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Economic driving in trucking companies a study of implementation and effects of the eco ladder for energy management

Tor-Olav Nævestad, Vibeke Milch, Jenny Blom

Institute of Transport Economics, Gaustadalléen 21, NO-0349 Oslo, Norway

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Abstract

The study examines the relationship between economical driving, energy management and (reductions in) fuel consumption in trucking companies, which have worked with eco driving and energy management through a one-year period. The companies are compared with a Reference sample of drivers from assumed average trucking companies. The study is based on survey data (*N*=366) from 14 companies and qualitative interviews (*N*=26) with managers and employees. To describe the companies' work on economical driving, we use the Eco Ladder for Energy Management, which specifies three levels for working with economic driving and energy management, with an increased scope of measures at each level. The study examines whether the companies at level 3, which have introduced the most measures aimed at economic driving and energy management, have had the largest reductions in fuel consumption. Results indicate that this is the case: The companies at level 3 have achieved approximately a 10% reduction in fuel in the study period, while the companies at level 2 have achieved lower reductions. The companies also report positive results for working environment. We argue that there are two mechanisms that explain why companies at level 3 have had the greatest effect. The first is that these companies are best at "cultivating" drivers with good scores in the fleet management system (and low fuel consumption), through systematic facilitation of an economic driving style. The second explanation is that the companies at level 3 are also best at working with other factors that affect fuel consumption, such as vehicle optimization and optimization of transport.

Previous

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Keywords

Trucking companies; Energy management; Economical driving

1. Introduction

1.1. Background

Truck transport is the dominant means of goods transport in Norway (Hovi, Caspersen, & Wangsness, 2014) and worldwide (Rodrigue, 2020). However, goods transport on roads has several negative effects in our society. Nearly 25% of energy-related global greenhouse gas emissions

come from transport and these emissions are projected to grow substantially in the years to come (UN, 2022). CO2 accounts for between 93 and 95% of the man-made greenhouse gases from truck transport (Mckinnon & Pieyck, 2009). In the 2030 United Nations Agenda for Sustainable Development, sustainable transport is mainstreamed across several sustainable development goals and targets. The importance of transport for climate action is further recognized under the United Nations Framework Convention on Climate Change (UNFCCC), and the transport sector will be playing a particularly important role in the achievement of the Paris Agreement (UN, 2022). As a result of this agreement, The EU and its Member States, acting jointly, are committed to a binding target of a net domestic reduction of at least 55% in greenhouse gas emissions by 2030 compared to 1990 (EU, 2022).

There are several different ways to reduce emissions from truck transport, such as getting more truck transport onto other forms of transport, reducing the need for transport, new systems for goods transport or new forms of production of goods, introducing alternative fuel types or energy sources, and introducing new technology that reduces vehicle energy consumption. However, such measures will require significant investments in new infrastructure, and will involve the replacement of existing vehicles. In anticipation of such measures, which have the potential to revolutionise energy use, working with economic driving and energy management in trucking companies will be an effective measure to reduce emissions from road transport (Sanguinetti, Queen, & Yee, 2020; Sullman, Dorn, & Niemi, 2015).

Most studies of economic driving with heavy vehicles show an average reduction in fuel consumption of between 5 and 10% (Ayyildiz, Cavallaro, Nocera, & Willenbrock, 2017). Some studies show larger reductions, for example around 16% in bus transport (Sullman et al., 2015) and a 27% reduction for heavy goods vehicles (Symmons, Rose, & Doorn, 2008). Economic driving is generally defined as a decision-making process that affects fuel consumption and emissions from vehicles to reduce the impact on the external environment (Sivak & Schoettle, 2012). First, we define driver-level economical driving. This is about driving style, such as low idle, smooth and low speed, as much rollout as possible, avoiding hard braking and abrupt acceleration, driving at the highest possible gear, etc. (cf. (Huang et al., 2018); Dekhordi, Larueab, Cholettec, Hesham, & Rakhadef, 2019; (Li, Vaezipour, Rakotonirain, & Demmel, 2019)). Sivak and Schoettle (Sivak & Schoettle, 2012) refer to this as economic driving at the "operational level".

In this study, however, we also define economic driving at the organisational and management level. This concerns how companies can facilitate an economic driving style among their own drivers, for example by installing fleet management systems that record the aforementioned aspects of an economic driving style, and facilitating systematic use of it through feedback, training, bonuses, etc. (Nævestad & Hagman, 2020).

Companies can also work more holistically with their energy use, and focus on factors additional to driving style, by implementing an energy management system (e.g. ISO:50001). Although there are few scientific studies of such measures, "business cases" indicate that companies may achieve around 20% energy reduction by implementing energy management systems, even more than is usually achieved by focusing solely on driving style (FCC Environment (*FCC environment 50001 business case*, 2000)). However, systems for energy management like ISO:50001 seem to be relatively complicated and resource-intensive.

Previous research shows that it is difficult for trucking companies to start implementing systems for economic driving and energy management (Díaz-Ramirez et al., 2017). Such systems often require considerable resources and expertise at various levels, and this can be a challenge for many trucking companies, because they are small. In Norway, 86% of them have fewer than five employees, while 80% have fewer than 10 employees at the EU level (Nævestad, Phillips, & Elvebakk, 2017). It is reasonable to think that small trucking companies have fewer resources (time, economy, expertise) than larger companies, and that this may pose a significant barrier to introducing systems for energy management and economic driving at the organisational level.

In a previous study, we therefore developed a simplified and research-based ladder model for how trucking companies can work with economic driving and energy management at the organisational level (Nævestad & Hagman, 2020). We call the model the Eco Ladder for Energy Management. The Eco Ladder describes an approach with the gradual introduction of specific measures, where companies will start with the measures that have the greatest effect and are easiest to implement, before moving on to the next level. The idea behind the Eco Ladder is that it should provide a set of simple and concrete management practices. The Eco Ladder has three levels, which describe specific management practices at each level.

However, the approach in the Eco Ladder has not been tested in empirical studies before. We do not know what the management practices in the Eco Ladder entail in practice in Norwegian trucking companies, or how much effect they have. We do not know if companies that have implemented many of the measures in the Eco Ladder have experienced greater reductions in fuel consumption than those who have implemented few of the measures, or whether some of the measures are more important than the others. We also do not know whether it is actually the case that the measures at the top level in the Eco Ladder have the greatest effect on fuel consumption and energy use in a Norwegian context.

In the present study, we try to obtain answers to these questions from a sample of Norwegian trucking companies that were supported financially by Enova to work on economical driving. Enova is a Norwegian government enterprise responsible for promotion of environmentally friendly production and consumption of energy. In the period –2012-2018, Norwegian trucking companies could apply to

Enova for financial support for measures aimed at economic driving through Enova's programme for energy management in land transport. The energy management program is based on the ISO standard for energy management: ISO:50001. Almost 100 companies applied during the project period, most with assistance from the Norwegian Truck Owners' Association (NLF). Companies could opt for a simplified version of the energy management programme, or an ambitious version of the energy management program. Most chose the simplified version, which is mainly about implementing and using fleet management systems. A few companies chose the ambitious version, which corresponds to an energy management system of type ISO:50001. In the present study, we use the Eco Ladder for energy management (cf. Section 1.3) to categorize the participating companies' measures. These were typically implemented in the “Enova campaign period”, which generally lasted for one year. Companies were committed to reporting results to Enova in the end of this period.

1.2. Aims of the study

The main aims of the study are to:

1) Examine the transport companies that were supported by Enova's measures to implement economic driving and energy management, and classify the companies at different levels in the Eco Ladder, and.

2) Examine the results (fuel reductions, economy, drivers perceived stress and time pressure) of the measures taken by companies at the various levels of the Eco Ladder.

When examining measures and outcomes we focus on the periods that the companies received financial support from Enova to work with economic driving and energy management. We refer to this as the Enova “campaign period”.

1.3. The Eco ladder for energy management

Based on previous research in Norway and internationally, we have concluded that three main measures aimed at economic driving and energy management have the greatest potential and are most realistic to implement for ordinary trucking companies (Nævestad & Hagman, 2020). These measures can be arranged on a ladder (cf. Fig. 1), where you start at the lowest level, before proceeding to the next step. Each step involves increased management measures and reduced fuel consumption. In contrast to the other three levels, we have also included a “level 0” in the model, which denotes a “traditional attitude” to fuel consumption. This attitude involves managers and drivers thinking that “the vehicle uses the fuel it has to use”, and that the drivers' driving style has little influence. Experts interviewed believed that this “traditional” attitude was the norm before, and that it still exists in several transport companies today (Nævestad & Hagman, 2020).

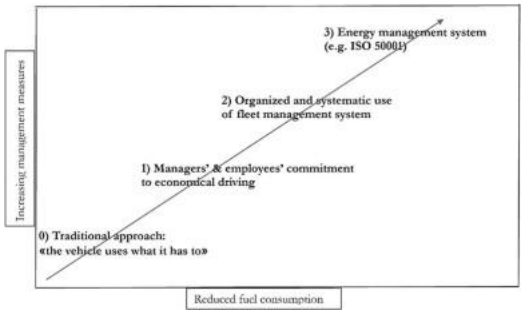

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Fig. 1. The Eco Ladder for management.

Level 1 refers to the commitment of managers and employees to economical driving, since this is a prerequisite for the introduction of organisational measures aimed at economic driving and a system of energy management. Since the introduction of such measures requires considerable resources, it requires a significant commitment from both managers and employees.

Level 2 refers to organised and systematic use of fleet management systems to record and map the driving style of the drivers, and systematic measures to facilitate economic driving through the use of such measures. The use of fleet management technology is the most fundamental element of companies' measures on economical driving. However, it is not sufficient only to have the technology present in the vehicles: the technology must also be used in an organised and systematic way. Individual feedback to drivers about their scores in the fleet management system is fundamental, so they can learn from it and change their driving style. In addition, training of drivers in an economic driving style is important. Various incentives (competitions and bonuses) to change driving style and achieve high scores also seem to be important measures.

Level 3 refers to system of energy management of type ISO:50001, or implementation of the most important principles in such systems, e.g. explicit goal for energy use reduction, analysis of current energy usage, implement measures to reduce fuel consumption, establish KPIs, follow up in line with the Plan-Do-Check-Adjust cycle of continuous improvement. Measures at this level are related to optimization of vehicles, equipment and transport routes and arrangements. This level is important, because it is the level that is believed to lead to the largest reductions in fuel consumption for trucking companies. At the same time, this system level is the most demanding to work with, because it requires systematic analyses of large amounts of data, and continuous follow-up and improvement. Specific management practices for each level in the Eco Ladder is provided in Table 1.

Table 1. 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 economical 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 economical 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 optimizing vehicles and equipment.
	4	The company maps transport and works actively to optimize routes and organize 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.

2. Previous research

2.1. Organisational environment management

The focus in the present study is on organisational environmental management (OEM), which we define as the combination of measures focusing on environment structure and environment culture. Environment structure refers to the formal aspects of environmental management ("how things should be done") as described in procedures, routines and organisational charts, etc. These aspects are often referred to as environmental management systems (EMS), aiming to aim to reduce the environmental impact of organisational activities (Johnson, Johanson, Anderson, & Södahl, 2013; (Comoglio et al., 2012)). There are several different EMS available, which can also be used in transportation. In the road sector, ISO 50001 and ISO 14001 represent the most relevant examples of international EMS standards, which focus on energy and the environment, respectively.

Environment culture refers to the informal aspects of environmental management ("how things are actually done") (cf. Antonsen, 2009). We define environment culture as shared ways of thinking and acting that are relevant for environmental issues, e.g. energy use, waste management (cf. Nævestad, 2010). This can be measured quantitatively as managers' and employees' perceived focus on energy management in the organisation. Qualitative studies of environment culture focuses on shared frames of reference which provides ways of seeing, which motivate and legitimize certain work practices, thereby proving norms for the preferred ways of doing things, influencing identities, regulating emotions etc. (Antonsen 2009; Nævestad 2010).

Below, we present previous research relevant to aim 1, which is to examine the transport companies' measures to implement economic driving (Level 2 in the Eco Ladder) and energy management (Level 3 in the Eco Ladder).

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 (Ayyildiz et al., 2017; Díaz-Ramirez 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 heavy goods vehicles (HGVs) measure a number of characteristics of the drivers' driving style, which are combined into five or six main aspects, to which the fleet management systems provide feedback (e.g. idling, anticipatory driving, braking, roll out, cruise control use and speed) (Nævestad, Blom, & Phillips, 2018; Walnum & 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 (Nævestad & 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 aspects measured in the fleet management system also measures a safe driving style. Experts interviewed by Nævestad and Hagman (Nævestad & 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 (Nævestad & Hagman, 2020). 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 calculations of the drivers' scores in the system are based on a number of different limit values, defining their fleet management system scores (for example for the number of hard decelerations, proportion of time at idle, proportion of time with 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. However, there are settings for this in the system, for example for long-distance transport and distribution driving. Another measure for 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 economical driving. Most studies of economic driving with heavy vehicles include some form of training of drivers in economic driving style (Strömberg & 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 (Ayyildiz et al., 2017; Díaz-Ramirez et al., 2017). The reason is that drivers' motivation is a fundamental factor for economical driving (Liimatainen, 2011). 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 (Ayyildiz et al., 2017; Díaz-Ramirez et al., 2017; Nævestad et al., 2018).

Implementation of the ISO 50001 standard or similar energy management systems involves the creation of a formal organisational energy policy with defined goals for reduced consumption, energy planning for how the goal is to be achieved and methods for monitoring one's own goal achievement, continuous monitoring of the situation using an internal audit system, measurement and analysis, identification of discrepancies, followed by corrective and preventive measures to ensure goal achievement (Johnson et al., 2013). The key element in EMS is the continuous improvement, achieved through the Plan-Do-Check Act (PDCA) (Comoglio et al., 2012).

2.2. Effects of economic driving and energy management

In this section, we present previous research relevant to aim 2, which is to examine the results of trucking companies' measures aimed at economic driving and energy management. Studies of economic driving in truck transport find reductions in fuel consumption of between 5 and 9% (Pinchasik, Hovi, Bø, & Mjøsund, 2021), 9.5% Thijssen and Hofman (Thijssen & Hofman, 2014), 6.8% (Díaz-Ramirez et al., 2017), 5.5% Ayyildiz et al. (Ayyildiz et al., 2017), 13.6% (immediately) and 4% (after three months) (Zavalko, 2018), between 5 and 15% Boriboonsomsin (Boriboonsomsin, 2015), 27% (Symmons et al., 2008). Studies focusing on bus transport are also relevant, because buses 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, Baptista, Duarte, Farias, & Shiftan, 2014), 6.8% (Strömberg & Karlsson, 2013), 4.4% (Zarkadoula, Zoidis, & Tritopoulou, 2007) and 2% (Af Wåhlberg, 2007).

Against this background, we can conclude that studies examining the effects on fuel consumption with heavy vehicles generally find reductions between 5% and 10%. In their meta-study of fleet management systems, which also includes passenger cars, Sanguinetti et al. (Sanguinetti et al., 2020) find a weighted average effect of a 6.6% reduction in fuel related to the introduction of fleet management systems. The figure is based on 17 studies and 23 effects.

There are very few scientific studies of companies that have introduced ISO:50001 energy management systems. However, we are familiar with “business cases” from companies that have introduced ISO:50001, and these often report around 20% reductions in energy use (*FCC environment 50001 business case*, 2000). This case study is from a company which also is involved in transport. Energy management systems focus on more factors influencing fuel consumption than driving style, optimizing e.g. vehicles, equipment and transport routes. Previous studies indicate that these factors have a greater impact on fuel consumptions than driving style (cf. (Ayyildiz et al., 2017; Sivak & Schoettle, 2012; Walnum & Simonsen, 2015)).

There are few to none studies of effects on working environment of measures focusing on economic driving and energy management. It should however be mentioned that the study of Nævestad and Blom (Nævestad et al., 2018) report of less perceived stress and time pressure and subsequently less sick leave among drivers following from economic driving measures. Other studies also examine the relationship between time pressure and economical driving, concluding that the former may hamper the latter (Ayyildiz et al., 2017; Strömberg & Karlsson, 2013).

2.3. Hypotheses

The aims of this study are to: 1) Examine the transport companies that were supported by Enova's measures to implement economic driving and energy management, to classify the companies at different levels in the Eco Ladder, and 2) Examine the results of the measures taken by companies at the various levels of the Eco Ladder. In the study, we classify the companies' measures according to the Eco Ladder. These are the measures that the companies implemented when they received support from Enova (typically through a one-year period). Based on the above-mentioned previous research, we hypothesize that the companies located at the top level of the Eco Ladder (i.e. with the most comprehensive implementation of measures) have:

1) The largest decreases in fuel consumption (*Hypothesis 1*).
2) The greatest degree of perceived focus on economic driving ("Environmental Culture") among drivers (*Hypothesis 2*).
3) The highest proportion of drivers with top scorers in the fleet management system that the company uses and lowest fuel consumption (*Hypothesis 3*).
4) The best results for working environment; e.g. lower levels of perceived stress and pressure among the drivers (*Hypothesis 4*).

Thus, the hypotheses concern the relationship between the level of implementation of measures (cf. aim 1) and results (cf. aim 2) based on previous research.

3. Methods

3.1. Design of the study

The study is based on two methods and data sources. The first is qualitative interviews with 26 company representatives: We interviewed 16 managers and 10 representatives of employees in 14 trucking companies in companies that have received support from Enova to work on economic driving. We used information from the interviews to categorize and rate the work on economic driving in the companies and place them at a level in the Eco Ladder. The second method is survey among drivers in 14 companies that have received support from Enova (N=225) to work on economic driving, and a Reference group (N=169) of drivers from supposedly average companies. We used the survey results to test our hypotheses among drivers in different companies that were placed at different levels in the Eco Ladder based on the interviews.

3.2. Qualitative interviews

3.2.1. Topics

The interviews were conducted over the telephone, and they lasted mostly between 60 and 90 min. The main purpose of the interviews was to obtain information about how companies work with economic driving and energy management, and their perceived results of this.

We started by asking about the company: the number of employees, what is transported, etc. Then we asked when the company began using economical driving/energy management, its motivation and important players in the use of these. We then asked which elements are the most important in the company's measures for economical driving, for example: goals, policies, fleet management systems, feedback to the drivers, training for improvement (from supplier, in-house, others), work with engagement, motivation and knowledge, competitions and bonuses. The purpose of this was to get sufficient background information to place the companies at a level on the Eco Ladder for Energy Management (Nævestad & Hagman, 2020) (cf. criteria in Table 1). We placed great emphasis on obtaining specific examples of practices in the companies; how often particular practices and incidents occur. We also asked for more detailed examples of the situations, how often certain events happen in a year etc. This information is important in order to analyse the results from the companies and place them at the right level.

We then asked about perceived results of the work of economic driving and energy management, on fuel consumption, company economy, drivers' driving style, road safety, accessibility, company reputation, drivers' well-being, drivers' perceived stress and time pressures, sick leave, costs of tyres, costs of maintenance and culture. We also asked for certifications related to energy management, safety management etc.

3.2.2. Qualitative analysis

We classify the companies at the Eco Ladder to map their level of measures related to economic driving and energy management in the "Enova campaign periods". We place the companies on the Eco Ladder for Energy Management based on criteria that we give the companies points for. The Eco Ladder for Energy Management has three levels but we only operate with criteria for levels 2 and 3. Level 1 is "Management and employee commitment to economic driving", which is a precondition for level 2 and 3. As we are interested in the actual implementation of measures at level 2 and 3 (these are the ones that give results), and as the implementation and use of measures at these level is a good indicator of commitment to economic driving and energy management (level 1), we do not use criteria for level 1 in the Eco Ladder. Table 1 presents 10 criteria. If we divide 10 points into a three-level scale, we might assume that level 2 companies score between 3.5 and 6.7 points, and that level 3 companies score between 7 and 10 points. It is important to accept that these criteria must not be interpreted "mechanically".

The criteria are used to obtain a simplified overview. In some cases, we give the score 0.5. This means that the company to some extent meets the criterion, or meets parts of it.

3.3. Quantitative survey

3.3.1. Recruitment of trucking companies

We asked all 100 companies that had received financial support from Enova for the Energy Management Program to participate in our study, and we worked to recruit companies and respondents to the study over a period of about six months. In an attempt to get a high response rate from the drivers in the companies that participated in the survey, we informed the respondents that we were drawing winners of two gift cards of NOK 3000 each among those who responded to the survey. Those who provided their name or telephone number at the end of the survey had the opportunity to participate in this draw.

3.3.2. The reference sample

Since the purpose of our study was to compare companies at different levels of the Eco Ladder for Energy Management (companies that have received support from Enova) with companies that work less with economic driving and energy management, we needed to "balance" the data by also including drivers from more "average" Norwegian trucking companies. One possible option could be to try to recruit companies from what we refer to as "Level 0". However, in previous research we have found that such recruitment works poorly, because there is often a strong correlation between working actively on a particular issue and wanting to participate in a survey on the same issue. Our contact person in a drivers' union suggested that organised drivers from companies without a collective agreement would correspond to a relatively good "industry average". and that these would be closer to what we could assume would be the average for Norwegian truck transport than the respondents we already had in the survey. In this way, we could better balance our sample and have better opportunities to test our hypotheses. Since this assumption proved correct in an earlier survey (Nævestad & Milch, 2020), we chose the same solution to balance our sample in the present survey. We refer to the respondents from companies without collective agreements as "The Reference Sample".

3.3.3. Characteristics of the respondents

3.3.3.1. Response rates at the different levels of the Eco ladder

We have classified eleven companies at level 2 in the Eco Ladder, and three companies to be at level 3 in the Eco Ladder. Table 2 shows the response rates in companies at the various levels of the Eco Ladder. The response rate is based on the number of drivers the survey was sent to in the company.

Table 2. The response rates in companies at the various levels of the Eco Ladder.

	Number	Percent
Reference	169	24%
Level 2	115	39%
Level 3	82	40%
Total	**366**	30%

Table 2 shows that the survey has a general response rate of 30%. However, Table 2 indicates that the response rate would be around 40% if we disregard the Reference Sample.

3.3.3.2. Respondents at the different levels

Table 3 shows the respondents' age broken down by group.

Table 3. Respondents' age distributed on the different levels in the Eco Ladder for energy management.

	<26years	26–35	36–45	46–55	56+	Total
Reference	8%	20%	26%	29%	18%	169
Level 2	10%	29%	24%	26%	12%	115
Level 3	16%	15%	32%	24%	13%	82
Total	10%	21%	27%	27%	15%	**100%**

	<26years	26–35	36–45	46–55	56+	Total
Total	37	78	97	99	55	**366**

We do not see a clear pattern when we look at the age distributions between the groups, except that the proportions in the youngest group are twice as large in the companies at level 3 as in the Reference Sample. A chi square test shows that the differences are not significant (P=0.154). It should also be mentioned that 6% of the respondents are female.

Respondents at the different levels on the Eco Ladder are relatively comparable when it comes to the types of transport that they are involved in. Looking at long distance transport, the shares are 29% (Reference), 37% (Level 2) and 24% (Level 3). The shares for distribution transport are 25% 20% and 21% respectively, while it is 17%, 16% and 27% for regional transport, respectively and 29%, 28% and 28% respectively for mixed transport.

3.3.4. Topics in the survey

1) **Background questions.** The survey includes eight background questions: Sex, age, experience, seniority in the company, number of 1000km of heavy vehicle driving over the past two years, what kind of transport drivers work with the most (long-haul transport of goods, distribution, regional transport, all three), industry type (construction, timber, piece goods, ADR, bulk, thermo, other), the nationality of the drivers.

2) **Training in economical driving.** The survey contains five questions about training in economical (and safe) driving, including drivers' perceived effects of such training.

3) **The use of fleet management systems and cruise control.** We also ask the respondents if they use a fleet management system. We ask those who answer yes to consider the following questions:

- I pay attention to my scores/marks in the fleet management system
- I change aspects of my driving style to improve my scores/marks in the fleet management system
- I follow the instructions of the fleet management system while driving
- I use the fleet management app on my phone.

The response options range from: 1) never/not applicable, 2) Monthly, 3) weekly, 4) daily to 5) several times a day. We merge these questions into a sum score index that measures active use of fleet management systems (min: 4, max: 20 points). (Cronbach's Alpha: 0.801). We also ask the respondents to describe their score/mark in the fleet management system. Five answer alternatives ranged from scores equalling E (lowest) to A (highest).

4) **Measures aimed at economic driving and energy management in the respondent's own company.** Five statements measure this:

- We have a clear goal for reduced fuel consumption
- Management regularly provides information on how we are doing in relation to the goal of reduced fuel consumption
- Drivers regularly receive information about (other drivers in the company's) high and low scores/marks from the fleet management system
- Management weekly surveys drivers' scores for economic driving
- Drivers get a bonus/reward for reducing their fuel consumption

Answer alternatives range from 1 (totally disagree) to 5 (totally agree). We merge these into a sum score index that measures (formal aspects of) environmental management (min: 5, max: 25). (Cronbach's Alpha: 0.780). We also use a short environmental management scale, in the analyses of factors predicting driver's use of the fleet management system. This index is comprised of two statements

- We have a clear goal for reduced fuel consumption
- Drivers regularly receive information about (other drivers in the company's) high and low scores/marks from the fleet management system

Answer alternatives range from 1 (totally disagree) to 5 (totally agree). We merge this into a sum score index (min: 2, max: 10) (Cronbach's Alpha: 0.610).

5) **Environmental culture in the respondent's own company.** The survey contains four questions about environmental culture in the respondents' own company. The purpose of these questions is to measure informal aspects of energy management and economic driving in the companies: how managers and employees actually work with this on a daily basis. We measure this with the following questions:

- Management often gives praise to drivers who have an economic driving style
- Management often emphasizes that we must have as low fuel consumption as possible
- In my company it is considered high status to have an economic driving style
- Drivers in my company compete over who has the most economic driving style

Answer alternatives range from 1 (totally disagree) to 5 (totally agree). We merge these into a sum score index that measures (formal aspects of) environmental management (min: 4, max: 20). (Cronbach's Alpha: 0.780).

6) **Working conditions.** The survey also contains questions about the extent to which drivers experience customers pushing and stressing drivers; the extent to which customers emphasise safety over deadlines; working environment, pressure and stress from managers. We have made an index based on three statements:

- In my job, I experience that customers push/stress drivers
- In my job I experience that managers push/stress drivers
- In my job, I experience that time pressure and deadlines can affect road safety.

Answer alternatives range from 1 (totally disagree) to 5 (totally agree). We merge these into a sum score index that measures work stress and pressure (min: 3, max: 15) (Cronbach's Alpha: 0.819).

7) **Perceived results of work on economic driving in the respondent's own company,** e.g. stress and time pressures in the work, dangerous situations in traffic, the reputation of the company.

3.3.5. Quantitative analysis

We have carried out two regression analyses. Regression analysis is a multivariate analysis used to calculate the effects of various independent variables on a single dependent variable. In the first regression analysis, we examine factors influencing drivers' scores in the fleet management system. In the second, we examine factors influencing drivers' use of fleet management systems. When including variables in the regression analyses, we include independent variables stepwise in different models. In the first models we, include variables that are related to the individual drivers, e.g. their experience, age, type of transport, before including variables related to organisational factors (e.g. environmental management, bonus, training, whether drivers compete to get high fleet management system scores etc.) and other work related factors (e.g. perceived work pressure and stress). The purpose of this is to try to identify the most important management practices in the Eco Ladder. We have used linear regression in the analyses, since these dependent variables are continuous. The regression analyses show the effects of the independent variables that we include, controlled for the other variables in the analysis. It must be pointed out that we cannot say anything about causality in these analyses, and that some of the connections we see may be due to so-called “un-measured” third variables.

4. Results

4.1. Mapping measures on economic driving and road safety

The first aim of the study is to map managerial practices related to economic driving and energy management in the companies that have been supported by Enova to work with economical driving, and place them at a level on the Eco Ladder. Based on the interviews, we classified eleven companies at level 2 in the Eco Ladder, and three companies to be at level 3 in the Eco Ladder. In the following, we describe the measures implemented by the companies at each level, before we test our hypotheses in 4.2 Decreases in fuel consumption, 4.3 Perceived focus on economic driving and energy management, 4.4 Percentage of drivers with top score, 4.5 Effects on drivers working environment, 4.6 Multivariate analyses.

4.1.1. Companies' systematic use of fleet management system

The most important eco driving measure in all the studied companies is the fleet management system which registers the drivers' driving style and which generates feedback to the drivers. All the studied companies have fleet management system in all or most of their vehicles. In the companies studied, the fleet management system is almost synonymous with measures aimed at economical driving. The systematics and frequency of the feedback to the drivers about their driving style from the fleet management system vary between the companies. In some companies there are no fixed routines for feedback to the drivers, in other companies the drivers receive feedback from the management on their driving style every week. The companies at level 3 are the ones that had the most frequent intervals with feedback on scores from managers to drivers.

Managers from Company L and I provided examples from their companies:

"I post a list of the individual vehicles in the house. There are regular drivers on each vehicle; they each know who they are [on the list]. I post the list in the dining room. At the same time, they have apps where they see what ranking they have. It is anonymized, so they do not see the names of the others, but they can see where they are on the list" (Manager, Company L).

"We only write the car number of the one that is best. (…) Every Monday we post the one that scores best on idle, driving style, which has least over speed and lowest diesel consumption. Everyone wants to take part in the competition. (…) Someone always comes by and asks how far they were from the top score. They ask, and it creates discussion between them." (Manager, Company I).

Results also indicate that training in economic driving from one's own company was particularly important among the respondents at level 3, and these drivers often also received other types of training, e.g. from car supplier or hired consultants. The results also show that more or less informal competitions between drivers are an important tool in the companies studied. Additionally, the results show a clear trend of increased use of bonuses to reward drivers' reductions in fuel consumption, for companies at each level on the Eco Ladder. The companies had many different schemes, with more or less complex bonus packages. These could be individual and or collective, and reward different aspects of both safe and economic driving style.

4.1.2. Energy management system

The Enova energy management scheme recommended an explicit goal of 10% reduction in fuel consumption in each company's one-year Enova “campaign period”. The results from the interviews show considerable variation when it comes to the companies' goals for fuel reduction. First, not all the studied companies had an explicit goal of reducing fuel by a certain proportion. Second, we found that among those who had explicit targets for reduction, not everyone had targets for a 10% reduction in fuel. Five companies had a 10% target for reduced fuel consumption in their Enova “campaign period”. Three of these are at level 3, and they more or less reached their explicit goals of reductions in fuel consumption. Several companies had lower goals. Third, it must be mentioned that several of the companies also focused on other goals than measuring fuel directly, such as reducing idling.

Defining a number of different parameters (KPIs) that are linked to the goal is the second important parameter in the energy management system. This requires an overview of key figures. Interviews indicate that especially the companies at level 3 continuously monitor, for example: a) drivers' driving style and scores for the parameters in the fleet management system, b) vehicle parameters (engine, tires, axles, software), c) cargo / tonnage, d) roads, road types, kilometers driven, topography, fall/inclination and not least the regularity of the routes for the drivers. These are some of the factors that affect the goal of reduced fuel consumption and other performance parameters, such as injuries/accidents, maintenance costs, tires, etc. The manager of Company O said that:

"We actively use statistics: accounting per car, and we make comparisons between cars, when it comes to fuel, repairs and tire consumption. It is thought-provoking that people do not keep active statistics. There is a lot that is done on the heel in the transport industry. There are great values at play, with a seemingly poor plan." (Manager, Company O).

Having an energy management system requires an overview of the key figures. All three companies at level 3 have a relatively good overview of the key figures related to energy management in their company. Some of the companies at level 2 also have an overview of some of the key figures.

The companies at level 3 also spend a lot of time optimizing vehicles, based on a recognition that driving style is only one of several factors that affect fuel consumption. Optimizing vehicles concerns getting the optimal engine size for a specific type of driving (i.e. distributing or long distance transport, hilly terrain, heavy loads etc.). An interviewed manager from company N, which has over 140 vehicles, stated that:

"Yes, he [the general manager] has done a systematic job. He has found the most economical engines, and then he has systematically replaced the large engines with smaller engines. In addition, the engines are adapted to the type of driving for which they are to be used; that is, whether it is distribution driving or long-haul transport" (Manager, Company N).

Companies at level 3 in the Eco Ladder also work actively to optimize driving routes and organize transport. This involves, for example, choosing routes that involve as low a consumption as possible, and having a good overview of where the vehicles are, so that the nearest vehicle can drive to where goods are to be picked up. The purpose of this measure is “to transport as much goods as possible for the fewest km”. Comprehensive analyzes of the company's energy consumption also involve analyses of other forms of energy consumption than fuel consumption, e.g. related to buildings, in line with a holistic approach to energy use that is part of the ISO: 50001 approach.

4.2. Decreases in fuel consumption

Our first hypothesis is that companies located at the top level of the Eco Ladder, and which have implemented most measures in the Eco Ladder in the Enova campaign period, have had the largest declines in fuel consumption. Our results largely support Hypothesis 1. The three level 3 companies experienced about a 10% reduction in consumption in a year, and several also experienced significant reductions after the period in which they received support from Enova.

A total of eleven companies was defined at level 2. One of the companies at level 2 experienced a >10% reduction, while the other companies at level 2 mentioned reductions that were lower than this. Not all the companies had specific numbers on reductions. Results are summed up in Table 4.

Table 4. Goals for reduced fuel consumption and results among the companies at different levels in the Eco Ladder for energy.

Eco Ladder level	Goals for reduced fuel consumption	Results for the one year "Enova campaign period"
Level 2 (11 companies)	Five did not have an explicit goal of 10% reduction in fuel consumption, but rather a general goal of reduced consumption. Three had reduced idling as a goal. Two had 10% fuel reduction as a goal. One company had no explicit goal with a given per cent reduction	Five companies reported a perceived lower consumption, but were unable to specify how much. Two were uncertain. There were three companies which specified the reduction in fuel consumption: one specified 3–5% reduction, another 5–6% and a third company reduced fuel consumption by 11%.
Level 3 (3 companies)	All three companies had 10% reduction as a goal	All three companies reached their 10% goal, although one was slightly below, with 9.8%.

4.3. Perceived focus on economic driving and energy management

Our second hypothesis is that companies located at the top level of the Eco Ladder, and which have implemented the most measures, have the greatest degree of perceived focus on economic driving among drivers. We measure this with indexes for environmental structure and environmental culture (cf. Section 3.3.4). The formal side (structure) is about what the organisation says it should do (formally) and what is explicitly stated in documents and plans, while the informal side (culture) is about what is actually done in the organisation on a daily (informal) basis.

The survey includes five questions that measure environmental structure, e.g. "We have a clear goal for reduced fuel consumption", "Management checks employees' economic driving scores every week", "Drivers regularly receive information about high and low scores/marks from the fleet management system" We have created an environmental management index based on these questions (Cronbach's Alpha: 0.780).

We have also created an index that measures the informal aspects of environmental management in the companies. The environmental culture index consists of four questions that deal with the actual day-to-day focus on economic driving style, e.g. "Management often gives praise to drivers who have an economic driving style", "In my company it is considered high status to have an economic driving style", "Drivers in my company compete over who has the most economic driving style" (Cronbach's Alpha: 0.831). Respondents' scores on the indexes for environmental management and environmental culture are shown in Fig. 2.

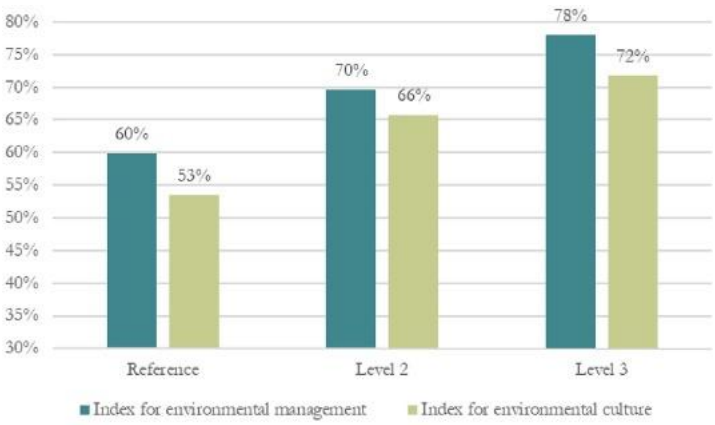

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Fig. 2. The respondents' scores on the indexes for environmental management and environmental culture. The Reference Group (N=169, Level 2 (N=115), and Level 3 (N=82).

As the maximum scores of the indexes are different, we show percentages of maximum scores for each index.

Fig. 2 indicates increase in the scores of the indexes for each level of the Eco Ladder, and that the companies that are at the highest level on the Eco Ladder have the highest scores on the indexes. This means that respondents at the highest levels of the Eco Ladder report the highest number of measures in their companies, and the highest perceived daily focus on economic driving and energy management in their companies. We use one-way ANOVA tests to compare whether the mean scores are significantly different. The mean scores between the different levels are significantly different on the index for environmental management ($P<0.001$) and the index for environmental culture ($P<0.001$). These results support Hypothesis 2.

4.4. Percentage of drivers with top score

Our third hypothesis is that the companies at the top level of the Eco Ladder have the highest proportion of drivers with top scores in the fleet management system, because they have the most measures to facilitate economic driving and energy management. Scores in the fleet management system measure driving style, and these scores are a relatively good proxy for fuel consumption, indicating an 11% reduction in fuel use if a driver improves from an E score (lowest level) to an A score (highest level).

Fig. 3 shows that 86% of respondents in the level 3 companies have a score equivalent to A or B. This is higher than Level 2 respondents, and Reference group respondents. We also see a pattern with increasing shares of A scores in the fleet management system ranging from the Reference group to Level 3. Chi square test show, however, that the differences between the groups are not statistically significant ($p=0.146$). Thus, the survey data do not support Hypothesis 3. In the interviews, most company representatives at both level 2 and 3 emphasised that average scores in the fleet management system improved significantly since they started working actively on economic driving. We do, however, not have an overview over the scores in all studied companies, as information were lacking about this. Good scores were, however, mentioned by interviewed level 3 company representatives, and these drivers had the lowest fuel consumption, as assumed in Hypothesis 3. (The representative from Company M stated for instance that in his company, there were 10% A level drivers and 80% B level drivers.) Thus, qualitative data seem to support Hypothesis 3.

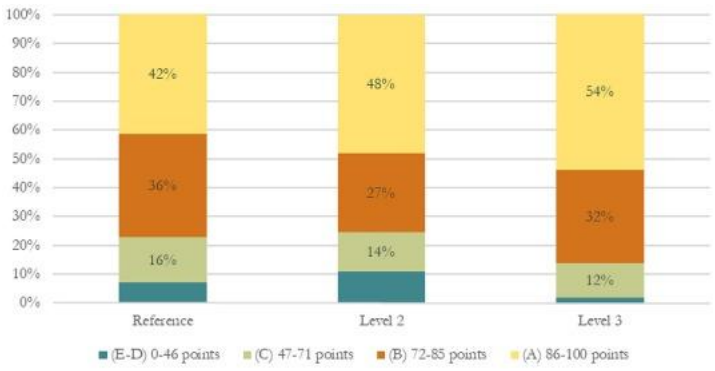

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Fig. 3. Respondents' responses concerning their own scores in the fleet management system. The Reference Group ($N=89$), Level 2 ($N=81$), and Level 3 ($N=59$).

It can be noted that Fig. 3 indicates a bias with respect to fleet management system scores in the Reference sample. This group has 78% A and B scores. In a typical industry average, the driver scores would have been more normally distributed around score C, according to the manufacturers of the systems. We expand more on this in Section 5.4.

4.5. Effects on drivers working environment

The fourth hypothesis is that drivers at the top level of the Eco Ladder report the best results for the working environment Fig. 4 shows the results for five statements related to this. The Reference group is not included in the Figure, as the questions only were directed to respondents in companies that had received support from Enova to work with economic driving.

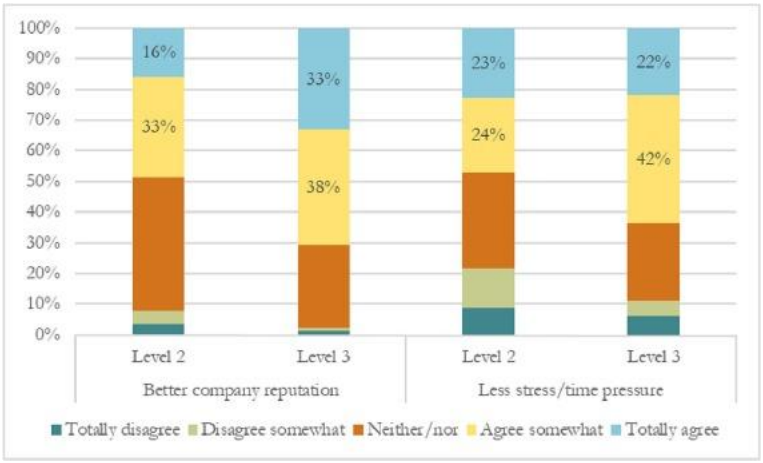

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Fig. 4. As a result of the company's economic driving measures: 1) The company's reputation has improved, 2) I experience less stress and time pressure in my work. Level 2 (N=81), and Level 3 (N=59).

We see that respondents in the companies supported by Enova believe that the company's work with economic driving has made them become prouder as drivers (58% agree in total), that the company has gained a better reputation (57% agree in total) and that they experience less stress and time pressure in their work (54% agree in total). Chi square test show that the differences between the shares agreeing at level 2 and 3 are statistically significant for the statement about company reputation ($p<0.01$) and the statement about stress and time pressure ($p<0.01$). Thus, our data support hypothesis 4, because the proportions who agree with the statements are significantly higher among companies at level 3 than at level 2.

4.6. Multivariate analyses

4.6.1. What explains drivers' scores in the fleet management system?

Scores in the fleet management system measure driving style, and these scores are a relatively good proxy for fuel consumption, indicating an 11% change in fuel consumption from score E to score A in the fleet management system. In Table 5, we conduct multivariate analyses to take a closer look at factors influencing drivers' scores in the fleet management system.

Table 5. Linear regression. Dependent variable: Drivers' scores in the fleet management system. Standardised beta coefficients.

Variable	Mod. 1	Mod. 2	Mod. 3	Mod. 4	Mod. 5	Mod. 6	Mod. 7
Experience	−0.022	−0.020	−0.032	−0.043	−0.045	−0.045	−0.046
Long-distance transport		−0.044	−0.050	−0.050	−0.028	−0.028	−0.028
Pressure and stress			−0.090	−0.078	−0.095*	−0.096*	−0.096*
Environmental management				0.185***	0.090	0.091	0.091
Fleet management use					0.446***	0.446***	0.447***
Additional training						−0.003	−0.003
Bonus for financial							−0.004
Adjusted R^2	−0.004	−0.006	−0.002	0.029	0.218	0.215	0.212

* $p<0.1$** $p<0.05$ *** $p<0.01$.

The first and most important result shown in the table is that drivers' active use of fleet management systems is the variable that has the greatest impact on their scores in the fleet management system. This variable is an index consisting of four statements about drivers' use of fleet management systems, e.g. whether they keep track of their scores/marks in the fleet management system, change driving style to improve scores/marks, follow the instructions from system while driving (cf. Section 3.3.4). Answer alternatives ranged from never/not applicable to several times daily.

The second main result is that environmental management contributes positively to drivers' scores. Environmental management is a sum total scoring index consisting of five statements (cf. Section 3.3.4) on measures on economic driving and energy management at the company level (cf. Fig. 2). The positive correlation we see suggests that drivers who are employed by companies that score high on this index (and thus have implemented more measures aimed at economical driving) tend to have higher fleet management system scores than drivers who work in companies with fewer measures implemented. We also see that the effect of the variable environmental management is removed when we include the variable fleet management use. This is probably due to the fact that the two variables are strongly correlated; because an important purpose of environmental management measures is to help drivers with their use of the fleet management system and help them to achieve high scores.

The third main result is that the variable "pressure and stress" contributes significantly at the 10% level and slightly negatively to scores in the fleet management system. This variable consists of three statements that are combined into an index measuring whether customers push/stress drivers, managers push/stress drivers, and whether time pressures and deadlines can affect road safety (cf. Section 3.3.4). Agreeing with these statements is related to lower scores in the fleet management system when we control for the other variables in the model. This indicates that stress and pressure is a factor that can hamper the work of economical driving.

The adjusted R^2 value in Model 8 is 0.212, which suggests that the model explains 21% of the variation in drivers' self-reported scores in the fleet management system.

4.6.2. What influences drivers' active use of fleet management systems?

In the analyses of factors influencing drivers' scores in the fleet management system in Table 2, we saw that their active use of the fleet management system was the most important variable. In Table 6, we examine factors influencing this variable.

Table 6. Linear regression. Dependent variable: Drivers' use of the fleet management system. Standardised beta coefficients.

Variable	Mod. 1	Mod. 2	Mod. 3	Mod. 4	Mod.5	Mod. 6	Mod. 7	Mod. 8
Ages 36–45	**0.165*****	**0.168*****	**0.158*****	**0.158*****	**0.158*****	**0.153****	**0.143****	**0.143****
Thermo-transport		0.097	0.088	0.075	0.076	0.062	0.076	0.076
Short environmental management scale			**0.273*****	**0.264*****	**0.263*****	**0.200*****	**0.194*****	**0.201*****
Training YSK				**−0.117***	**−0.115***	**−0.112***	**−0.113***	**−0.111***
Additional training					0.008	−0.004	−0.006	0.001
Drivers compete						**0.140****	**0.128***	**0.123***
Bonus for financial							**0.104***	**0.104***
Pressure and stress								0.046
Adjusted R^2	0.023	0.029	0.100	0.110	0.106	0.118	0.125	0.123

* p<0.1** p<0.05 *** p<0.01.

The first and most important result shown in Table 6 is that the variable "Short environmental management scale " is the variable that is most strongly related to drivers' use of fleet management systems. Drivers who are employed by companies with clear targets for reduced consumption, and where drivers receive regular information about high and low scores, seem to be using the fleet management system more actively to improve their own scores. The short environmental management variable was developed based on bivariate analyses of the environmental management practices that were most strongly correlated with drivers' use of the fleet management systems.

The second main result from Table 6 is that the variable "Age 36–45" is the variable that has the second greatest impact on drivers' use of fleet management systems to improve their own economic driving style. The variable consists of two values: 1) All other age groups, and 2) 36–45 years, because drivers aged 36–45 had the highest scores on the index that measures drivers' use of the fleet management system.

The third main result from Table 6 is that the variable "Drivers in my company compete over who has the most economic driving style" is the one that has the third greatest impact on drivers' use of fleet management systems to improve their own economic driving style. This indicates that internal competition between drivers can help drivers use the fleet management system more actively to improve their own scores.

The adjusted R^2 value in model 8 is 0.123, which suggests that the model explains 12% of the variation in drivers' use of fleet management systems.

5. Discussion

5.1. Companies' measures for economic driving and energy management

The first aim of the study was to examine the transport companies that were supported by Enova's measures to implement economic driving and energy management, and classify the companies at different levels in the Eco Ladder. We have classified five companies low on level 2 of the Eco Ladder and six companies high on level 2 of the Eco Ladder, and we have classified three companies at level 3 of the Eco Ladder. The companies' level on the Eco Ladder is important, because this is the basis for hypothesis testing, where we compare reductions in fuel consumption at the different levels of the Eco Ladder and other outcome measures, e.g. the scores on environmental management, environmental culture, and working environment. Classifying companies' work according to an Eco ladder model with the gradual introduction of measures is, as far as we can see, unique. We have not seen any other examples of this. Our study provides a broad definition of economical driving, in order also to focus on factors related to energy management, and factors that have a greater effect on fuel consumption than driving style (and which are thus more important) (Ayyildiz et al., 2017; Walnum & Simonsen, 2015). We only know of Sivak and Schoettle (Sivak & Schoettle, 2012) as an example of another study that also uses such a broad definition of economic driving to refer to more than driving style. Unlike Sivak and Schoettle (Sivak & Schoettle, 2012), we focus on more levels than the operational, tactical and strategic: we connect this approach to energy management system and we also focus on professional drivers.

5.2. Results of economic driving and energy management

The second aim of the study was to examine the results of the measures taken by companies at the various levels of the Eco Ladder. Our results largely support Hypothesis 1, that the companies located at the top level of the Eco Ladder, and which have implemented the most measures in the Eco Ladder in connection with support from Enova, have had the largest decreases in fuel consumption in the Enova campaign period. The three level 3 companies experienced about a 10% reduction in consumption, and several also had significant reductions after the period when they received support from Enova. The fact that companies that work most efficiently with economic driving see the biggest results is in line with previous research showing the importance of implementing fleet management systems, feedback, training, competitions and bonuses (Ayyildiz et al., 2017; Díaz-Ramirez et al., 2017). However, our study differs from previous research on two important points. The first is that our focus is on companies (or companies at different levels) and not small groups of drivers internally in, or across, companies. The second point is that our study uses a ladder approach to classify companies' measures, where we distinguish between those who have many measures implemented and those who have fewer measures. This analytical approach is unique. This indicates that the scope of measures is significant, in line with Sanguinetti et al. (Sanguinetti et al., 2020), which finds that several measures in combination (fleet management, feedback, training, bonus) have a greater effect than one measure (for non-professional drivers). Our study is also unique because it indicates the importance of energy management system measures, which is at level 3 in the Eco Ladder.

The results also support Hypothesis 2, that the companies located at the top level of the Eco Ladder have the greatest degree of perceived focus on economic driving among drivers. We measure this with indexes for environmental management and environmental culture. It seems that the high scores for environmental culture in companies at level 3 indicate a better learning environment for drivers.

Our results only partly support Hypothesis 3; that companies at the top level of the Eco Ladder have the highest proportion of drivers with top scores/marks in the fleet management system (and the lowest fuel consumption). Although we saw a pattern with increasing shares of A scores in the fleet management system ranging from the Reference group to Level 3, the differences between the groups were not statistically significant. Thus, the survey data do not support Hypothesis 3. Good scores were, however, mentioned by interviewed level 3 company representatives, and these drivers had the lowest fuel consumption, as assumed in Hypothesis 3. Thus, qualitative data seem to support Hypothesis 3. Level 3 companies achieved the greatest fuel use reduction in the Enova period (10% reduction), and we know that fuel consumption is closely related to fleet management system scores. (Manufacturers state that an improvement from E to A equals 11% reduction in fuel use.) The multivariate analyses show that the environmental management of companies is the most important factor that influences drivers' active use of fleet management systems, which is the factor with the greatest impact on drivers' marks/scores in the fleet management system. Successful “cultivation” of drivers with high marks/scores in the fleet management system is presumably an important reason why Level 3 companies had the greatest fuel use reduction in the Enova period, in addition to the Level 3 management practices focusing on energy management. This latter point is also important to note. Previous research shows that the Level 3 management practices are more important for fuel consumption than level 2 practice focusing on driving style (Pinchasik et al., 2021; Walnum & Simonsen, 2015). This could also be an explanation why we do not see statistically significant differences between the fleet management scores of the level 2 and level 3 drivers in the sample, in addition to possible sample biases. These issues indicate needs for further research.

Our data largely support *Hypothesis 4*; that drivers at the top level of the Eco Ladder report the best results for the working environment. We have seen that over half of the respondents in the companies supported by Enova believe the company has gained a better reputation and that they experience less stress and time pressure in their work. Our data largely support hypothesis 4, because the proportions who agree with the statements are higher among companies at level 3 than at level 2. The results on stress and time pressure are in accordance with previous research (cf. (Nævestad et al., 2018)). However, previous research also shows that stress and pressure are an important factor that may hamper work with economic driving and energy management (Ayyildiz et al., 2017; Strömberg & Karlsson, 2013). In other words, this may be both

cause and effect. We cannot therefore draw robust conclusions about the extent to which economic driving leads to less stress and pressure, based on the quantitative data, or whether low levels of stress and pressure are a prerequisite for economical driving. The qualitative data with stories about drivers' everyday lives may indicate the former.

5.3. Conceptual model of relationships

In Fig. 5, we show a conceptual model of the strongest and significant correlations from the multivariate analyses, as well as relationships that we have indications of from the interviews.

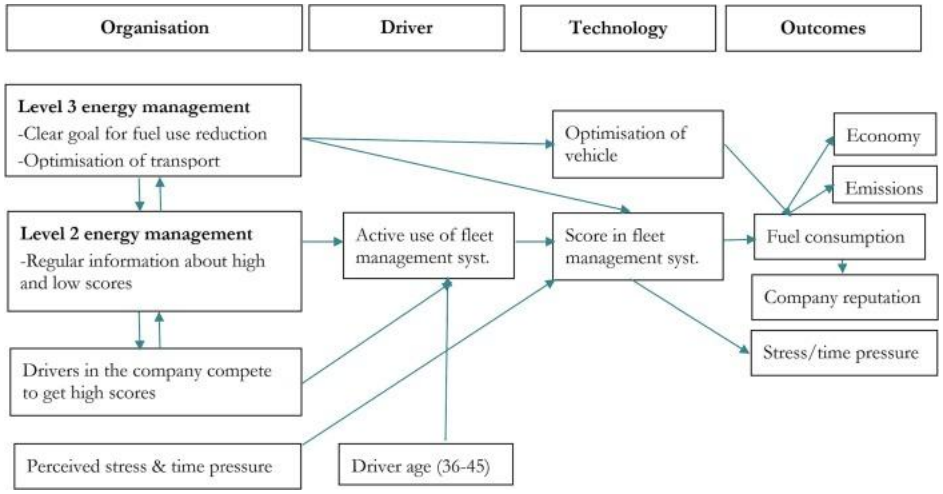

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Fig. 5. Conceptual model of significant correlations from three regression analyses with the following dependent variables, a) Score in fleet management system, b) Drivers' active use of fleet management system and c) Environmental management, including relationships we have information about from interviews.

The conceptual model shows that the relationship between economic driving and relevant results can be divided into relationships between factors at technology level, driver level and organisational level. We show correlations for management practices at levels 2 and 3 of the Eco Ladder. Concerning the effects of level 2 management practices, we see that drivers' active use of fleet management systems is the variable that has the strongest impact on drivers' marks/scores in the system. We are also looking at level 3 management practices. Explicitly stated goals of reduced consumption influence drivers' active use of fleet management systems. The interviews also indicate that the optimisation of vehicles and the organisation of transportation are related to reductions in fuel consumption, but this must be examined more closely in future research.

5.3.1. Gamification

The importance of the variable “drivers' active use of fleet management systems” indicates that frequent (daily) use of the fleet management application on the mobile phone is strongly related to drivers' scores. Through the phone, drivers' get feedback on their scores (for example, *E*-A, 10–100, 1–10), in an appealing visual format, which provides various colour codes for achievements (red, yellow, green). Drivers are given feedback on key aspects of their own driving style and specific tips on what to do more or less of in order to get better scores. Such info is also provided in screens in the cars, or e.g. in e-mails. In addition, drivers often receive (daily) feedback about other drivers' scores in the company more or less anonymously, so that they can compare themselves with others and compete with them. Much of this is in line with the principles of “gamification”, which is about bringing in elements of games and play to motivate people to participate in various activities (Magana & Munoz-Organero, 2015). This is done, for example, by using displays or web pages reminiscent of games with visual feedback showing colours or “emoticons”, score scorers, etc. The purpose is to motivate the participants, and make it fun for them to participate. The red, yellow and green colour codes is about influencing people's choices without coercion, because green scoring provides a form of reward that we would like to achieve. This is especially effective when combined with the use of social networks, where, for example, a person competes with others, as in this case. Such gamification measures have become very popular over the past decade, and research shows that they are also effective in motivating drivers to drive economically. Our study indicates that the informal competition between the drivers is a key mechanism motivating drivers to work systematically with the fleet management system.

5.4. Methodological weaknesses and questions for future research

The conclusions are largely based on self-reported numbers. It is important to remember that the conclusions are based on self-reporting, with the possible biases that this may entail. For example, respondents may remember wrongly or poorly, they may potentially over report positive things about themselves and underreport negative things, etc. However, we do not have indications of significant effects of such impacts in our data.

Low response rates in some companies and small numbers in some groups. The present study is based on relatively small numbers. Although we asked all the companies that had been supported by Enova to participate, only a selection of them wanted to participate. With a low response rate, it may be asked how representative those who have responded in the companies are of the companies' employees overall, and thus perhaps also of the level of the Eco Ladder on which the company is classified. Future studies should include more companies.

The Reference Sample is not representative. The reason for including the Reference Sample is that this should represent a typical industry average, with which we can compare the "Enova companies". In a typical industry average, however, the marks for drivers would have been more normally distributed. That is not what we see: Almost 80% of the drivers in the Reference Group have top marks in the fleet management systems, i.e. A or B. A typical industry average should have been more normally distributed around score C, according to the fleet management system manufacturers.

Self-selection among drivers? It seems that the bias in the Reference sample is caused by self-selection: drivers who are interested in economic driving (indicated by high scores in the fleet management system) are also interested in participating in studies about economic driving. As a consequence, we have small numbers in the groups with low marks/scores in our sample. There are only 16 drivers with marks corresponding to *E*-D and only 36 drivers stating that they have marks corresponding to C. Thus, it seems that our study shows a sample effect: among the respondents, there is an over-representation of drivers with high scores. Among the level 2 and especially level 3 company drivers, we would expect a bias involving drivers with high scores, as these companies work actively with improving drivers' scores. It is challenging to separate this from the mentioned self-selection bias, indicating the need for high response rates. However, we did not expect similar bias in the Reference sample. Future studies should include more drivers with low scores to get representative Reference samples. However, as drivers with low scores might be less motivated to participate in studies about economic driving, it is also important to identify ways to motivate/recruit them.

Possible recruitment bias among level 2 and level 3 drivers? It is also relevant to ask whether such a recruitment bias also is present among level 2 and level 3 drivers. It is difficult to assess this. The shares of A and B score drivers among level 3 companies seem to be in accordance with interview results from these companies. This also seem to apply to the level 2 companies, although not all managers had the same overview of driver scores in these. It is also important to remember that we recruit drivers among companies that work very actively with economical driving, and that these therefore have a strong predominance of drivers with high scores.

Examine the effects of specific management practices in the Eco Ladder. We assume that the companies at the top level of the Eco Ladder have the greatest reductions in fuel consumption, because they have most measures aimed at factors other than driving style, in addition to the measures aimed at driving style This is based on previous research, which shows that conditions other than driving style have a greater impact on fuel consumption (Ayyildiz et al., 2017; Díaz-Ramirez et al., 2017; Sivak & Schoettle, 2012; Walnum & Simonsen, 2015). We do, however, not have the data to be able to test this hypothesis quantitatively in multivariate analyses. However, we know from our descriptions in Section 4.1 that the companies at level 3, which have had the largest reductions in fuel consumption, are also those which have worked systematically with the management practices at level 3 of the Eco Ladder. We were also told examples of this in the interviews. However, companies at level 3 have also worked well, or best, with the management practices at level 2 of the Eco Ladder, and we cannot draw conclusions with our data on what has the greatest effect. This is an important question for future research. Additionally, future research should also map the importance of specific level 2 management practices in the Eco Ladder. This is important to find the isolated influence of competitions, and bonuses and training, etc. The same applies to the specific level 3 management practices in the Eco Ladder, such as organisation of transport, vehicle optimisation and equipment, for example by studying companies that work specifically on this.

There is a need for studies with a robust design. The present study is only a cross-sectional study, and future studies, with test and control groups and before and after measurements, might be able to provide more robust conclusions about the effects of specific management practices. Robust studies might also be able to provide more information about the complex cause and/or effect relationships that we have discussed in this study. Such studies could e.g. examine the importance of the working environment (perceived stress and pressure) for economic driving and energy management, with a focus on the extent to which this is both cause and effect.

There is a need to map more effects of economic driving and energy management, e.g. the effects of economic driving and energy management measures on tyre and maintenance expenses, for example, through workshop data, effects on emissions etc.

Identifying key influencing variables. We have tried to identify the most important management practices in the Eco Ladder and other key contextual factors in the multivariate regression analyses. The variables that are included in the multivariate regression analyses are mostly based on previous research suggesting their importance. This is the basis for the variables that are tested in the multivariate analyses. Although some of the key independent variables contribute significantly, indicating important results, the explained variation in the

dependent variables are generally relatively low. This especially applies to the analysis of factors influencing drivers' use of the fleet management system. Thus, although our analyses indicate important findings, most of the variation in the dependent variables remain unexplained in our analyses. This indicates an important issue for future research: to identify variables influencing drivers' use of the fleet management system and their associated scores.

6. Conclusion

The present study examines the relationship between economical driving, energy management and (reductions in) fuel consumption in trucking companies, which have worked with Eco driving and energy management through a one-year period. To describe the companies' work on economical driving, we use an approach that we call the Eco Ladder for Energy Management. The Eco Ladder specifies three levels for working with economic driving and energy management, with an increased scope of measures at each level. The results show a clear correlation between the scope of measures, measured as levels in the Eco Ladder, and reductions in fuel consumption. Level 3 companies have achieved approximately a 10% reduction in fuel in the period we study, while the companies at level 2, with one exception, have achieved somewhat lower reductions. The results also show a number of positive additional effects of the measures aimed at economic driving and energy management, e.g. related to company reputation and perceived stress and time pressure among the drivers.

CRediT authorship contribution statement

Tor-Olav Nævestad: Conceptualization, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Supervision, Project administration, Funding acquisition. **Vibeke Milch:** Formal analysis, Investigation, Writing – original draft. **Jenny Blom:** Formal analysis, Investigation, Writing – original draft.

Declaration of Competing Interest

The authors declare no conflict of interest.

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