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Effects on accidents of police checks of drivers of heavy goods vehicles in Norway

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ABSTRACT

During the period from 2007 to 2019, the number of drivers of heavy goods vehicles checked by the traffic police in Norway varied substantially. It declined during the first years of the period, then increased. This paper studies where there is an association between these variations and annual changes in the number of accidents involving heavy goods vehicles. A negative relationship is found: the more drivers checked, the fewer accidents. The relationship can be described by means of a dose–response function. The function indicates that when the number of drivers checked by the police is reduced by 50%, one may expect the number of accidents involving heavy goods vehicles to increase by 7.5%. A 50% increase in the number of drivers checked will be associated with a 3.5% reduction in the number of accidents, and a 150% increase in the number of drivers checked will be associated with an 8.6% reduction in the number of accidents.

Introduction

From 2007 to 2020, the number of injury accidents in Norway where heavy goods vehicles were involved declined from 786 to 251; a reduction of 68%. Several factors may have contributed to this decline. A study has been made with the aim of identifying as many contributing factors as possible and try to quantify their contributions (Nævestad et al., 2022). One potentially relevant factor that was found to vary substantially from year to year during the study period, was the number of drivers of heavy goods vehicles who were checked by the police. While the Public Roads Administration conducts technical inspections of heavy goods vehicles, the police checks are directed at driver behaviour, like speed, drinking or use of drugs, compliance with hours of service and rest regulations, and seat belt wearing. The number of drivers checked by the police declined during the first years of the period, but then increased substantially. This paper examines whether there is a relationship between the annual changes in the number of heavy goods vehicle drivers checked by the police and annual changes in the number of accidents. The main question asked in the paper is: Is an increase in the number of drivers of heavy goods vehicles checked by the police associated with a reduction in the number of accidents involving heavy goods vehicles, and, conversely, is a reduction in the number of drivers checked by the police associated with an increase in the number of accidents?

Previous studies

A search in Google Scholar using "Police enforcement targeted at drivers of heavy goods vehicles" as search terms did not identify any studies that have evaluated the effects on accidents of police enforcement targeting drivers of heavy goods vehicles. It is clear, however, both that the behaviour of drivers of heavy goods vehicles is related to accident involvement, and that monitoring of behaviour can influence it. Thus, the two main conditions identified by Elvik (2004) for a road safety measure to have an effect on accidents are fulfilled: (1) The measure must influence a risk factor known to increase the number of accidents, and (2) The measure influencing this risk factor must not lead to offsetting behavioural adaptation.

Mehdizadeh et al. (2019), using the driver behaviour questionnaire and self-reported data on accident involvement, found that traffic violations by drivers of heavy goods vehicles increased their risk of accident involvement. Han et al. (2021) confirmed this finding. Mafeni Mase et al. (2020) found that installing cameras monitoring driver behaviour was associated with a reduction of speeding and harsh braking.

There are today fleet management systems that can monitor driver behaviour like speed, acceleration and deceleration in great detail

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(Nævestad, 2020). Moreover, alcohol ignition interlocks are increasingly installed by major transport companies. One might therefore think that there is little need for police enforcement targeted at drivers of heavy goods vehicles. However, in Norway, most freight transport companies are either run by a single individual or have only a few employees. These small businesses will rarely see the need for investing in a fleet management system. International statistics (Adminaité-Fodor and Jost, 2020) show that speeding by heavy vehicles is widespread on roads with speed limits below 90 km/h. Seat belt wearing among drivers of heavy goods vehicles is lower than among car drivers (Adminaité-Fodor and Jost, 2020). Therefore, there is still a role for police enforcement.

The effects on accidents of police enforcement are best described in terms of an accident modification function, which is a dose–response curve having changes in the amount of enforcement as its argument and changes in the number of accidents as outcome variable (Elvik, 2011, 2015). This paper will examine whether such a curve can be found for police checks of drivers of heavy goods vehicles in Norway and whether it resembles curves that have been estimated for police enforcement in general.

Data

The number of injury accidents involving heavy goods vehicles in Norway during the period 2007–2020 is characterised by a strong downward trend; see Fig. 1.

It is obviously important to control for this trend when estimating the association between a factor showing large annual variations and corresponding annual variation in the change in the number of accidents. It is, however, not possible to do so by including year as an independent variable in a multivariate statistical model. The year variable will capture the trend very well and drown out the influence of any other variable included in the model, since the residuals around the trend line are quite small. The first challenge is therefore to account for trend without including year in a model.

The way to do so is to build a model that includes one or two variables that are positively related to the number of accidents, i.e. show a decline in values over time, but are not as highly correlated with the number of accidents as year. The data used in this study are shown in Table 1.

The number of trucks shows a declining trend over time. The variable labelled age-weighted mean risk is intended to measure the effect on the mean risk of drivers of heavy goods vehicles of the fact that over time the population of these drivers has become more experienced. This variable also shows a declining tendency over time. Both these variables have a positive correlation with the number of accidents, unlike year, which has a very high negative correlation with the number of accidents.

Analysis

To estimate the association between annual changes in the number of drivers of heavy goods vehicles checked by the police and annual changes in the number of accidents, a negative binomial regression model was developed. The number of accidents involving heavy goods vehicles was dependent variable. The independent variables were number of trucks, age-weighted mean risk and number of drivers

Table 1
Data used in study.

Year	Registered trucks	Million km driven	Drivers checked by police	Age-weighted mean risk	Accidents
2007	84,742	1722	22,580	1.486	786
2008	84,350	1886	15,188	1.465	675
2009	82,694	1737	14,537	1.453	581
2010	81,330	1799	9475	1.449	602
2011	80,160	1832	10,337	1.464	521
2012	79,857	1938	10,436	1.453	551
2013	79,437	1950	10,980	1.446	459
2014	78,668	1909	10,587	1.443	384
2015	77,120	1883	26,038	1.440	312
2016	75,238	1818	41,131	1.453	335
2017	73,808	1855	31,156	1.448	327
2018	72,405	1760	34,639	1.446	333
2019	72,078	1798	38,672	1.445	319

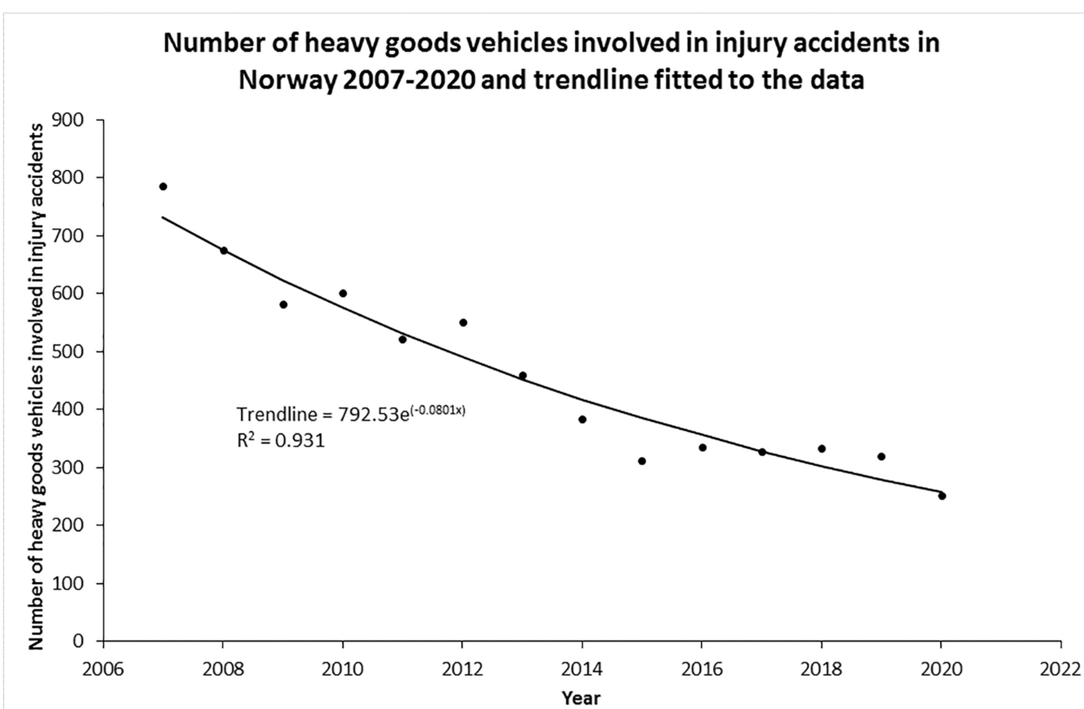

Fig. 1. Number of heavy goods vehicles involved in injury accidents in Norway 2007–2020 and trend line fitted to the data.

checked by the police per million kilometres of driving. The coefficients estimated are shown in the upper panel of Table 2.

To assess the quality of the model, three statistics are used, see the lower panel of Table 2. The first is whether model predictions are biased. The model predicts 6184.6 accidents for all years. The recorded number of accidents was 6185. It is concluded that model predictions are unbiased. The second statistic is the goodness-of-fit of the model. This is assessed in terms of the over-dispersion parameter. The amount of over-dispersion found in a data set can be described in terms of the over-dispersion parameter, which is estimated as follows:

$$Var(x) = l \times (1 + ml) \quad (1)$$

In Eq. (1) μ denotes the over-dispersion parameter. Solving Eq. (1) with respect to the over-dispersion parameter gives:

$$m = \frac{\frac{Var(x)}{\lambda} - 1}{\lambda} \quad (2)$$

If the mean (λ) and variance (Var(x)) of the raw data are known, the over-dispersion parameter of the crude data can be estimated by applying Eq. (2). Denoting the over-dispersion parameter of the raw data as μ_{crude} and the over-dispersion parameter of the fitted model as μ_{model} the Elvik index of goodness-of-fit is defined as follows:

$$\text{Elvik} - \text{index of goodness} - \text{of} - \text{fit} = 1 - \frac{\mu_{model}}{\mu_{crude}} \quad (3)$$

The model was found to explain 95.6% of the systematic variation in the number of accidents according to the Elvik-index. The third statistic regarding the quality of the model is autocorrelation among the residual terms. None of the autocorrelations at various lags were found to be statistically significant. It is therefore concluded that the model is good enough for the purpose of estimating the association between police checks of drivers of heavy goods vehicles and the number of accidents involving these vehicles.

Table 3 shows how the model has been applied to estimate the association between changes in the number of police checks of drivers of heavy vehicles and the changes in the number of injury accidents involving heavy goods vehicles.

The first column shows the recorded number of accidents year-by-year. The year 2020 is not included as the Covid-10 pandemic made it abnormal in many ways. The column labelled “model-predicted accidents” shows the number of accidents predicted by the model. It is seen that the model adequately predicts the declining number of accidents. The next column, labelled “accident modification factor” shows the annual accident modification factor associated with police checks of drivers of heavy goods vehicles. It was estimated by multiplying the estimated coefficient (−0.008) by the annual number of drivers checked per million kilometres driven with heavy goods vehicles. When the predicted number of accidents is divided by the accident modification factor, we get the “counterfactual predicted accidents”, which is the model prediction of what the number of accidents would have been if police checks of drivers of heavy goods vehicles did not exist. In the next two columns, the annual changes in the model-predicted and counterfactual predicted number of accidents are estimated. Next the difference between these annual changes are taken, labelled “difference-in-differences” in Table 3. The difference-in-differences shows the net annual changes in the number of accidents associated with annual changes in the number of drivers checked by the police. It is seen that some of these changes are positive, i.e. indicate an increase in the number of accidents, and some are negative, i.e. indicate a decline. However, these changes are not absolute increases or reductions in the number of accidents, but rather show whether the downward trend was weaker (positive numbers) or stronger (negative numbers) in a given year than it would have been if police checks did not exist.

Table 2
Negative binomial regression model and quality assessment of model.

Parameter	Estimate	Standard error	P-value
	Panel A: Regression coefficients		
Constant term	−10.013	2.3210	0.000
Registered trucks	0.0000460	0.00000842	0.000
Age-weighted mean risk	8.678	1.9840	0.000
Drivers checked by police/million km	−0.008	0.0042	0.047
Over-dispersion parameter	0.0046		
	Panel B: Assessment of model quality		
Bias	The predicted number of accidents is 6184.6; the recorded number is 6185. The model is unbiased		
Goodness-of-fit	The dispersion parameter is 0.0046. The model explains 95.6% of the systematic variation in the number of accidents		
Autocorrelation of residuals	Autocorrelation of residuals at lag 1 is 0.096 with a standard error of 0.248; none of the autocorrelations are statistically significant		

Results

The two columns to the right in Table 3 show the application of the difference-in-differences estimates to develop a dose–response function for the association between police checks of drivers of heavy goods vehicles and changes in the number of accidents involving these vehicles. Annual changes in the number of drivers checked are stated as relative numbers. A value of 0.61 means a reduction of 39% from the previous year. A value of 2.49 means an increase of nearly 150% from the previous year. Changes in the number of accidents are also stated as relative values. These changes are annual changes in the model-predicted number of accidents. A value of −0.064, for example, is an accident reduction of 6.4%.

Fig. 2 plots the annual changes in the number of accidents (vertical axis) as a function of the annual changes in the number of drivers checked (horizontal axis). A logarithmic function has been fitted to the data points. This function is a dose–response curve for the changes in the number of accidents associated with changes in the number of drivers checked. The standard error of the slope is 0.014. This means that a lower 95% curve varies between an accident increase of 4.1% (to the left) to a reduction of 6.1% (to the right). The upper 95% curve varies between + 6.8 % and −11.1%.

The dose–response curve passes close to the joint points of no change on both axes (1.00 on the horizontal axis; 0.00 on the vertical axis), consistent with the idea that it is changes in the amount of enforcement that produces changes in the number of accidents, whereas a stable level of enforcement maintains a stable level of safety.

Discussion

Some previous studies of police enforcement have tried to model the effects on accidents of enforcement by means of dose–response curves (Elvik, 2011, 2015). These studies have found that the number of accidents is associated with changes in the level of enforcement. If enforcement is reduced, there is a tendency for the number of accidents to increase. If enforcement is increased, there is a tendency for the number of accidents to decline, although the rate of decline becomes gradually smaller the larger the increase in enforcement is.

The curve found in this study is consistent with these characteristics. It rises steeply if enforcement is reduced and falls at a gradually smaller rate if enforcement is increased. The size of the changes in the number of accidents associated with changes in the amount of enforcement in this study are very close to those found by Elvik (2015). Does this reflect a causal relationship? It might well do so, but claiming causality is not justified in a study based on as few data points, and with as limited control of potentially confounding factors as this study. Residual confounding cannot be ruled out although it is difficult to think of a specific

Table 3
Analysis to obtain dose–response curve for police checks of drivers of heavy goods vehicles.

Year	Count of accidents	Model-predicted accidents	Accident modification factor	Counterfactual predicted accidents	Annual difference in predicted	Annual difference in counterfactual	Difference-in-differences	Relative change of checks	Relative change of accidents
2007	786	790.9	0.900	878.4					
2008	675	677.9	0.938	723.0	−113.1	−155.4	42.4	0.614	0.063
2009	581	562.6	0.935	601.5	−115.3	−121.5	6.2	1.039	0.011
2010	602	522.9	0.959	545.4	−39.7	−56.1	16.5	0.629	0.031
2011	521	563.0	0.956	589.0	40.2	43.7	−3.5	1.071	−0.006
2012	551	506.8	0.958	529.1	−56.3	−60.0	3.7	0.954	0.007
2013	459	469.3	0.956	490.9	−37.5	−38.2	0.7	1.046	0.001
2014	384	439.3	0.957	459.2	−30.0	−31.7	1.7	0.985	0.004
2015	312	372.9	0.895	416.5	−66.4	−42.7	−23.7	2.493	−0.064
2016	335	356.1	0.867	410.9	−16.8	−5.6	−11.2	1.636	−0.076
2017	327	333.6	0.874	381.6	−22.5	−29.3	6.9	0.742	0.068
2018	333	300.3	0.854	351.5	−33.3	−30.1	−3.2	1.172	−0.011
2019	319	289.2	0.842	343.5	−11.1	−8.0	−3.1	1.093	−0.011

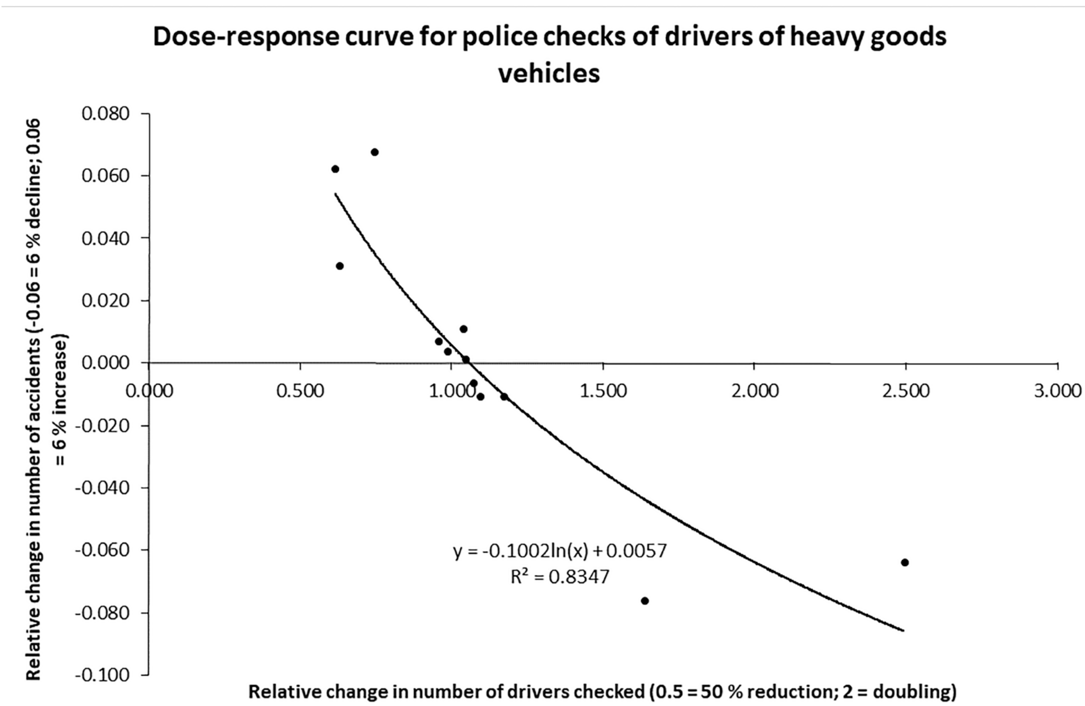

Fig. 2. Dose-response curve for police checks of drivers of heavy goods vehicles.

confounding factor that might generate the pattern found in this study.

A report by the European Transport Safety Council (Adminaité-Fodor and Jost, 2020) found that speeding by heavy vehicles was widespread on roads with speed limits below 90 km/h. Use of seat belts is lower among drivers of heavy goods vehicles than among car drivers (Adminaité-Fodor and Jost, 2020). Thus, unsafe behaviour that can be reduced by means of police enforcement is found in many countries.

Although there is still a role for police enforcement, new technology may reduce the need for it in the future. New safety standards introduced for heavy goods vehicles in Europe recently include electronic stability control, autonomous cruise control and seat belt reminders (Adminaité-Fodor and Jost, 2020). Transport companies increasingly use fleet management systems that monitor driver behaviour in detail and allow for the use of reward systems for drivers who drive safely and economically (Nævestad, 2020). Alcohol ignition interlocks are also becoming common. Thus, technology can address several aspects of driver behaviour in ways that reduce the need for police enforcement. Nevertheless, full market penetration of these technologies will take many years. In the meantime, police checks of drivers of heavy vehicles can contribute to improving safety.

Conclusions

It is concluded that annual changes in the number of injury accidents involving heavy goods vehicles in Norway from 2007 to 2019 are closely related to annual changes in the number of drivers of heavy goods vehicles checked by the police in the same period. These changes cannot, however, explain the large decline in the number of injury accidents involving heavy goods vehicles in this period. It can only explain part of the comparatively small annual variation in the declining trend.

A 50% reduction in the number of drivers checked by the police was associated with an increase of 7.5% (95% CI: 5.6; 9.4) in the number of injury accidents involving heavy goods vehicles. A 50% increase the number of drivers checked by the police was associated with a 3.5% reduction (−2.4; −4.6) in the number of heavy goods vehicles involved in injury accidents.

These findings may not remain valid in the future. New technology, including electronic stability control, autonomous cruise control, seat belt reminders, intelligent speed adaptation, alcohol ignition interlocks, and fleet management systems may to a large extent replace traditional police enforcement. However, replacing enforcement by technology will take many years and police enforcement can therefore still make a contribution to safety.

CRediT authorship contribution statement

Rune Elvik: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **Live Tanum Pasnin:** Data curation, Writing – review & editing. **Tor-Olav Nævestad:** Conceptualization, Writing – review & editing, Supervision, Project administration, Funding acquisition.

Declaration of Competing Interest

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

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