

Summary

Safety culture, safety management and risk in road goods transport companies

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In the present study we examine the relationship between safety culture, safety management and risk in four groups of road goods transport companies, which to different extents have implemented measures directed at organisational safety management. The four groups are: Reference sample (presumed sector average), Level 2 at the Safety Ladder (focus on speed, seat belt and driving style), Level 3 at the Safety Ladder (also focus on work related factors with implications for transport safety), and Level 4 at the Safety Ladder (have also safety management system). We use data from a survey (N=533), qualitative interviews (N=30) and a literature review. Results from the literature review indicate that a good safety culture is related to positive safety behaviour and lower accident risk in goods transport companies. Survey results indicate that safety culture scores increase at each level of the Safety Ladder, while the accident risk decreases. We argue that this is due to increased focus on safety management at each level, and we discuss thoroughly what this focus involves. Our literature review indicates that the focus on safety culture and safety management generally is lower in the road sector than in other transport sectors, as companies in the road sector do not have the same legal requirements to safety management systems (SMS). We use interview data, survey data and the literature review to analyse good safety management practices at the different levels of the Safety Ladder for safety management in goods transport. We do this to show what other goods transport companies may learn from the management practices which seem to be related to good safety culture and low accident risk at each level. We mention 15 different such practices. It is important to note that there is considerable uncertainty related to the importance of each management practice for safety and safety culture, and that they need to be examined further in future research.

Background and aims

Transport with heavy goods vehicles (HGVs) is the dominant mode of goods transport in Norway. HGVs make up the largest total transported tons and ton kilometres, compared with maritime transport and rail transport. However, the considerable HGV transport on roads of varying quality throughout the country throughout the year affects the numbers and types of accidents on Norwegian roads. Norway has about 35 % more killed per capita in HGV accidents than the average for Europe. These are often serious accidents with significant proportions of severely injured and killed due to heavy vehicle weight. An average of 688 people are injured in accidents involving HGVs each year (most of them are other road users). A total of 138 of these people are severely injured or killed in the accidents.

Although there are relatively few systematic studies in this area, research indicates that increased focus on organizational safety management can lead to increased road safety. The two only robust studies found of this indicate that such measures may reduce the prevalence of traffic accidents by between 20 and 60 %. In a previous study, we suggested that between 7 and 56 deaths and severe injuries could have been avoided annually in Norway in the period 2007-2016, if more goods transport companies had worked systematically with safety culture and safety management.

In addition, previous studies show that hauliers transporting dangerous goods (road tanker) by road have a 75 % lower risk of accidents than other goods transport companies. This indicates what can be achieved through systematic organizational safety management (and special framework conditions).

However, it seems that neither transport companies, nor authorities focus sufficiently well on the importance of work-related risk factors for transport safety. We have previously suggested an approach that we term the Safety ladder for goods transport, which consists of four measures. This is suggested on the basis of a systematic literature study of organizational safety measures, an analysis of studies of accidents with drivers at work, and industry characteristics (86 % of companies have fewer than five employees).

The main aims of the present study are to:

- 1) Generate new knowledge about the factors influencing safety culture in transport companies.
- 2) Examine whether the safety culture in goods transport companies can be influenced, and
- 3) Identify the measures which, in that case, may be applicable to influence safety culture to reduce the number of accidents.

The Safety Ladder for goods transport

We define organizational safety management as the combination of informal and formal organizational measures aiming to increase the safety in organizations. We may refer to the formal organizational measures as safety structure, and the informal as safety culture.

Based on previous research in Norway and internationally, we concluded that four main measures aimed at organizational safety management have the greatest transport safety potential and are most realistic for regular goods transport companies.

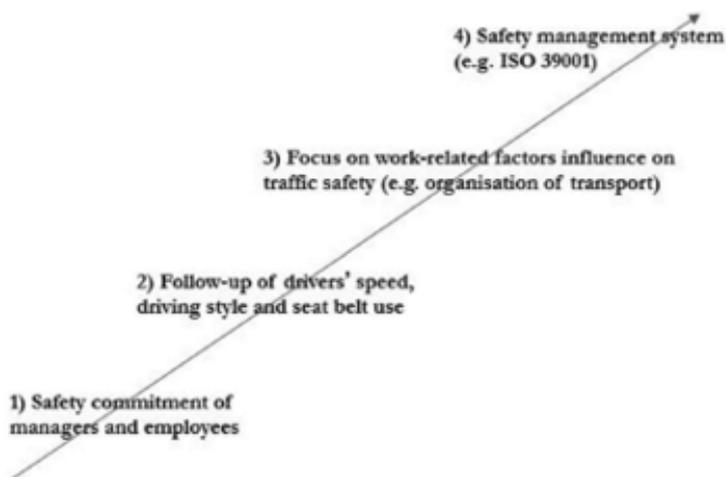


Figure S.1 Safety ladder for safety management in goods transport.

effect. The first step in the ladder, “Managers’ commitment to safety”, is the most basic step in the Safety Ladder, because research shows that this is usually a prerequisite for the company’s safety work to be successful. The second step in the safety ladder is “Follow-up of driver speed, driving style and seat belt usage”. This is aimed at the main risk factors associated with drivers identified in the analysis of fatalities involving drivers in work. The third step in the Safety Ladder is “Focus on work-related factors influence on transport

These four measures can be arranged on a ladder, starting at the lowest level, before proceeding to the next step, see figure S.1. The idea behind the Safety Ladder is that companies start at the bottom of the ladder if they have no measures aimed at work-related risk factors in the company. Based on previous research, we assume that the lowest levels are easiest to do something about and that they have the greatest

safety”. Given little focus on organizational safety management in goods transport companies, it is important that managers and employees in these companies develop an awareness the importance of work-related factors in transport safety. This applies, for example, to the organization of transport, with the consequences for drivers’ experience of stress, time pressure, fatigue, etc. The fourth step in the Safety Ladder is to implement a “Safety Management System”, such as ISO:39001, or other similar alternatives.

Data sources and methods

The study is composed of six sub-goals, which correspond to six different activities:

1) Literature review of the relationship between safety culture and safety outcomes in goods transport, what the research literature says about whether safety culture can be influenced, and which measures that may be appropriate for this purpose. We have conducted a systematic literature review of all available studies of safety culture interventions in road, rail, maritime and aviation. We found a total of 20 studies. We compare the road sectors with these other transport sectors, as there are relatively few studies from road, and as we believe that road may learn from the other sectors.

2) Make a safety indicator which can be used to ascribe companies to specific levels in the Safety Ladder. The indicator shall define the extent to which the Safety Ladder has been implemented in the companies, and have the potential to be used to regularly benchmark transport companies in general.

3) Qualitative interviews (N=30) about safety culture and safety management with managers and employee representatives in the companies. The main purpose of the interviews was to get information about how the companies work with organisational safety management, and to allocate them at the correct level in the Safety Ladder.

4) Survey to map safety management, safety culture and work-related factors (e.g. speed, driving style, seat belt use, fuel consumption, pay systems, work pressure, work descriptions/procedures and training) among drivers in road goods companies. The survey involves four groups of road goods transport companies, which to different extents have implemented measures directed at organisational safety management. The four groups are: 1) Reference sample (presumed sector average), 2) Level 2 at the Safety Ladder (focus on speed, seat belt and driving style), 3) Level 3 at the Safety Ladder (also focus on work related factors with implications for transport safety) and 4) Level 4 at the Safety Ladder (have also safety management system). All companies at level 2, 3 and 4 are recruited through the Norwegian Truck Owner’s Association (Norges Lastebileier-Forbund, NLF).

5) Estimate the risk of traffic accidents in the companies, and analyse the relationship between safety culture and accident risk in the companies. The accident risk is calculated by estimating the kilometres driven with a HGV by drivers at each Safety Ladder level in the last two years, and relating this to the number of accidents that they have been involved in while driving a HGV in the same period.

6) Make a list with examples of good practices for management of safety culture, safety management and measures related to the different steps of the Safety Ladder.

An important purpose of the study has been to test three key hypotheses about the relationship between safety culture, safety management and accident risk in the four groups that the present study focuses on:

- 1) Companies' safety culture scores will increase in average at each Safety Ladder level.
- 2) The scores on relevant measures of safety management and work related factors with implications for transport safety will increase at each Safety Ladder level.
- 3) Companies' accident risk will decrease in average at each Safety Ladder level.

The relationship between safety culture and safety outcomes

We measure safety culture by means of the GAIN-index, which provide a sum score based on 24 questions measuring five themes (the minimum value is 24 points, the maximum value is 120 points). Results indicate that the scores on the GAIN index for safety culture is improved at each level of the Safety Ladder, and that the safety culture score at level 4 in the Safety Ladder is 12 points higher than the Reference sample.

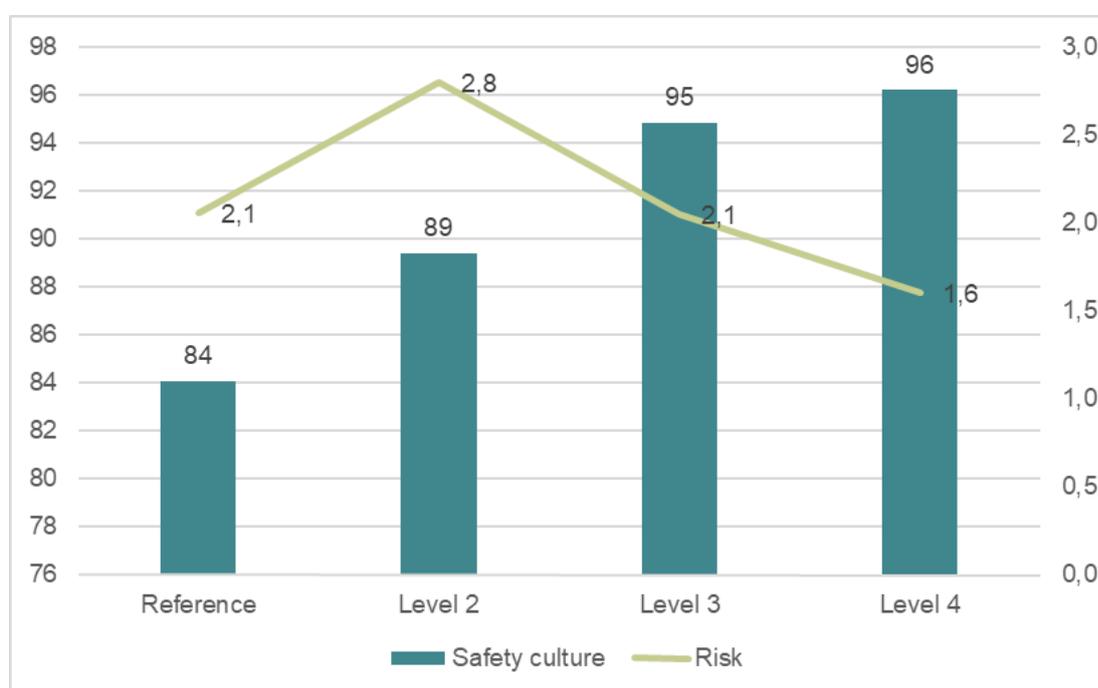


Figure S.2: Average scores of the GAIN index for safety culture in the four groups, and accident risk based on numbers from the survey. The GAIN index is comprised of 24 questions with five answer alternatives (Min: 24, Max: 120). Reference (N=80), Level 2 (N=39), Level 3 (N=126) and Level 4 (N=288).

Additionally, we also find that the accident risk in average decreases for the companies at each level of the Safety Ladder, as Figure S.2 indicates. It, must however, be noted that we find small differences between the safety culture scores of level 3 and 4 at the Safety Ladder. Different reasons for this are discussed.

The results from the survey also indicate that the scores of relevant measures of safety management are improved at each increased Safety Ladder level. Safety management is defined as the companies' follow up of drivers' speed, driving style and seat belt use, focus on work related factors with implications for transport safety and safety management system.

We conduct a logistic regression analysis of the factors influencing respondents' accident involvement in the course of the last two years. This indicates that safety culture contributes to a lower risk of accident involvement, and that type of transport also

influences respondents' accident involvement: Drivers involved in transport of dangerous goods seem to have a lower risk of being involved in traffic accidents.

Results from the literature review also indicate that safety culture is related to positive safety behaviours and lower accident risk in goods transport companies. However, it also indicates that it may be difficult to conclude about the causal relationship between safety culture and safety outcomes (accidents) in these studies. There are few high-quality studies (i.e. with pre-post measurements and control groups) examining the relationship between safety culture and safety outcomes in goods transport. In addition, there are very few studies that actually use accidents and/or incidents as measures of safety outcomes.

Can safety culture be influenced, and if so, which measures are most appropriate?

As our results indicate that a good safety culture is related to a positive safety behaviour and lower accident risk, we discuss which measures (safety culture interventions, management etc.) that may be most appropriate to influence safety culture to reduce the number of accidents in transport companies. This is done first, based on data from the survey and the interviews, and second, based on data from the literature review. Analysing data from the survey, we conduct a regression analysis to examine the factors influencing safety culture in our sample. Analyses indicate that especially safety management is the variable which contributes strongest to explaining the variation in safety culture scores among the respondents. In that manner, we can examine the contributions of different factors (e.g. respondents' age, type of transport, safety management). The index for safety management is comprised of nine questions; three for each level at the Safety Ladder. These questions concern management focus on speed and seat belt, company policies for this, focus on how the private life of the drivers (e.g. little sleep, stressing life situation) may influence traffic safety, whether drivers postpone assignments if they feel tired or unfit, functioning reporting systems, risk analyses and work descriptions/procedures.



Figure S.3: Average scores of the GAIN index for safety culture in the four groups, and average scores on the index for safety management. The GAIN index is comprised of 24 questions with five answer alternatives (Min: 24, Max: 98).

120). The index for safety management is comprised of three questions for each level (2, 3 and 4) of the Safety Ladder (Min: 9, Max: 45). Reference (N=80), Level 2 (N=39), Level 3 (N=126) and Level 4 (N=288).

Regression analyses show that the index for safety management explains nearly 80 % of the variation in safety culture. This indicates that the management practices at the different steps of the Safety Ladder, which the safety management index measure, are strongly related to safety culture. We therefore conclude that it seems that the safety management practices at the different steps of the Safety Ladder represent a viable way of influencing safety culture in goods transport companies. The result that safety culture can be developed by implementing a safety management system is an approach which we have seen in the literature review from the other transport sectors. When comparing the road sector with these, it becomes evident that these other sectors have legal requirements to safety management systems. These systems are strongly related to safety culture in the sense that the systems are required to maintain different aspects of safety culture, e.g. routines for reporting, just culture and learning. It may therefore seem that the development of good safety culture aspects in sectors with safety management system requirements to a considerable extent can be related to the systems.

Our literature review indicates that there is generally a lower focus on safety culture and safety management in the road sector compared to the other transport sectors, probably as the road sector do not have the same requirements for safety management systems. We have however also seen that there is no one-to-one relationship between implementing a safety management system and good safety culture. This is evident in the results from the interviews and the survey. The literature review also indicates that all the studies (with one exception) from both the road sector and the other sectors report of positive results of the studied safety culture interventions, both for safety culture, behavior and accidents/incidents (when all these different aspects are measured). The quality of the studies does however vary considerably. Few of the studies are based on a robust design, with before and after measurements with relevant control groups.

The main problem with the evaluated studies is that it is difficult to use them to point to the mechanisms contributing to cultural change, and which are effective. Thus, we identify four basic and common elements in the interventions from the four sectors. The most important element in all the interventions seem to be to increase the risk awareness of managers and employees through joint discussions of work hazards. The review of the interventions indicate that this mainly is done through four key processes:

- 1) Assign a key person (usually a manager) to be responsible for implementing the intervention.
- 2) Institutionalize joint discussions and assessments of work risks, involving both managers and employees.
- 3) Implement and continually follow up measures based on these joint discussions and risk assessments, e.g. reporting systems, training.
- 4) Maintain effective communication about safety questions in the organization, in accordance with the principles of an informed safety culture.

These four characteristics share many commonalities with safety management systems, and they indicate that it in many instances is difficult to discern aspects of safety management systems from aspects with safety culture. This is interesting, as it shows how closely intertwined formal (structure) and informal (culture) aspects of safety are. This also strengthens the conclusion from the analyses of the data from the interviews and the survey: safety management and the implementation of a safety management system may be a viable way of developing a good safety culture.

We will especially underline two lessons concerning how to develop good safety culture in goods transport companies, based on the survey and interview data from the companies and the literature review.

The first is that the development of safety culture is contingent on the management's continuous emphasis on the importance of safety in the company. The majority of the interviewees underlined that developing a positive safety culture is about communicating the standards applying to safety in the company, and the behaviours they expect from the drivers. It was also mentioned that the situation may rapidly "slip out", if managers fail to maintain focus. The literature review indicates that management commitment to safety is the most important aspect of a positive safety culture, and that what managers "focus on, measure and control regularly" is one of the most important mechanisms that managers can use to create a good (or bad) safety culture. We have, based on the interviews identified 15 good management practices, located at the different steps of the Safety Ladder. In the analyses of the survey data, we have seen a clear relationship between scores on these practices and safety culture scores. The result that the companies at step 4 in the Safety Ladder score higher than the companies at step 2 is not surprising in this perspective. The reason is that the companies at step 4 (generally) work with all these 15 practices at once, while the companies at step 2 perhaps only work with half of these practices. This is the most relevant explanation to the relationships that we have seen between safety culture and safety management. It is also the most relevant way of supporting our conclusion that working systematically with safety management, in line with the practices that we have described for each step of the Safety Ladder, is a good way of developing safety culture in transport companies.

Continuing this line of reasoning, we may mention that the second lesson is that we see that the companies with the highest safety culture scores also work systematically with employee involvement, e.g. in processes of continuous improvement, focusing on safety data analysis, measures and follow up. Some of them mentioned examples of special measures that also may create a sense of community, ownership and identity. This approach is in line with the four basic characteristics that we argued were common in all the safety culture interventions that we analyse in our literature review. The most important element in all the interventions seem to be to increase risk awareness through common discussions about work hazards, involving both managers and employees. Based on this, we concluded that there does not seem to be decisive differences between safety culture interventions and implementing systems for safety management. In both instances, the result is contingent on the fact that the intervention or the system not only becomes a formal description of "how things should be done", but also the informal way that "things actually are done". We have for that reason provided extensive discussions in the report, focusing on the relationship between formal and informal aspects of safety management; between structure and culture. In addition, we have, based on the literature study, discussed eight factors influencing the success of safety culture interventions.

The importance of framework conditions

Previous research indicates that safety management, safety culture and accident risk are strongly related to framework conditions, and we have also examined these relationships in the current study. Accordingly, our regression analyses of factors influencing safety culture indicate that type of transport (ADR) and customer focus on safety contribute significantly. The latter variable is comprised of two questions that have been combined: «Safety is more important than deadlines for our customers» and "Safety is more important than price for our customers". In the regression analyses, we also examined factors influencing drivers'

accident involvement. These analyses indicate that the framework conditions of the companies and the drivers contribute significantly: Drivers who drive dangerous goods (ADR) have a lower accident risk. This is the variable with the strongest contribution in the analyses. This result is in accordance with previous research.

Our regression analyses indicate relationships between framework conditions, safety culture, safety management and accident involvement in the studied companies. This is illustrated in Figure S.4.

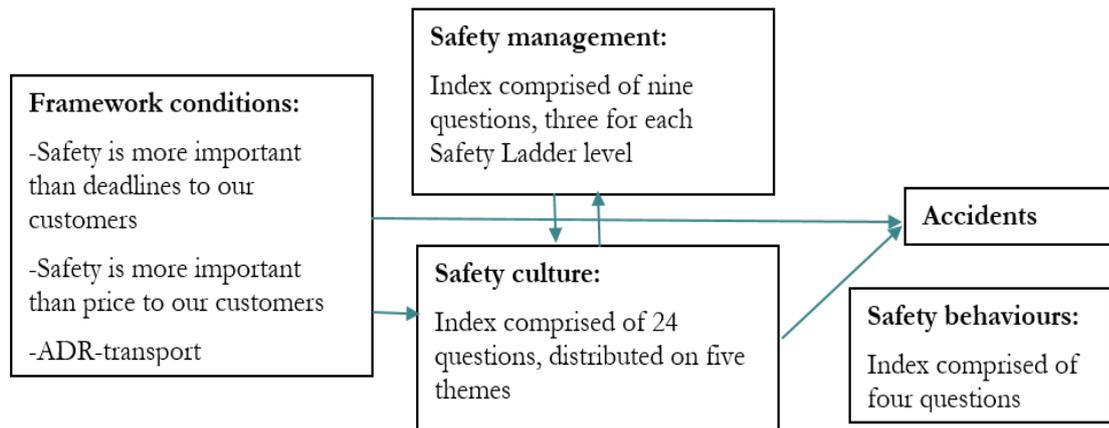


Figure S.4. Relationships between framework conditions, safety culture, safety management and accident involvement in the studied companies, as indicated in the regression analyses.

The relationship between structure and culture

When discussing hypotheses about the relationship between structure and culture, and structure as a possible way of implementing a good safety culture, it is important that we remember that there are several level 4 companies in our sample, with relatively low safety culture score, despite comprehensive safety management systems. This applies for instance to Company Q, O and K, which all have below 90 points on the GAIN index. It is, however, crucial to mention that the numbers from these companies are highly uncertain, due to few respondents from the companies (a total of 33 respondents).

While safety structure generally refers to “the way we should do things here”, as defined in organisational charts, procedures and routines, safety culture describes the “way we actually do things here”, as reflected in the daily patterns of action among employees in the company. Research indicates that it is futile to have advanced safety management systems if employees in practice act in other ways than prescribed by the systems. This illustrates that it is more important to have a good safety culture than a good safety structure, as safety culture concerns what you actually do in the company. We have at least three companies at level 4 in the study, that both have comprehensive systems and good safety culture scores: Company J, I and P (>100 points). Two of these companies also had the highest and the second highest response rates in first data collection period of the study (before additional measures to increase the response rate was implemented). Based on the interviews, we conclude that one of the things that these companies have in common, is that they use a “continuous improvement” approach with a considerable extent of employee involvement. These companies obtain an overview of the risks that they face through analysis of reported incidents, use of key statistics etc., and they implement measures and follow them up together with the employees. Additionally, this approach also involves good

communication between managers and employees concerning safety issues. This is an approach which is in accordance with the four key elements of safety culture interventions that we identified in the literature review.

Good practices for safety management

We use interview data, survey data and a literature review to analyse good practices for safety management at the different steps of the Safety Ladder for safety management in goods transport. We do this to provide other companies with the opportunity to learn from the measures we believe to be related to the scores for safety culture, safety management and accident risk at the different steps of the Safety Ladder. In our study, we point to 15 management practices which seem to be related to good safety culture scores and low accident risk:

- 1) Policy for speed, driving style and seat belt use.
- 2) Fleet management system recording drivers' speed, driving style and fuel consumption.
- 3) Regular (daily, weekly, monthly) feedback about the driving style to drivers
- 4) Speed limiter set on a lower level than the factory settings of 89/90 km/h.
- 5) Follow up of drivers' seat belt use.
- 6) Wage system developed to minimize drivers' stress and fatigue.
- 7) Drivers are encouraged to stop and postpone assignments, if they perceive that it is unsafe to complete them.
- 8) When assignments are planned, companies conduct an (formalized) assessment of the strain (e.g. stress, fatigue) on the driver that the new assessment will involve.
- 9) Joint focus among employees and managers on the importance of work related factors for transport safety.
- 10) Functioning reporting system, which is used by employees.
- 11) Reported incidents are regularly analysed (by the company) to learn.
- 12) The company regularly conducts formalized risk assessments (based on predefined methods) for all their assignments.
- 13) Well-developed set of procedures that are known and perceived as meaningful by the employees.
- 14) Well-developed training program (theoretical, practical) of a certain duration, with predefined requirements to driver competence and knowledge, and activities to fulfil the requirements.
- 15) Well-developed systems aiming to disseminate safety information to drivers.

It is important to stress that there is considerable uncertainty concerning the specific importance of each of these management practices for safety and safety culture, and that they must be examined further in future research. Every practice is, however, supported by at least one previous study (regardless of quality), and they are prevalent among the level at which they are located. Point 1-5 specially apply to step 2 at the Safety Ladder, point 6-9 specially apply to step 3, and point 10-15 specially apply to step 4. The companies at the higher levels have generally applied most of the practices common among the companies at the lower levels.

Methodological challenges and weaknesses

1) We cannot be certain whether the identified mechanisms actually explain the identified differences between the different steps of the Safety Ladder. The differences between the levels may be due to third variables that we have been unable to measure, e.g. related to framework conditions, technology and vehicles. In this study, we only focus on some aspects of safety management, and these are aspects related to organisational safety management: safety culture and safety management systems. We argue that it is important to focus on these issues, as it previously only has been done to a limited extent.

2) Our conclusions regarding good practices are uncertain. It is important to note that there is considerable uncertainty related to the importance of each of the fifteen good management practices for safety and safety culture. This must be examined in future research. We have not conducted before and after studies of each of the separate management practices; neither have we included control groups in our study. This is necessary to be able to conclude about the importance of each management practice.

3) The factors explaining why companies reach a certain safety level are often more complex than indicated by the Safety Ladder. We simplify in our analyses to be able to analyse relationships between variables, but seeing the world through these simplifications, we risk missing important details. We have tried to compensate for this by interviewing company representatives.

4) The safety culture level varies considerably between the companies at the different levels. It is important to remember that there are several important differences between the companies at the different levels of the Safety ladder. We discuss different factors that may shed light on the discrepancies between culture and structure.

5) We cannot know what affects what. We suggest that safety management systems may provide a way of implementing safety culture in companies, but we cannot conclude about causality in the present study. Safety culture and safety structure mutually affect each other, and it is therefore difficult to separate analytically between them. It is for instance conceivable that companies with a good safety culture are motivated to implement more safety management measures. On the contrary, we may also hypothesize that companies with good safety structure are unable to develop good safety culture despite several measures.

Questions for future research

1) Eco driving as a safety measure. The management representative from company I said that his company has reduced the fuel consumption with 10 % during the last year, and that this also has involved a 40 % reduction in vehicle damages. Given that safety culture interventions often are comprehensive, require a lot of time, resources and competence, and that it may be challenging to motivate managers in goods transport companies to implement measures focusing on safety culture and safety management systems, this may also be an interesting safety measure.

2) We need more high-quality studies of safety culture and safety structure, which also focus on mechanisms. The literature review indicates that we need more high-quality studies (with pre and post measurements and control groups) of safety culture and safety structure interventions. Additionally, it is important that these studies examine the effects of the specific elements and mechanisms that make up the interventions. This

applies for instance to the good management practices that we have identified in the present study. These are, as noted, associated with a considerable degree of uncertainty.

3) *Prospective study.* The literature review indicates the need for prospective studies, measuring safety culture and safety management at a given start time, before following the development in organisations over time, with respect to accidents and incidents. The present study can make the basis for such a prospective study. We know that the Truck Owner Association (NLF) actively cooperates with many, or most of the participating companies about organisational safety management. We also know that many of the companies develop their own measures, and/or receive assistance from other parties. It would be interesting to follow the participating companies further, now when we have conducted the first measurements and interviews. Future studies could examine whether companies that have implemented more measures, improve their safety management and safety culture scores, perhaps reaching a higher level at the Safety ladder.

4) *«Spillover» and «crossover» effects from professional to private driving.* The study of Naveh and Katz Navon (2015) examine so-called spillover effects of organisational safety measures in companies employing drivers at work to these drivers' private driving. Additionally, it is also conceivable that drivers who have been exposed to safety culture interventions develop new ways of thinking and acting in traffic which also influence the traffic safety behavior of their close relatives («crossover»). This is an interesting area for future research, which shows that measures directed at drivers at work may be effective far beyond their predefined target groups.

5) *The importance of NLF's measures for safety culture, safety management and accident risk.* Nearly all the companies that we study are involved in NLF's measures focusing on organisational safety management. We have also seen that these measures correspond to different levels in the Safety Ladder, and that increases in Safety Ladder levels also are related to increases in scores for safety culture and safety management and similar decreases in accident risk. We have also seen that the Reference sample, which we hypothesize represents a good business average, provide lower scores. It would be interesting to do more systematic analyses of the importance of NLF's measures for safety culture, safety management and accident risk.

6) *The basis for a web tool.* The study may potentially form the basis of an IT-tool for safety management and safety culture in goods transport, which companies can use to: 1) Measure and evaluate their safety culture and safety management, and 2) Based on the results from the measurements and the assessments obtain a generated and tailor-made intervention package, based on their own scores. We have previously made the basis for such an IT-tool for the Swedish Labour Inspection Authority (Nævestad & Bjørnskau 2012), and we have been in dialogue with the three-party business sector program for goods transport, discussing the opportunities to develop such a tool. We are familiar with a considerable interest for such a tool, e.g. from the Norwegian Labour Inspection Authority. The NLF or the Norwegian Public Roads Administration may also use the results for further development of their own work on organisational safety.