc.) on display in the vehicles, or on mobile phone applications. Managers in transport companies can see all the drivers/vehicles' scores, and often make compilations of these, which are more or less regularly distributed to the drivers. The algorithm calculations of the drivers' scores in the system are based on a number of different limit values (for example for the number of hard decelerations, proportion of time at idle, proportion of time using cruise control). How drivers score on these parameters will also depend on the type of driving they have, where and when they drive, etc. This can make it complicated to compare drivers' scores in the system (Liimatainen 2011). However, there are settings for this in the system, for example for long-distance transport and distribution driving. Another measure of company-level economic driving is individual feedback to drivers from the systems. Individual feedback to drivers about their scores in the fleet management system is fundamental, because it is a prerequisite for drivers to learn from the feedback and change their driving style (Ayyildiz et al., 2017). A third measure is training in economic driving. Most studies of economic driving with heavy vehicles include some form of training of drivers in economic driving style (Strömberg and Karlsson 2013, Symmons et al. 2008). A fourth measure is formal or informal competitions between drivers in having as economical a driving style as possible. Various incentives (competitions and bonuses) to change driving style and achieve high scores seem to be important measures (Diaz-Ramirez, 2015; Ayyildiz et al., 2017). Drivers' motivation is a fundamental factor for economic driving. Informal competitions, whether against oneself and one's own previous scores or others' scores, therefore seem to be an important motivating force. A fifth measure that is implemented to increase driver motivation is bonuses associated with having as economical a driving style as possible (Diaz-Ramirez, 2015; Ayyildiz et al., 2017; Liimatainen 2011).

1.3.2. *Effects on fuel consumption*

This section presents previous research relevant to the second aim of the study. Despite the potential for fuel reductions related to economic driving in truck transport, the author is only aware of four studies examining the effects of economic driving on fuel consumption in goods transport on roads. These find reductions in fuel consumption of 6.8 % (Díaz-Ramirez et al., 2017), 5.5 % Ayyildiz et al. (2017), between 3 % and 11 % (Nævestad, Milch og et al. 2020) and 27 % (Symmons et al. 2008). There are also several studies that focus on bus transport. These studies are relevant, because busses are heavy vehicles. The studies from bus transport find reductions in fuel consumption of 11.6 % and 16.9 % (immediately and after six months) (Sullman et al., 2015), 4.8 % (Rolim et al. 2014), 6.8 % (Strömberg and Karlsson 2013), 4.4 % (Zarkadoula et al. 2007), between 1% and 6% (Duarte et al., 2013) and 2 % (Af Wåhlberg 2007).

Against this background, it can be concluded that studies examining the effects on fuel consumption with heavy vehicles generally find reductions between 5 % and 10 %. In a recent meta study, Sanguinetti et al. (2020) find a weighted average effect of a 6.6 % reduction in fuel related to the introduction of fleet management systems for passenger cars.

1.3.3. *Effects on road safety*

This section presents previous research relevant to the third aim. There are few studies examining the road safety effects of economic driving and fleet management systems, especially with heavy goods vehicles, and it is therefore also relevant to include studies of passenger cars. To the knowledge of the author, there are five studies that contain separate empirical investigations of the relationship between economic driving and road safety (Af Wåhlberg 2007; Symmons et al. 2008; Jamson et al. 2015; Toledo and Shiftan 2016; Nævestad and Milch 2020). The first study finds no effects on road safety, due to the low effect of the studied measure of economic driving: only 2 % fuel reduction. A similar effect on accidents would be too small to identify. The second study measures road safety as the fact that drivers look far ahead (as measured by passengers observing this) and finds no effects (Symmons et al. 2008). The third study does not focus on road safety effects (Jamson et al. 2015), but on what type of feedback has the greatest effect, and whether the test subjects focus on economy or safety when they have to choose. The fourth study finds effects on both road safety and fuel consumption. The study concludes that feedback from fleet management systems can lead to a reduction of between 3 and 10 % in fuel consumption and an 8 % reduction in safety incidents (Toledo and Shiftan 2016). This is a study involving 150 private cars used by over 350 drivers over a year. The fifth study, which includes 14 goods transport companies, finds that the companies that have implemented the most measures for economic driving and energy management have had the greatest reduction (10 %) in fuel consumption and a 33 % lower risk of accidents with property damage in regional and long-haul transport than a Reference Sample of drivers from presumed average companies (and no difference in the risk of distribution transport) (Nævestad and Milch 2020). This study finds a correlation between drivers' scores in the fleet management system and their accident risk. The drivers' scores in the fleet management system were related to their active use of the fleet management system (checking scores, changing driving style to improve scores, etc.), which in turn was related to the companies' facilitation of economic driving.

An important underlying hypothesis in all the evaluated studies seems to be that a defensive, slow driving style, focusing on smooth acceleration/deceleration, avoiding hard braking, driving at the highest possible gears and anticipating the pending traffic conditions, is both economical and road-safe (Toledo & Shiftan 2016; Huang et al. 2018). Driving style is the most important mechanism mediating the relationship between economic driving and road safety in the majority of the studies evaluated.

1.3.4. Control variables

This section presents previous research relevant to the fourth aim of the study.

1.3.4.1. Factors influencing accident risk in goods transport. Accident risk is the first measure of road safety in the study. When looking at developments in road safety over time in goods transport companies, it is also important to control for “other” factors that influence accident risk in goods transport. The first factors that influence accident risk in goods transport are demographic variables. Nationality affects accident risk for professional drivers of heavy vehicles (Nævestad and Hovi 2020). Age is also an important variable that affects drivers’ accident risk: younger and older drivers often have a higher risk (Bjørnskau, 2015; Charbotel et al., 2010). Sex also affects accident risk: male drivers have a higher risk of getting involved in accidents involving passenger cars than female drivers (Bjørnskau, 2015). Most drivers of heavy goods vehicles are men.

The second factor affecting accident risk in goods transport is exposure, measured as number of kilometres driven each year (Elvik et al. 2009). The third factor affecting accident risk in goods transport is the (sub)sector. Trucks transporting dangerous goods have a 75 % lower accident risk than other trucks (Elvik et al. 2009), presumably because the sector’s focus on safety is higher, which is reflected in rules/enforcement, training and transport buyers’ focus on safety. The fourth factor that can affect the accident risk of professional drivers is experiences of time pressure and stress (Davey et al. 2006; Öz et al. 2013). The fifth factor is the safety behaviour of drivers, for example, excessively high speed (Mitchell and Driscoll, 2004; Nævestad et al. 2015) and aggressive driving (Warner et al. 2011). The sixth factor is organisational safety culture. Goods transport companies with a good safety culture have a lower accident risk than companies that score lower on safety culture (Nævestad, Blom et al. 2020).

The seventh factor is the general reduction of accident risk in society. The risk of personal injury accidents with HGVs have been reduced in recent years, but this has not happened with property damage accidents (Nævestad et al 2022). The eighth factor affecting accident risk in goods transport is organisational safety management. Nævestad, Blom et al. (2020) describe trucking companies’ safety measures according to the Safety Ladder for Safety Management in goods transport, and find that the accident risk decreases for the companies at each level of the ladder.

1.3.4.2. Factors influencing safety culture. Safety culture is the second measure of road safety in the study, and it is important to control for “other” factors that influence safety culture when comparing developments from 2013 to 2018. Safety culture is often referred to as safety-relevant aspects of culture in organisations (Hale, 2000). The first factor affecting safety culture in transport companies is management’s focus on safety in the organisation (Flin et al., 2000). The second factor affecting safety culture in transport companies is formal safety measures, or safety management systems (SMS) (cf. Naveh and Katz-Navon, 2015; Murray et al., 2009: 2012; Wallington et al 2014). SMS are formally required as a measure to facilitate good safety culture in other transport sectors. SMS refers to the formal aspects of safety management (“how things should be done”) as described in procedures, routines and organisational charts, etc. Safety culture refers to the informal aspects of safety management (“how things are actually done”) (Antonsen, 2009). The Safety ladder for safety management in goods transport is a method for classification of the extent of SMS implementation in transport companies, and a recent study indicates improvements in safety culture scores with increasing SMS implementation (Nævestad, Milch og et al. 2020, Nævestad, Blom et al. 2020). The Safety ladder for goods transport describes an approach with an increasing prevalence of, and focus on structural safety measures in road goods transport companies. The first level focuses on managers’ safety commitment, the second on driving style and seat belt use, the third on work related factors influencing road safety (e.g. fatigue, stress) and the fourth level focuses on SMS measures (e.g. risk analyses, measures for reporting incidents and organisational learning).

The third factor affecting safety culture in transport companies is safety framework conditions such as rules/enforcement, competition and regulation, which vary considerably from one sector to another (Bjørnskau and Longva, 2009). The fourth factor affecting safety culture in transport companies is demographic factors (Guldenmund et al., 2013).

2. Method

2.1. Design of the study

The study is based on two quantitative (2013, 2018) and three qualitative (2013, 2018, 2020) data collections. The first data collection was in 2013, and involved a quantitative and qualitative mapping of safety culture and safety management in three goods transport companies that were selected on the basis of an assumption that they have good safety cultures (Nævestad and Bjørnskau 2014). The first aim of the 2013 study was to identify common characteristics describing how trucking companies with good safety cultures work on safety. The second aim was to test a scale for measuring safety culture in trucking companies (i.e. the GAIN-scale for organisational safety culture) (GAIN, 2001).

The second data collection was in 2018, when the three companies were included in a study of safety management and risk in goods transport companies, together with 14 other companies (Nævestad, Blom et al. 2020). The 2018 study had four aims: 1) To map the safety structure in companies at different levels of the Safety ladder, 2) Examine whether safety culture is improved with increased structural measures for companies at different levels of the Safety Ladder, 3) Examine whether the accident risk decreases at each Safety ladder level, and 4) Discuss practical implications.

2.2. Surveys

2.2.1. Recruitment of respondents

The three companies in the 2013 study were recruited by the employer organization NHO-Transport, which provided us with contact persons in each company. In two of the three companies in the 2013 study, the respondents were recruited by the contact persons in each company giving us the e-mail addresses of the drivers. Questionnaires were then distributed through emails to all drivers in each company. Two reminders were sent by e-mail to the respondents at 14-day intervals, and the contact persons in the companies were also asked to remind drivers of the survey. In the third company (Company C), the contact person did not have the e-mail addresses of the drivers, so paper forms were sent to the company and distributed among the drivers, together with cover letters and pre-stamped return envelopes. It was assumed that it would involve some more effort from the respondents to fill in and return the questionnaire on paper, so here drivers who answered were allowed to participate in a lottery where the winner received a gift card of 1000 NOK. Respondents were informed about this in the information letter.

The companies in the 2018 data collection and study were selected with the assistance of contact person in the Norwegian Hauliers' Association (NLF: "Norges Lastebileier-Forbund"). The survey consisted of four different groups: 1) Reference group, 2) Companies at Level 2 in the Safety ladder, 3) Companies at Level 3 in the Safety ladder and 4) Companies at Level 4 in the Safety ladder. The data collection period lasted for a period of about six months. To get the highest response rate possible, both individual gift card draws (NOK 3000) and collective company rewards for companies with high response rates (NOK 2000) were used. To include drivers who either were unable or unwilling to answer the survey through the web-based scheme, we also offered drivers to answer the survey through paper-based schemes and per telephone interviews. The 2018 data collection and study involved Company A, B and C and 14 other companies.

2.2.2. Response rate

In Table 1 the response rate in the three companies in 2013 and 2018 is shown. There are about four and a half years between the two surveys. The first was conducted in the last quarter of 2013, while the second survey was conducted around March 2018. The surveys were sent out to the drivers of the companies.

2.2.3. Topics in the survey

The surveys in 2013 and 2018 contain six common topics. The reports of Cronbach's Alpha values for the indexes, refer to the values from the 2018 survey. All questions reported here are in both surveys. If some questions only were present in one of the surveys, this is made explicit.

(1) **Background questions**: sex, age, experience, seniority in the company, number of 1000 km of heavy vehicle driving during the last two years, employment status (permanent, part-time, independent, temporary agency), what kind of transport drivers work with the most, driver nationality.

(2) **Organisational safety culture**: The adapted version of the GAIN index for safety culture, consists of 23 questions from the Operator's Safety Handbook *(GAIN, 2001). The GAIN index is largely influenced by the key elements of Reason's (1997) definition of good safety culture. The 23 questions comprise the following five themes:

A. **Management's attitude to and focus on safety.** The theme is comprised of 7 questions (Cronbach's Alpha: 0.897), e.g. "Management is aware of the most important safety challenges in the company", "Management often discusses safety issues with the drivers", "Management stops dangerous work assignments and activities".

B. Employee **attitude to and focus on safety.** The theme is comprised of 3 questions (Cronbach's Alpha: 0.620), e.g. "Drivers encourage each other to drive in a safe way".

C. **Reporting culture and reactions to incident reporting.** The theme is comprised of 5 questions (Cronbach's Alpha: 0.833), e.g. "After an incident or accident has happened, precautions are taken to prevent it from happening again, "All safety problems and deficiencies that are reported are corrected in a short time".

D. **Training / training in safety thinking.** The theme is comprised of 4 questions (Cronbach's Alpha: 0.844), e.g. "Drivers in my company receive adequate training to drive safely".

E. **General safety** issues **in the organization in question.** The theme is comprised of 4 questions (Cronbach's Alpha: 0.677), e.g. "Vehicle safety checks are carried out regularly", "The safety of this company is generally well taken care of".

The GAIN index is constructed by summing the scores on the 23 questions, which show the respondents' in the companies mean

Table 1
Response rate in the three companies in 2013 and 2018.

	2013		2018	
	Number	**Percent**	**Number**	**Percent**
Company A	122	58 %	81	40 %
Company B	26	36 %	28	20 %
Company C	62	40 %	33	30 %
Total	210	48 %	142	31 %

scores on the GAIN questions. The minimum score is 23 (1×23) and the maximum score is 115 (5×23). The Cronbach's Alpha value of the index in the sample is 0.944. We piloted and changed the wording of some of the questions in the GAIN index in a previous study (Nævestad and Bjørnskau 2014), to make it more relevant and meaningful for drivers in goods transport. The index originally includes 25 questions.

(3) **Proxy for companies' use of fleet management system:** The survey includes one question that is used as a proxy for companies' use of fleet management system: "Management detects any drivers who are not driving in a safe way". This question was used both in the 2013 and the 2018 survey, as it originally was part of the GAIN-index for safety culture. In the present study, this question is used as a proxy for companies' use of fleet management system, as it focuses on an important consequence of managers' use of fleet management system: overview of the driving styles of all the drivers. Based on this, it is reasonable to hypothesize no change in Company A on this question from the first (2013) to the second (2018) data collection, as this company already had a fleet management system in the first data collection. Contrary to this, increased scores on this question can be expected in Company B and C, as these companies implemented fleet management systems after the first measurements. The main advantage with this proxy is that it was used in both the 2013 and the 2018 survey.

(4) **Work-related conditions and framework conditions**: drivers' wages (fixed pay, fixed salary combined with bonus schemes, pay only per assignment and other), the extent to which they experience transport buyers pressing and stressing drivers and transport buyers' focus on road safety, e.g. "In my job, I experience that customers are pressing/stressing drivers". The 2018 survey also included a "Customer focus on safety" index, comprised of two items (Cronbach's Alpha: 0.774): "Safety is more important than deadlines for our customers", and "Safety is more important than price to our customers".

(5) **Safety behaviours.** The 2018 survey includes four questions about drivers' behavior in traffic: "I sometimes disregard the speed limit on a motorway", "I sometimes disregard the speed limit on a residential road", "I sometimes accept some risk because "the situation requires it" (e.g. due to time pressure, bad weather) and "I sometimes break the traffic rules to get ahead faster". A road safety behaviour index was made of these four questions (Cronbahch's Alpha: 0.752).

(6) **Accident involvement.** The surveys include questions about drivers' accident involvement in the last two years, while driving a heavy vehicle at work.

2.2.4. Multivariate analyses

Two regression analyzes have been conducted, to examine the factors influencing the two key measures of road safety in the study. These analyses focused on the data from the second measurement (2018), where we saw an improvement in the two indicators of road safety. First, a regression analysis was conducted to assess the variables explaining whether respondents have been involved in accidents over the past two years while driving a heavy vehicle. Logistic regression analysis was used, since the dependent variable is dichotomous (i.e. accident: 1 = no, 2 = yes). Second, a regression analysis was conducted to assess the conditions explaining variation in organizational safety culture. Linear regression was used, since the dependent variable is continuous. The regression analyzes show the effects of the independent variables that are included, controlled for the other variables in the analyses.

2.3. Qualitative interviews

A total of 15 interviews were conducted (see Table 2). Interviews with the managers were conducted in Company B and C in 2013, 2018 and 2020. Interviews with employee representatives were also conducted in companies B and C in 2013 and in 2018. Interviews with personnel in Company A was conducted in 2013 and in 2020. The author visited Company A in 2013 and had a comprehensive interview and tour with two managers. Qualitative interviews with a driver and another person in the company were also conducted in 2013. Finally, in 2020, a follow-up interview was conducted with a manager in Company A.

2.3.1. Topics in the interview guides

The interviews were conducted over the telephone (with one exception) and the length varied between 40 min and about two hours. The main purpose of the interviews in 2013 and 2018 was to get information about how companies work with organisational safety management and safety culture, including measures to influence drivers' driving style. In the interviews in 2018, interviewers systematically asked about the various management practices in the Safety Ladder for goods transport (Nævestad, Blom et al. 2020). The interviews in 2020 were also about the companies' measures aimed at economic driving in the period 2013–2019. Interviewers asked when the companies had introduced fleet management systems and the results of this work, in particular the number of traffic accidents in the company before and after the introduction of fleet management systems and conditions that may explain this. Interviewers also asked for safety measures during the period, to take this into account in the analyses of the effects of measures for

Table 2
Number of interviews in the three companies.

	2013	2018	2020	Total
Company A	4	0	1	5
Company B	2	2	1	5
Company C	2	2	1	5
Total	8	4	2	15

economic driving on road safety.

2.3.2. Analysis

The interview data was analysed to place the companies at a level on the Safety Ladder (Table 3) and a level on the Eco Ladder (Table 4). In these analyses criteria that were developed in Nævestad, Blom et al. (2020) and Nævestad et al. (2022) were used. The Safety Ladder and the Eco Ladder are based on systematic literature reviews, and have been validated in previous empirical studies (Nævestad, Blom et al. 2020, Nævestad et al 2022). The classifications of companies at each level in the Safety ladder and the Eco Ladder at each time period were done by two researchers independently, who discussed any disagreements, aiming to develop a common understanding of the classification and placing of each company.

If we divide the nine criteria in Table 4 by 4 to set a scale, we can assume that level 2 companies score between 2.25 and 4.5 points, companies at level 3 score between 4.5 and 6.75 points, while companies at level 4 score between 6.75 and 9 points.

The Eco ladder for energy management has three levels, but this study only operates with criteria for levels 2 and 3. If we divide 10 points into a scale of three levels, we can assume that level 2 companies score between 3.5 and 6.7 points, and that level 3 companies score between 7 and 10 points.

2.4. Calculation of risk of property damage accidents

The accident risk in the three companies is compared over time (2012–2013 vs 2016–2017) with the general accident risk of property damage with heavy goods vehicles during the study period. This is done on the basis of figures on kilometre driven with Norwegian heavy goods vehicles (based on Statistics Norway's Lorry Survey), which is presented in Nævestad and Hovi (2020). These exposure figures are combined with figures on property damage accidents that were obtained from the TRAST register of damages and estimated compensations, reported by insurance companies.

The insurance industry in Norway records all property damage in a register called TRAST.[1] These damage reports are based on damage reports filed with the companies. Property damage accidents includes all accidents where there has been damage to the motor vehicle.

3. Results

3.1. Description of the companies

Company A transports dangerous goods across Norway for large established customers, with whom it has long-term contracts. The company has about 200 drivers. The company is certified according to ISO:14001, ISO:9001. The company has departments both in Norway and in other countries. It was merged with a larger international company in the study period.

Company B has about 140 drivers in 2018. The company transports goods and distributes merchandise and foodstuffs. The company has had the same CEO throughout the period that is examined.

Company C has about 110 drivers. The company transports animals and tank transport as well as different types of cargo. The company participates in the Norwegian Truck Owners Association's "Fair transport" and KMV schemes. The company is also certified according to ISO:14001. The company got a new CEO in 2014.

3.2. Characteristics of the respondents

Table 5 shows background information about the respondents in the three companies.

First, Table 5 shows that the samples from each company consist mostly of men. Second, Table 5 shows that the samples in Company A and C have driven more km on average in 2018 than 2013. Third, it can be concluded that the samples from the companies in 2018 are generally somewhat younger than in 2013.

3.3. Company measures focusing on economic driving and fleet management use

This section presents the companies' implementation of measures focusing on economic driving and systematic fleet management use in the period 2013–2018. This section relates to the first aim of the study, which is to describe the measures that the companies have introduced for economic driving and fleet management system use in the period 2013–2018.

3.3.1. Company A

Managers and employees in Company A have had a strong focus on safe and economic driving style throughout the study period. Drivers are informed of the company's focus on this when they are hired and they must sign contracts where they commit to a certain driving style monthly. The company has also hired its own driving instructor and work in accordance with environmental standards, such as ISO:14001.

[1] This presentation is based on the description given in: https://www.finansnorge.no/statistikk/skadeforsikring/trast—trafikkskadestatistikk/.

Table 3
Criteria for classifying the companies' level on the Safety Ladder.

LEVEL 2	1	Speed, driving style and seat belt policy that is known by drivers
	2	Fleet management system in place and continuously follows up on drivers' speed and driving style.
	3	Drivers regularly receive feedback (weekly, monthly) on speed and driving style from the system.
LEVEL 3	1	Wage system set up with a view to minimising drivers' stress and fatigue.
	2	Drivers are encouraged to abort or postpone assignments if they believe they are not safe to carry out, and do in fact do so.
	3	When planning assignments, the fatigue and stress impacts that a new assignment will entail on drivers is mapped
LEVEL 4	1	The company has a functioning reporting system, which is used both by employees (reports) and managers.
	2	The company regularly conducts formal risk analyses for all its assignments
	3	The company has a good training programme, with predefined, theoretical and practical sequences of activities and a plan for knowledge goals and activities to achieve and assess the objectives.

Table 4
Criteria for classifying the companies' level on the Eco Ladder.

LEVEL 2	1	The company has a fleet management system on all vehicles and a system for analysing the data
	2	The company has routines for regular individual feedback to drivers (e.g. daily), about their economic driving style and consumption, based on data from the fleet management system
	3	The company has a system for training drivers in economic driving
	4	The company has routines/systems to motivate drivers to drive economically, through organised competitions between the drivers
	5	The company has routines/systems to motivate drivers to drive economically, through bonuses related to economic driving
LEVEL 3	1	The company has a policy of stated goals for reduced energy use in general and fuel consumption in particular (and the manager regularly informs drivers how they are doing in relation to the goal).
	2	Management has a good overview of all key figures, such as diesel consumption, energy use, costs, development and scores in the fleet management system, and investigates the effects of measures taken.
	3	The company has a systematic (analytical/mapping) focus on saving fuel through optimising vehicles and equipment.
	4	The company maps transport and works actively to optimise routes and organise transport (transport the most goods for the fewest km)
	5	The company conducts comprehensive analysis and takes measures aimed at all energy use in the company.

Table 5
The respondents' age and sex and mileage in the three companies in 2013 and 2018.

	2013			2018		
	Comp. A	Comp. B	Comp. C	Comp. A	Comp. B	Comp. C
Proportion of men	98 %	96 %	99 %	99 %	100 %	91 %
Thousand km last 2 years	106	85	83	141	78	115
<26 years	2 %	27 %	11 %	1 %	36 %	18 %
26–35 years	12 %	27 %	13 %	21 %	18 %	15 %
36–45 years	29 %	15 %	18 %	24 %	18 %	9 %
46–55	46 %	12 %	36 %	40 %	14 %	39 %
> 56	12 %	19 %	22 %	14 %	14 %	18 %
Total (Age)	100 %	100 %	100 %	100 %	100 %	100 %
Number	122	26	76	80	28	33

The company had *a fleet management system* before the interview in 2013. They used results from this system and the tachograph to give feedback to the drivers about their driving style, e.g. their speed in given areas. The company was in the process of replacing their fleet management system when we conducted the interviews. In the period after the interviews in 2013, they put in place a new system. The new system focuses on free roll (rolling without touching the gas pedal), predictive driving, cruise control, over-speed and hill driving (i.e. using as little energy as possible upwards and rolling over hill tops). The drivers in Company A receive monthly *feedback* from management about their scores, and they can see the scores daily on mobile phone application, if they have downloaded this to their phones. As mentioned, Company A also provides *training* to the drivers from their own driving instructor associated with the company. Company A has *informal "competition"* between drivers to get the highest score, by "publishing the scores" from the fleet management system internally. Company A does not give *bonuses* to drivers for economic driving or scores in the fleet management system.

The company aims to reduce diesel consumption, but they have not set a specific target of how much reduction they should achieve in a given period. Over time, they have replaced all the vehicles, and it was mentioned that these are highly fuel efficient. The company also collaborates with competitors to avoid empty driving on their return trips, avoid idling, to save the environment and expenses. The company does not focus on energy mapping and measures related to activities beyond transport.

3.3.2. Company B

Fleet management system. Company B started focusing on speed and driving style after a number of single vehicle accidents in 2010. The company implemented a fleet management system on all vehicles in 2014–2015. They use a system that is "vehicle independent", called Saga Truck. The motivation for implementing this system concerned three things: 1) To obtain a tool to work actively with driving style, 2) To obtain better mapping of the driving and data on distance, fuel consumption and time use and 3) Automatic download of tachograph data. The company focuses in particular on two parameters from the fleet management system. The first is idling. The second is a "risk indicator", which the manager reports the results for each month at the company level. The company has goals for both parameters, and these have been included as part of local pay agreements with trade unions. Employees receive pay increases, or bonuses based on whether they reach the goals. The goal for the whole company has been to get below 700 h of idle per month and a score below 0.2 on the risk indicator. These figures are followed over time, and they are renegotiated if the drivers are unable to fulfil them. The company has a scoreboard where the figures are presented monthly, either as red (goals have not been reached) or green (goals have been reached). The head of Company B said that the risk indicator in the fleet management system measures g-forces at work (e.g. sudden braking, acceleration, excessive high speed in curves), because these are indicators of accident risk. This is what has caused the most accidents in the past. The indicator of g-forces is triggered by sudden braking or acceleration or excessive speed in curves, based on given limit values.

Feedback. The company provides weekly feedback to drivers on the HGVs g-forces, fuel consumption and idle driving indicator. The scores are placed on a board where the drivers pick up and deliver goods. There they can see their achieved score for last week. Drivers also have access to a smartphone application, where they can view the scores.

Training. Interviewers also asked for more specifics on training for the individual driver, and the manager said that the company focuses on the drivers who stand out negatively on the indicator of g-forces in their training. The follow-up is based on measurements from the fleet management system. They follow the drivers over time to improve their driving style. They focus in particular on safe driving style in the follow-up of the drivers.

Competition. Company B also uses various incentives to motivate drivers to get the best scores possible. For example, there is a competitive element to the fact that each driver's score is "published" internally weekly.

> It becomes a form of competition. They are given a score each time g-force over a specific limit value sends an impulse, and it is the number of events in which this impulse is measured that provides the score. When we started, the average was 0.45 and last month it was 0.18. (Manager, Company B).

Figures for diesel consumption and idling consumption are also shown on the monthly score board. The manager emphasised that the drivers in this "competition" are divided into groups comparable in terms of the type of driving and the type of equipment. There can be from 3 to 10 people in each group (max 15) and they learn weekly how they compare to the scores in the system overall.

Bonuses. Drivers' scores are also linked to bonuses, which they achieve in groups, and the size of the bonus is negotiated annually with the drivers. Drivers receive pay raises based on the goals they are given from the fleet management system. The manager said that:

> This ensures us attention to what we want with driving style. If we renegotiate [the goal for bonuses], it's because the group as a whole hasn't achieved its goal. This means that the culture and driving style are developing negatively and that people aren't taking idling seriously. It's symbolic because we get it as a theme… what we want to draw attention to. (Manager, Company B).

The general bonus for achieved goals is a salary of two extra NOK an hour, but the bonus is based on a package that includes more. Drivers also receive a personal bonus of five NOK per hour if they drive damage-free for one month.

3.3.3. Company C

Company C was financially supported by Enova to work on economic driving for a one-year period.[2] The company has a fleet management system in all vehicles. The company started doing this at the beginning of 2014, but they did not start systematic work on fleet management systems until they were supported by Enova in 2016. The project period for which they received funding was one year from 01/11/2016.

Fleet management system. The manager said that 95 % of drivers have fleet management systems from Scania or Volvo in their vehicles, and that they are ranked automatically on speed, braking, fuel consumption, idling and a number of other parameters. In addition, the company also distinguishes the type of transport, for example, between distribution and long-distance, so the comparisons between drivers can be fair.

Feedback. Drivers receive information about their scores in the fleet management system from management every-two months, but it was emphasised that the drivers who use the mobile phone application can see these scores every day if they wish.

Training. The drivers who have had the lowest scores in the fleet management system are contacted by management representatives when drivers' fleet management system scores are distributed. These drivers are selected for extra training to improve their scores. The company also used a consultancy firm professionalized in driver training during the "Enova period".

Competition/bonus. The company publishes the scores of its drivers internally, and sets up competition between drivers competing for good scores. The company also has a bonus system or competition between the drivers, where high scores in the fleet management system over time (90 or higher for at least 9 out of 12 months) are included as one of several criteria. The other criteria are the absence of vehicle damage or damage to goods over given sums, and a certain reporting of a certain number of safety incidents to the company's reporting system. The company also has in place elements related to the energy management system, such as fuel reduction goals, measures of reduced idling, overview of key figures and shift to HGVs with smaller engines to save fuel.

[2] Enova is a Norwegian government enterprise responsible for promotion of environmentally friendly production and consumption of energy.

3.3.4. Classification of the companies on the Eco ladder

In, Table 6 the companies' measures for economic driving and energy management is classified on the Eco ladder. The classifications are based on analysis of interviews with managers and employees of the companies (cf. Section 2.3.2)., and were made by two researchers independently.

Table 6 shows that the companies are fairly similarly placed in the Eco ladder, but that Company A is somewhat higher due to measures related to the organisation of transport and optimisation of equipment. This shows that the measures that the companies have worked on during the study period are mainly about facilitating economic driving style through measures at Level 2 of the Eco ladder (i.e. implementation of fleet management system with driver feedback).

3.3.5. Results on the proxy for fleet management system use

The following question is used as a proxy for companies' use of fleet management system: "Management detects any drivers who are not driving in a safe way" (Answer alternatives ranged from 1 = totally disagree to 5 = totally agree). This question was used both in the 2013 and the 2018 survey. As Company A already had a fleet management system in the first data collection, it was hypothesized no change in Company A on this question from the first (2013) to the second (2018) data collection. Increased scores on this question was hypothesized in Company B and C, as these companies implemented fleet management systems after the first measurements. Comparisons of scores in 2013 and 2018 support these hypotheses. The score for Company A was 3.4 points in both 2013 and 2018, while the scores for Company B at these points of time were 3.2 and 3.7 (16 % improvement), while scores for Company C were 3.4 and 4 (18 % improvement).

3.4. Results on fuel consumption and economy

This section relates to the second aim of the study, which is to examine the effects on fuel consumption during the study period. Managers from each company were interviewed about the effects the measures have had on fuel consumption and economy.

Company A aimed to reduce fuel consumption through the implementation of fleet management system. However, the interviewee said that the company did not have a specific goal for reduced fuel consumption related to the use of the fleet management system. The interviewed manager of this company mentioned that they keep a close eye on the vehicles' consumption, and that the new vehicles use significantly less fuel.

Company B had a particular goal of reducing idling when they installed fleet management systems. The manager said that earlier (in 2014) they had a monthly average of about 1800 h of idling driving, with a lower number of vehicles. Now they have fulfilled targets of less than 700 h idle a month. This means that Company B saves around NOK 300,000–400,000 a year solely through reducing idling.

Company C originally had a target of 10 % fuel reduction from 01/11/2016 to 10/11/2017, in connection with the support of Enova. They managed a reduction of 5–6 % during this year. This could potentially correspond to savings of NOK 2.4 million in one year for the company.[3]

3.5. Road safety results

This section addresses aim 3, which is to examine effects on road safety, measured as accident risk and safety culture during the study period.

3.5.1. Accident risk based on survey data

The accident risk in the companies in 2013 and 2018 have been calculated, based on figures from the surveys, where drivers have stated 1000 s of kilometres driven and the number of property damage accidents for the previous two years. Table 7 shows mileage, accidents and risk for the last two years in the three companies in 2013 and 2018.

Fig. 1 shows developments between the two measurement periods in the three companies.

Fig. 1 shows that the accident risk is similar in Company A in 2013 and 2018, and significantly lower than in the other two companies. This is not surprising, since Company A transports dangerous goods, which generally have a lower risk of accidents than other HGV transport. In line with what the managers said in the interviews, Fig. 1 indicates that the risk in Company B has been reduced by 52 % in the period, while risk in Company C has been reduced by 36 %.[4]

At the same time, calculations based on the TRAST database of property damage accidents involving HGVs show that developments in the risk of such accidents have remained relatively stable during the two time periods (cf. Table 8). As in the data for the companies, mileage and number of property damage accidents were merged for 2012–2013 and 2016–2017 respectively.[5] The data on kilometres driven with HGVs per year are from Nævestad and Hovi (2020) Table 8 refers to the two periods as 2013 and 2018, as in Table 7.

[3] This assumes 100,000 km a year per vehicle, a vehicle that consumes about four litres per mile on average and a diesel price of NOK 11 a litre.

[4] The differences have been significance-tested, and none of them are statistically significant, due to small numbers. We should therefore not place decisive emphasis on the significance tests. A significantly higher number of accidents is needed per year, in order to test whether the differences in each company from 2013 to 2018 will be statistically significant.

[5] The data from the survey are from the new year/spring 2018. For your convenience, TRAST data and exposure data from are compared for 2016 and 2017.

Table 6
Classification of the companies' level on the Eco ladder.

			Company A	Company B	Company C
LEVEL 2	1	Fleet management system	1	1	1
	2	Regular information	1	1	1
	3	Training	1	0.5	0.5
	4	Competitions	1	1	0
	5	Bonuses	0	0	1
LEVEL 3	1	Stated goals	0.5	1	1
	2	Overview of key figures	0.5	1	0.5
	3	Optimisation of vehicles and equipment	1	0.5	0.5
	4	Optimisation of transport	1	0	0
	5	Comprehensive analysis of all energy use	0	0	0
		Total with 10 criteria:	7	6	5.5
		Level with 10 criteria:	3	2	2

Table 7
Mileage, accidents and risk for the last two years in the three companies in 2013 and 2018.

Year	Exploit	Millions of km	Accidents	Risk
2013	Company A	13,0	9	0.7
	Company B	2.2	6	2.7
	Company C	5.0	11	2.2
2018	Company A	11.4	8	0.7
	Company B	3.8	5	1.3
	Company C	2.2	3	1.4

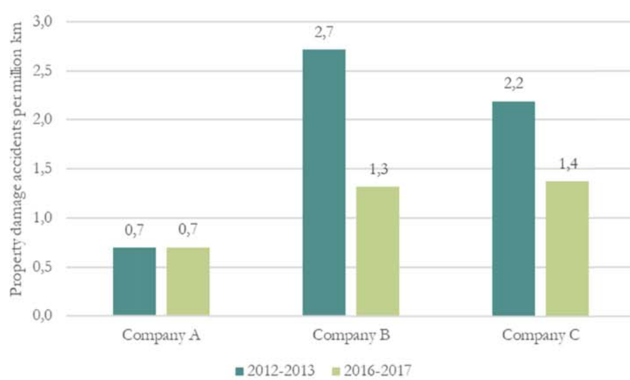

Fig. 1. Accident risk measured as the minimum number of property damage accidents per million kilometres driven in the last two years in the three companies in 2013 and 2018.

Table 8
Kilometres, accidents, heavy vehicles in accident with property damage and risk of property damage accidents for Norwegian-registered heavy goods vehicles in 2013 and 2018.

Year	Millions of km	Property damage	Risk of property damage
2013	3641	30,679	8.4
2018	3358	33,875	10.1

Table 8 shows a slight increase in the risk of property damage in the period 2016–2017, compared to the period 2012–2013. In other words, the risk of property damage to heavy goods vehicles has not decreased in the study period (2013–2018), as is has in company B and C.

3.5.2. Property damage accident development based on interview data

3.5.2.1. Company A. The interviewed manager in Company A could not provide a concrete quantification of development in the accident rate before and after the implementation of the fleet management system. The company has worked with fleet management systems throughout the study period, and they also had a fleet management system before we did the interviews in 2013. In addition, the company has had a greater focus on safety, more safety measures at many different levels and a higher level of safety than the other two companies throughout the period. This must be seen in the context of the company's transport of dangerous goods.

3.5.2.2. Company B. Company B has a "risk indicator" in the fleet management systems of all vehicles in the company. The indicator is triggered by g-forces at work, caused by acceleration or by sudden braking. The manager said the average for this was 0.45 when they started using the fleet management system in 2014 and that in October 2017 it was 0.18. He also said that he saw a clear correlation between scores on this indicator and the development of property damage accidents in the company. In 2014, when they started using the fleet management system, the company had about 25–30 accidents a year and 80 heavy vehicles (and a 0.45 risk indicator score). He said that since 2014 they have had a steady decline in accidents each year, and that they had 15–16 accidents in 2018, with more vehicles than in 2014 (95 vehicles) (and a 0.18 risk indicator score). Additionally, the character of the accidents have changed: earlier, there were more high speed single accidents with comprehensive economic costs for the company. He added, however, that they had more accidents in 2019 again (25 accidents per 95 vehicles), breaking the trend of gradual decline in accidents from 2014. He mentioned that this could be due to several things, but most importantly; the fleet management system had been out of use for about a year in that period. He said that when the fleet management system was up running again, the company's risk indicator score was 0.30, and that they used a month go get it lower than 0.2 again. The head of Company B also said that the company halved its insurance premium after they started working actively on fleet management systems in 2014. To sum up, results from Company B since 2014 indicates a clear relationship between the use of fleet management systems, feedback on driving style, drivers' driving style and accident risk.

3.5.2.3. Company C. The head of Company C said that during the period they were supported by Enova to work on economic driving, from November 2016 to November 2017; they had their lowest-ever cost level related to property damage accidents:

> We have carried out the Enova project 31/10/2017, with a focus on driving style. It was standard to reduce fuel consumption by 10 %. That's a lot. We couldn't do that. We had a reduction in fuel use of between 5 % and 6 %. In addition, we had our lowest-ever damage cost level. (Manager, Company C).

This is the same period that the company worked most systematically on measures aimed at economic driving. He also mentioned that drivers' scores in the fleet management system improved on average in the company:

> The company's average score [in the fleet management system] has increased significantly in the period since 2016 to date. In Scania we had many that were at the lowest and the second lowest level. There are no people left there. Now we're in the middle or better. (...) Development in accidents from 2016 to 2019 has improved, because the higher score you get in the fleet management system, the more defensively you drive. (Manager Company C).

He also said that in 2017 they experienced a halving of the their insurance premium in the past four years due to their lower number of accidents. The manager of Company C reported, however, an increase in the number of accidents in 2018, due to harsh winter conditions, with a subsequent reduction in 2019 again.

3.5.2.4. Organisational safety culture. Fig. 2 shows the development of organisational safety culture in the three companies from 2013 to 2018.

Fig. 2 shows that the organisational safety culture has improved significantly in Company B from 2013 to 2018, with a 8-point increase in the GAIN index for safety culture. This corresponds to an improvement of 10 %. We also see an improvement in the safety culture in Company C, with a four-point increase on the GAIN index. This corresponds to an improvement of five per cent. The safety culture score in Company A fell by three points on the GAIN index, or three per cent.[6]

3.6. How can we explain any observed effects on road safety during the period?

This section addresses the fourth aim of the study, which is to discuss how we can explain any observed effects on road safety during the study period.

3.6.1. Company road safety measures

The full description of organisational safety measures in 2013 and 2018 are provided in Appendix 1. This is the basis for Table, which 9 shows classifications of companies' safety measures according to the Safety Ladder for safety management, in 2013 and 2018. The classifications are based on analysis of interviews with managers and employees of the companies (cf. Section 2.3.2)., and were made by two researchers independently. The criteria in the Safety Ladder are described in more detail in Table 3.

We can summarise that Table 9 shows that Company A is at Safety Ladder Level 4 (and has the most comprehensive safety

[6] T-tests have been conducted to investigate whether the differences in the scores are statistically significant in the two different periods. Results show that when comparing the mean scores for safety culture in 2013 and 2018, the significance level for Company A was 0.42, while it was 0.051 for Company B and 0.11 for Company C. However, as in the calculations above, the figures for the companies are small and associated with considerable uncertainty.

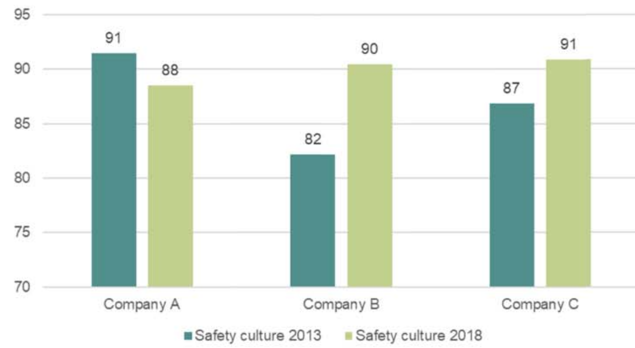

Fig. 2. Organisational safety culture in the three companies in 2013 and 2018. The GAIN safety culture index has a minimum score of 20 points (1*23), a maximum score of 115 points (5*23).

measures) in both 2013 and 2018, while Company B and C are at Safety Ladder Level 3 in 2013 and 2018. This implies lower accident risk and higher safety culture levels in Company A than in Company B and C. Table 9 shows that the largest changes in the companies from 2013 to 2018 is that the companies' have installed functioning fleet management systems during the period, which they use to give drivers regular feedback on various aspects of driving style. We also see that no significant new safety measures have been introduced in Company B and C beyond fleet management systems, (i.e. that any improvements in safety from 2013 to 2018 cannot be attributed to other safety measures). Company A had a fleet management system in 2013, but they had just had their original system replaced, and the new one was not fully implemented during the interviews.

3.6.2. *Framework conditions*

The surveys in 2013 and 2018 also include questions about framework conditions. Results for these are included, to investigate whether differences in framework conditions can explain the improvements in road safety in Company B and C. The following questions were included, to measure stress and pressure both in 2013 and 2018 "In my job, I find that customers are pushing/stressing drivers." The proportions that (fully/partially) agreed with the statement in Company A were 16 % in 2013 and 10 % in 2018. The proportions agreeing in Company B were 35 % in 2013 and 36 % in 2018. The proportions agreeing in Company C were 29 % in 2013 and 43 % in 2018.

3.6.3. *Multivariate analyses*

Table 10 and 11 examine the factors explaining the accident risk and organisational safety culture in the studied companies. These analyses control for and test the contributions of key variables like respondents' age, type of transport, perceived customer pressure/stress, indicator of fleet management use, customer focus on safety, and other variables found to be important in previous research.

3.6.3.1. *Factors predicting accident involvement.* A logistic regression analysis was conducted to examine the variables predicting variation in accident involvement over the past two years. Logistic regression is used, as the accident variable has been recoded into a dichotomous dependent variable (accidents: yes/no). Table 10 shows the results of seven regression models with respondents' accident involvement over the past two years as a dependent variable.

First, age contributes significantly to accident involvement, controlled for the other variables in the model. The odds ratios indicate that drivers over 26 years old have a lower accident risk than drivers younger than 26 years old.

Second, safety culture contributes significantly in Models 3–6. The odds ratios indicate that a high safety culture score is related to lower risk of accident involvement, controlled for the other variables in the model (e.g. type of transport, kilometers driven, proxy for

Table 9
Classification of the companies' level on the Safety Ladder.

			Company A		Company B		Company C	
			2013	**2018**	**2013**	**2018**	**2013**	**2018**
LEVEL 2	1	Policy: speed, driving style and seat belt	1	1	1	1	0.5	1
	2	Fleet management system	1	1	0	1	0	1
	3	Regular feedback	0	1	0	1	0	1
LEVEL 3	1	Payroll system	1	1	1	1	0.5	0.5
	2	Postponing assignments	1	1	0.5	0.5	0	0
	3	Mapping stress/fatigue	1	1	0.5	0.5	1	1
LEVEL 4	1	Functioning reporting system	1	1	0	0	0	0
	2	Formal risk analyses	1	1	0	0	0	0
	3	Good training programme	1	1	0.5	0.5	0.5	0.5
		Total with 9 criteria:	8	9	3.5	5.5	3	5
		Level with 9 criteria:	4	4	3	3	3	3

Table 10
Logistic regression. Dependent variable: Accident involvement last 2 years (No = 0, Yes = 1). Odds ratios.

Variable	Mod. 1	Mod. 2	Mod. 3	Mod. 4	Mod. 5	Mod. 6	Mod. 7
Kms driven	1.003	1.003	1.002	1.001	1.001	1.001	1.001
Age (<26 = 0,>26 = 1)		**0.223****	**0.184****	**0.146****	**0.099*****	**0.098*****	**0.083****
Safety culture			**0.960****	**0.959****	**0.953****	**0.953****	0.963
Type of transport (ADR = 0, Not ADR = 1)				0.689	1.001	1.005	0.462
Customer pressure/stress					0.631	0.630	0.608
Fleet man. system proxy						0.989	0.911
Road safety behaviour							**1.385*****
Nagelkerke R	0.015	0.083	0.150	0.154	0.190	0.190	0.299

* $p < 0,1$ ** $p < 0,05$ *** $p < 0,01$.

Table 11
Linear regression. Dependent variable: GAIN safety culture index. Standardized beta coefficients.

Variable	Mod. 1	Mod. 2	Mod. 3	Mod. 4	Mod.5	Mod. 6
Age (Other = 1, 46–55 = 2)	0.059	0.064	0.070	0.094	0.095	0.041
Type of transport (Other = 1, ADR = 2)		-0.042	-0.139	**-0.140***	0.153	0.134
Customer pressure/stress			**-0.222****	-0.063	-0.074	-0.044
Customer focus on safety				**0.648*****	**0.639*****	**0.530*****
Company (Comp. A = 1, B,C = 2)					0.309	0.186
Fleet man. system proxy						**0.355*****
Adjusted R^2	-0.004	-0.009	0.024	0.423	0.427	0.531

* $p < 0,1$ ** $p < 0,05$ *** $p < 0,01$.

fleet management system use). Safety culture ceases to contribute significantly in Model 7, when road safety behaviour is included. This indicates that safety culture is closely related to road safety behaviours, which is the most important variable explaining drivers' accident involvement.

Third, road safety behaviours contributes significantly, controlled for the other variables in the model. The odds ratios indicate that higher scores on this index (i.e. riskier driving) are related to accident involvement. Safety behaviour is an index comprised of four behaviour variables: speeding in residential areas, speeding on motorways, whether drivers sometimes violate traffic rules to get quicker to their destination and whether they accept "a little" risk if the situation demands it. It seems that these behaviours are related to accident involvement. This is the most important variable predicting accident involvement in the model.

The Nagelkerke R value in Model 7 is 0.299, which indicates that the model explains about 30 % of the accident involvement of respondents in the sample.

3.6.3.2. Factors predicting organisational safety culture. Table 11 shows the results of six regression models with the adapted GAIN safety culture index as dependent variable.

The analyses show first that type of transport contributes significantly and negatively in Model 4, which means that transport of dangerous goods (ADR) is related to lower safety culture scores, controlled for the other variables in the model. This is surprising, but it can be explained by the fact that Company A (which transports dangerous goods) has a slightly lower safety culture score than the two other companies in the 2018 measurement.

Second, the variable customer pressure/stress contributes negatively and significantly to safety culture in Model 3, indicating that drivers who perceive this rate the safety culture in their companies as lower. This variable ceases to contribute significantly in Model 4, when customer focus on safety is included. This indicates that the two variables focusing on customers are strongly related, and it seems that they measure almost the same, although the first variable measures the negative aspect of it, and the second the positive.

Third, the proxy for fleet management system use contributes significantly and positively in Model 6, indicating that this is closely related to safety culture. This is in line with the comparisons of mean scores, which indicated an increase in the proxy for fleet management system use and for safety culture in Company B and C (and stable scores in Company A). The analyses indicate these relationships, also when controlling for key variables.

Finally, the Adjusted R^2 value in Model 6 is 0.531, indicating that the model explains 53 % of the variation in respondents' scores on the organisational safety culture index. This indicates that the model is good.

4. Discussion

4.1. Measures for economic driving

The first aim of the study was to map the measures the companies have introduced for economic driving in the period 2013–2018. First, the companies have implemented fleet management systems, which is the most basic element of companies' work on economic driving (Diaz-Ramirez, 2015; Ayyildiz et al., 2017; Sanguinetti et al. 2020).

Second, the companies provide feedback to the drivers, which is a prerequisite for drivers to learn from and change their driving style (Ayyildiz et al., 2017).

Third, the companies provide training to the drivers. Most studies of economic driving with heavy vehicles describen a form of training of drivers in economic driving style (Rolim et al. 2014, Strömberg and Karlsson 2013, Symmons et al. 2008, Zarkadoula et al. 2007, Af Wåhlberg 2007). However, there is variation among the companies in what kind of training is given and what it is about, and to whom it is given. This is a topic that should be investigated more specifically in future research. Ayyildiz et al. (2017) argue in favour of focusing only on drivers with the lowest scores, because doing something about these is most effective at "pulling the average up" (with the least use of resources). The results seem to support this approach, because it is used by all three companies.

Fourth, the studied companies have more or less informal competitions between drivers about driving style. These competitions mean that drivers' scores are regularly "published internally" for drivers in the companies so that drivers can see their scores and compare them with other drivers' scores. Previous research also shows that this is important, because drivers' motivation is a fundamental factor (Diaz-Ramirez, 2015; Ayyildiz et al., 2017; Nævestad, Blom et al. 2020; Magana and Munoz-Organero, 2015; Sanguinetti et al. 2020).

Finally, Company B and C have also introduced bonus schemes related to economical and traffic-safe driving style. These are relatively complex.

It can therefore be concluded that the companies have introduced a handful of measures for economic driving during the study period, and that Company A started before the other two companies. However, it is difficult to conclude which of the measures is most important. Fleet management systems and feedback to drivers are, however, fundamental, because it is a prerequisite for the other measures.

Regular feedback to drivers about their scores so that they can continuously learn and change their driving style seem to be crucial. This continuous improvement process at the driver level seems to be particularly effective when combined with more or less informal competitions between drivers, because this provides identity, pride and sense of social community in a group of workers who basically have a relatively lonely job. This is in line with a gamification approach (Magana and Munoz-Organero, 2015; Nævestad, Milch og et al. 2020).

4.2. *Effects on fuel consumption and economy*

The second aim applies to effects on fuel consumption. The companies report significant economic effects of the companies' implementation of fleet management systems and measures aimed at economic driving during the study period (2013–2018). Company B had a particular goal of reducing idling, and reported savings of around NOK 300,000–400,000 in a year. Company C achieved a fuel reduction of 5–6 % in the period during which they received support from Enova (01.11.2016 to 10.11.2017). These results are in line with previous research examining the effects of economic driving on fuel consumption in goods transport (Díaz-Ramirez et al., 2017; Ayyildiz et al. 2017; Symmons et al. 2008) and in bus transport (Sullman et al., 2015; Rolim et al. 2014; Strömberg and Karlsson 2013; Zarkadoula et al. 2007; af Wåhlberg 2007). These previous studies generally find reductions in fuel consumption of between 5 % and 10 %.

4.3. *Effects on road safety*

The third aim was to map the effects on road safety, measured as accident risk and safety culture during the period. This is done based on data from surveys in 2013 and 2018. The results show that road safety in Company A has been very high and stable from 2013 to 2018. The accident risk in Company A has been significantly lower than in the other two companies at both measurement time points. This is not unexpected, since Company A transports dangerous goods and therefore has a stable and low risk of accidents. Previous research shows that the risk in such companies is 75 % lower than in other goods transport companies (Elvik et al. 2009). In line with this, we see that the risk in Company A in 2013 was 74 % lower than in Company B. The results also show stable high scores for safety culture in Company A even though the score has been reduced slightly in 2018.

The survey results show a marked improvement in the safety level in Company B and C from 2013 to 2018. Accident risk in the companies has decreased by 52 % and 36 % respectively during the period. We also see improvements in organisational safety culture scores of 11 % and 4 %, respectively. This could be a result of drivers' perception of increased focus on safety in the companies, following from the implementation of fleet management systems and increased focus on their driving style. Management commitment to safety is the main element in safety culture measurements (Flin et al 2000), and the main focus in the GAIN index for safety culture that is used in the present study (GAIN, 2001).

The improvements in Company B indicate a significantly increased perceived focus on road safety in the company. The observed decreases in accident risk are also supported by the interview data. Managers in Company B and C said that companies have halved their insurance costs during the study period and that the number of accidents has decreased.

The positive effects on road safety are in line with the results of the few studies examining this (Toledo and Shiftan 2016; Nævestad and Milch 2020). Toledo and Shiftan (2016) conclude that feedback from fleet management systems can lead to an 8 % reduction in safety incidents. The results of the study are also in line with the conclusions of Nævestad and Milch (2020), which find relationships between measures for economic driving, effects on fuel consumption and effects on road safety. As noted, Af Wåhlberg (2007) does not find a traffic safety effect of economic driving, but this study only found a 2 % reduction in fuel consumption, and a traffic safety effect corresponding to this would probably be too low to identify.

Figures on the risk of property damage accidents based on the TRAST register have also been included in the study, and these do not show a decrease in risk from 2013 to 2018, as we have seen for Company B and C. This strengthens the assumption that the decrease in risk that we have seen in these two companies is due to special measures.

4.4. How can we explain observed effects on road safety during the period?

4.4.1. What are the mechanisms operating between economic driving and safety?

The fourth aim is to explain observed effects on road safety during the period. The relationship between economic driving and road safety can first be explained by factors at the driver level. An underlying hypothesis in the studies examining the road safety effects of economic driving is that a defensive, slow and smooth driving style is both economic and safe (cf. Dekhordi et al 2019). Toledo & Shiftan 2016; Nævestad and Milch 2020). The findings support this hypothesis, because we see a decline in accidents related to Company B and C's systematic use of fleet management systems and other measures for economic driving. This interpretation is also supported by the results of the multivariate regression analyses, indicating that the relationship between systematic use of fleet management system (measured by the proxy for this) is closely related to safety culture, which in turn is closely related to road safety behaviours and accident involvement. Section 4.4.4 expands further on these relationships.

Second, the relationship between economic driving and road safety can be explained by factors at the technology level, because the fleet management system measures and reward criteria both for economy and safety (Nævestad and Milch 2020). It is the fleet management system that records driving style, provides feedback and regular feedback on results from it ensures the maintenance of drivers' economical and safe driving style. This indicates that it is important to remember that the companies have not implemented "pure" economic driving measures through their use of fleet management systems. These systems record several different driving style parameters, which are: 1) Related to both economy and safety (e.g. predictive driving, braking), 2) mostly related to economy (e.g. idling), 3) mostly related to safety (e.g. over speeding,). The latter will also be related to economy, as lower speed is related to lower fuel consumptions. This indicates that the parameters recorded in the fleet management systems are related to both economy and safety. It seems that the reason for this is that the two aspects of driving style largely coincide. There are, however, some conflicts between aspects of safe and economic driving style. This relates to free-rolling, which is rolling without touching the gas pedal. It is economic to roll at high speed downhill, to roll as far as possible to save fuel. This might, however, involve rolling at dangerously high speeds, e.g. in curves, or when approaching intersections etc. The fleet management system is therefore designed to impede, in the sense that the fleet management score algorithms "punishes" over speeding (e.g. speeds higher than 85 km/h). Over speeding is measured as one of five to six aspects, and it has a decisive count when the general score is calculated by the algorithm.

4.4.2. Could the changes be due to other safety measures in the period?

When drawing conclusions about effects of measures aimed at economic driving, it is important to control for safety measures introduced during the period. This is the reason that the companies have been classified according to the Safety Ladder for goods transport in both 2013 and 2018 (Nævestad, Blom et al. 2020). The Safety ladder describes the most important safety measures that can be introduced in goods transport companies, related to driving style, work-related conditions with significance for road safety and safety management system (Nævestad, Milch og et al. 2020). Company A is stable at the top level (level 4) in the Safety Ladder, which equals a safety management system of type ISO:39001 or similar. The far lower accident risk in Company A, which largely is due to this safety management system, indicates that safety measures are more important for safety than economic driving measures. The lower accident risk in Company A is also related to various framework conditions related to transport of dangerous goods, but the safety management system is closely related to these.

Company B and C are stable at level 3 in the Safety Ladder, both in 2013 and 2018. These two companies have not introduced significant new safety measures in 2018, beyond introducing fleet management systems that record driving style and that regularly giving feedback to drivers about their driving style during the studied period. It can thus be concluded that the effects that we have seen on road safety and economy from 2013 to 2018 in Company B and C are not due to other safety measures that have been introduced during the period.

4.4.3. Could the changes be due to changes in framework conditions?

Drivers' experiences of stress and pressure from customers is important, because it influences driving style, such as speed, which in turn is related to accident involvement and risk (Davey et al. 2006; Öz et al. 2013). More recent studies also indicate the importance of framework conditions like driver stress and time pressure (Useche et al 2019; Llamazares et al 2021). The results of the multivariate analyses are in line with this, as they indicate that customer stress/pressure and customer focus on road safety are important predictors of organisational safety culture. Drivers' perceptions of stress and time pressures has been compared in 2013 and 2018. The numbers are relatively similar in Company A and B, but drivers in Company C experience a higher level of stress in 2018. This could potentially be due to new customers, new organisation of transport internally in the company that makes drivers more susceptible to stress, new type of transport, or new drivers who have a higher propensity to experience stress. Higher levels of stress would potentially have had a negative impact on the safety level and safety culture in Company C (Davey et al. 2006; Öz et al. 2013). We see, however, the opposite: the accident risk and safety culture during the study period have been improved, despite higher experiences of stress and pressure. This is hard to explain. Based on the interviews, it can also be concluded that there is considerable stability in the framework conditions of the three companies we are studying, e.g. related to their types of transport.

4.4.4. Model of the observed relationships

The multivariate analyses examined factors influencing the safety outcomes that the present study focuses on. These analyses indicated that the most important variable influencing drivers' accident involvement was drivers' safety behaviours. Organisational safety culture also influenced driver accident involvement, but the influence of this variable was primarily mediated through drivers' safety behaviours. This means that results indicated that safety culture influences drivers' safety behaviours (Nævestad, Blom et al. 2020), which in turn is related to accident involvement (cf. Mitchell and Driscoll (2004); Davey et al 2006; Nævestad et al. 2015; Warner et al. 2011). As indicated, these relationships have also been found in previous studies. The multivariate analyses also indicated a relationship between driver's age (<26 years) and accident involvement, which also is in accordance with previous research (Bjørnskau, 2015; Charbotel et al., 2010).

The multivariate regression analyses also examined factors influencing organisational safety culture, and indicated that a key variable here was the proxy for companies' systematic use of fleet management system. This relationship between systematic use of fleet management system and safety culture has also been found in previous research (Nævestad, Milch og et al. 2020). The most important relationship between the studied variables are illustrated in Fig. 3.

To sum up, the multivariate regression analyses indicate the relationships and mechanisms (i.e. driving style) between the two safety outcomes that we focus on in the present study (accident risk and safety culture), supporting and supplementing the results that was observed over time in the qualitative and quantitative data. The study indicates that systematic use of fleet management system improves safety culture, which improves safety behaviour, which reduces accident involvement.

The relationships depicted in Figure 3 might shed light on the improvements we have seen over time in the study, as we see improvement in the proxy for companies' use of fleet management system (the "intervention" variable) in Company B and C, and improvement in the outcome variables: safety culture and accident involvement. As expected, we saw no improvements in neither the intervention variable or the outcome variables in Company, which was used as a control company.

Finally, the statistical analyses also support the study's focus on framework conditions (e.g. customer induced stress, customer focus on safety) influencing the safety outcomes, and this is also in line with previous research (e.g. Davey et al 2006; Nævestad, Blom et al. 2020).

4.5. Methodological weaknesses and strengths

(1) ***The study is not a full-fledged experiment.*** The study is not a full-fledged experiment, or in other words the studied companies have not been randomly selected for the study and then randomly chosen to experiment and control groups (although it has before and after measurements). Additionally, the control company differs markedly from the other two, because it transports dangerous goods and has a very high level of safety. It is probably difficult for Company A to raise the level of safety further, and it may therefore be questioned how good this company is as a control company. On the other hand, it was chosen as control partly because it had a fleet management system in place a few years before the others. In addition, the study controls for a general development in the risk of property damage accidents in Norway in the study period. The main strength of the present paper is that it actually has measured safety outcomes before and after implementation of fleet management systems, controlled for implementation of safety measures, over a period of four years.

(2) ***Could the changes be due to differences in the samples?*** Road safety is measured as accident risk and safety culture based on self-reported figures. The study therefore depends on the samples we have in the different years to be comparable. At the same time, we see that the response rates in the different years vary and that they are sometimes low. Different distributions when it comes to driver age in the samples may influence results, as driver age is related to accident risk (Bjørnskau, 2015; Charbotel et al., 2010). The samples from the companies in 2018 are generally somewhat younger than in 2013. This implies higher risk, but we see the opposite. It is also important to remember that the qualitative data confirm the impression of reduced risk from the survey.

(3) ***Self-reported figures.*** The estimates of accident risk and safety culture are based on self-reported figures with the possible biases that this may entail. For example, respondents may have incorrect perceptions of the number of kilometres driven or the number of accidents, and this may affect the risk estimates. The qualitative data support, however, the quantitative results.

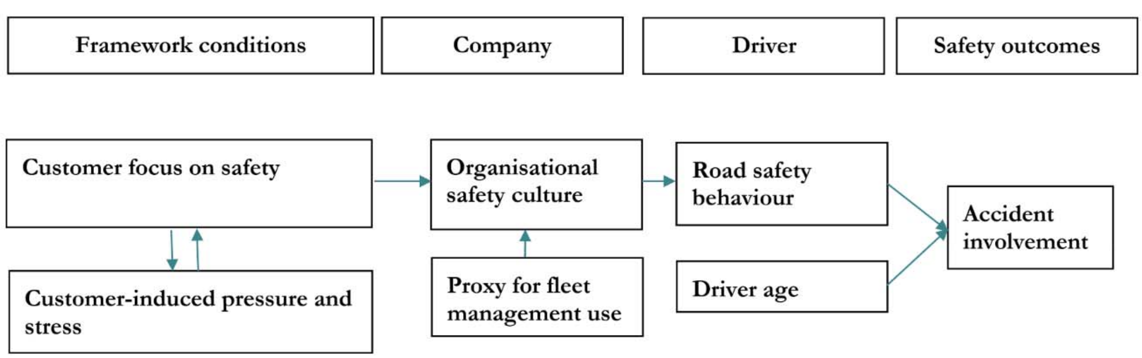

Fig. 3. The most important relationships identified in multivariate regression analyses of factors influencing drivers' accident involvement and organisational safety culture.

(4) ***Relatively few companies.*** To draw robust conclusions about the relationships that we observe, the study should ideally have included even more companies. However, the results are supported by the study by Nævestad and Milch (2020), which includes 18 companies. The present study is important, as it compares status both before and after measures for economic driving and fleet management at company level, and examines results. In addition, there are few studies that control for organisational safety measures, as in the present study, by comparing the scope of measures, based on the Safety Ladder in 2013 and 2018. Finally, there are also few studies that control for general development in the risk of heavy goods vehicles during the study period, as the present study does.

(5) ***The quality of indicators.*** The study includes one question that is used as a proxy for companies' use of fleet management system: "Management detects any drivers who are not driving in a safe way". This question is used as a proxy for companies' use of fleet management system, as it focuses on an important consequence of managers' use of fleet management system: overview of the driving styles of all the drivers. However, based on the interviews, it is evident that managers in Company B and C already in 2013 detected drivers who drove unsafe, e.g. through complaints from the public, other drivers, or through accident involvement. It must however be noted that the use of fleet management system would greatly improve their ability to detect unsafe driving, as it continuously records several aspects of their driving style. The main advantage with this proxy is that it was used in both the 2013 and the 2018 survey. Thus, we are able to compare improved scores and test the hypothesis of no improvement in Company A, as they already had a fleet management system in 2013. The quality of this proxy is suggested by the fact that there was no improvement on it for Company A from 2013 to 2018, but improvement in Company B and C, as one should expect. Thus, it seems that this proxy measures the type of intervention that is studied. However, future studies should include better indicators of systematic use of fleet management systems, focusing on the five practices in the Eco Ladder level 2, i.e. implementation of fleet management system, feedback to drivers, training of drivers, informal competitions and bonuses. Nævestad, Milch og et al. (2020) developed an index using some of these questions, and it was strongly related to drivers' systematic use of the fleet management system to improve their own scores (e.g. through checking their scores regularly and continuously trying to improve their scores through following the advice from the system on how to change specific aspects of their driving style).Moreover, Figure 3 indicates that the proxy for fleet management use influences safety culture, which influences road safety behaviours which in turn influences accident involvement. However, based on Nævestad et al (2020a), we would also expect the proxy for fleet management use to influence drivers' road safety behaviours. As the main outcome variables in the present study are accident risk and safety culture, we, have, however, not conducted multivariate analyses of factors influencing road safety behaviours. Future studies should, however, examine how companies' facilitation of drivers' fleet management system use influence drivers' use of such systems and how this influences specific aspects of their driving style, e.g. related to acceleration, deceleration, roll-out, idling, cruise-control use etc. In this way, more specific knowledge about the studied relationships can be developed.

4.6. *Suggestions for further research*

(1) ***Study based on data from fleet management systems.*** The weaknesses of questionnaire data that are discussed above are a good argument for also using data from fleet management systems in future studies.

(2) ***Savings in maintenance and tyre expenses.*** The managers of Company B and C also emphasised that economic driving and the use of fleet management systems are associated with significant savings related to maintenance, but they did not have any concrete estimates for this.

(3) ***Savings on expenses related to accidents.*** Managers in Company B and C emphasised the importance of financial savings associated with avoiding accidents. However, the study has not been able to quantify savings of this type. Such estimates are an important area for future research, which should also include calculations of costs related to extra crew on a vehicle, time out of commission and any customer loss. Information about this could provide additional motivation for managers to implement relevant measures.

5. Conclusion

The study indicates that measures for economic driving in general and fleet management systems in particular have a good effect on road safety. Survey data indicate that the accident risk in Company B and C has decreased considerably in the post-measurement in 2018, and the safety culture has improved. The interview data also suggests lower accident risk. The discussion indicates that these effects cannot be explained by referring to implementation of other safety measures during the period, changes in framework conditions, demographic changes in the samples, or a decrease in the risk of property damage accidents with heavy goods vehicles during the study period. However, it is concluded that safety measures seem to have the best effect on road safety, because Company A, which has a well-developed safety management system (equalling level 4 in the Safety Ladder), has a higher level of road safety than the other two companies through the study period.

There are several practical implications to draw from this study. The first implications relate to managers of trucking companies. The study indicates that these should implement five measures to increase the likelihood of positive effects for economy and road safety. The first measure is to implement fleet management systems recording several key aspects of a safe and economic driving style ("optimal driving style"). This system provides scores for each aspect and a total score for drivers' optimal driving style. Implementing such a system is the most basic element of companies' work on economic/safe driving. The second measure is to provide feedback to the drivers about their driving style, which is a prerequisite for drivers to learn and change their driving style. Third, companies should provide training to drivers, to assist their improvement, by showing what they should do to improve their driving style on the specific aspects. Companies should also include incentives for drivers to improve their driving style. The fourth measure is to facilitate this through informal competitions, where drivers are informed about driving style scores in the company, so drivers can see their scores and compare them with other drivers' scores. Fifth, bonus schemes related to safe and economic driving style can also be introduced to increase drivers' motivation to improve their driving style scores. These five management practices refer to regulation of driving style. The study indicates that the greatest safety impacts could be expected from combining these with safety management practices at the system level, i.e. the implementation of safety management system (i.e. level four in the Safety Ladder).

Finally, there are also practical implications to draw for regulatory authorities and other third parties enabling trucking companies' work with the five practices facilitating systematic use of fleet management systems. Company C's systematic work with fleet management system was facilitated by Enova, which is a Norwegian government enterprise responsible for promotion of environmentally friendly production and consumption of energy. Enova assisted Company C through information about implementation of Energy management systems in goods transport, e.g. by providing information about what it means to work systematically with fleet management system in practice, and by showing expected outcomes. Enova also provided financial support to Company C to facilitate implementation of the measures during a one-year period, and this was considered crucial by the manager. Thus, both this result and the results of the five management practices in the Eco Ladder level 2 indicates, in line with previous research, that information to companies and drivers is most effective when it is accompanied by other measures (e.g. legislation, education) (c.f. Faus et al 2021).

CRediT authorship contribution statement

Tor-Olav Nævestad: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Project administration, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix 1. The companies road safety measures in 2013 and 2018

Company A has a speed, driving style and seat belt policy that is known by drivers. The vehicles have a speed limiter which is set at maximum 80 km/h. The drivers in Company A must sign a form each month, stating that they will not exceed 80 km per hour, that they will use a seat belt and that they will refrain from using a mobile phone while driving. The HGVs have fleet management systems and provide feedback, although they changed this system at the time of the interviews in 2013 (cf. Section 3.3.1). The company also uses a driver instructor to provide individual and collective training in defensive driving. The drivers are paid by the hour or fixed, based on average hour estimations. Drivers are also obliged by contracts to postpone assignments if they perceived the conditions to be hazardous, e.g. due to challenging winter weather conditions. The company also has a comprehensive, formal training programme for new drivers, a functioning hazard reporting systems (avg. 400 reports per year) that is used to build a learning culture, and it carries out formal risk analyses regularly. The most important change in the company safety measures from 2013 to 2018 was that the company had updated their fleet management system to a new type.

Company B has a self-declaration that the drivers must sign and commit to upon employment. The declaration focuses on driving style and speed, stating that drivers shall follow speed limits, laws and regulations, drive defensively and carefully. The vehicles have a speed limiter which is set at maximum 84 km/h. The management also has driver interviews, which are a kind of employee interview where conditions such as driving style, safety, risk, attention and control of vehicles are discussed between the manager and the drivers (focus on the drivers' individual «control zone»). The company did not have a fleet management system in 2013, but implemented this later (cf. Section 3.3.2). This is the main change in the company's safety measures in the period. The drivers are paid by the hour, and there are different rates for distribution and long distance driving. Examples were given of drivers who were stressed due to customer pressure and in these cases, drivers were supported by middle managers. Drivers are encouraged to postpone assignments if they consider conditions to be hazardous. The company has a driver training programme for new drivers.

Company C has a policy for drivers' speed choices and driving style, and drivers are notified by the manager, if he receives reports from the public about unwanted driving style. The new vehicles have a speed limiter which is set at maximum 85 km/h. The company did not have a fleet management system in 2013, but implemented this later (cf. Section 3.3.3). This is the main change in the company's safety measures in the period. The drivers are paid by the hour or fixed. The company has a hazard reporting system, but it is not well known or used systematically by the drivers. Newly hired drivers are included in a training programme where other drivers function as their mentors.

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