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Valuing the risk and social costs of road traffic accidents – Seasonal variation and the significance of delay costs

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ABSTRACT

By using a conventional risk model, and a time loss model for delay, the risk, severity, and social costs of road traffic accidents have been estimated on a rural transport corridor in an area with large seasonal variations. The novelty of the study lies in the comparison of the estimates between seasons, and the inclusion of delay costs when assessing the total social costs of accidents for private motor vehicles and heavy vehicles. Increasing congestion in urban areas has motivated researchers' interest in studying the cost of delays due to accidents. However, still many countries, such as Norway, do not include delay costs when estimating the social costs of road accidents. In this study, we show that these costs can constitute a significant proportion of the social costs of accidents in rural areas, particularly during winter in regions with strong seasonal variations. The delay costs on the studied road section constituted on average 10% of total annual social costs of accidents, and were nearly 70% higher than the accidents' material costs. By including these inconvenience costs, we would achieve better estimates of the social costs of accidents, which would in turn give rise to more accurate assessments of the costs and benefits of accident reduction measures, as well as measures reducing the response time when accidents happen. Many road safety measures have been aimed at reducing accidents involving death and serious injury. This analysis shows that it can also be beneficial to take measures to reduce the number of less severe accidents, particularly in rural areas where delay costs can be high when the roads are closed because of accidents. It is thus, particularly important that such costs are included in project assessment tools to ensure that rural areas do not lose the fight for road investments.

1. Introduction

Steep mountains and long fjords characterize the topography of the region that has been the case for study herein. For this reason, many of the roads in the region are steep, narrow and curved. Combined with cold winters that cover the road surface with snow and ice, this often creates difficult driving conditions, which further increase the risk of accidents (Shankar et al., 1995; Usman et al., 2010). Drivers may deal with challenging driving conditions in winter in various ways. Some cancel their trips or choose other transport routes or modes. Others take safety precautions such as equipping vehicles with spike tires and chains (Koetse and Rietveld, 2009; Steimetz, 2008; Strandroth et al., 2012) or meeting the increase in task difficulty by lowering their speed and increasing their level of concentration (Jørgensen and Pedersen, 2002); however, road traffic accidents still occur. Some accidents result in deaths and injuries, while others are restricted to property damage and delays. Regardless, roads must typically close temporarily after an accident in order for the rescue crew to clean up debris.

The aim of this paper is twofold. First, the risk and severity of accidents on a rural road section with cold and snowy winter weather is derived – more specifically, the 632-kilometre European highway 6(Ev6) through Nordland County connecting northern and southern Norway. The results are compared between the summer and winter season and between private motor vehicles and heavy vehicles. Second, the total social costs of these accidents in winter and summer are estimated with particular focus on the delay costs imposed on road users when the road closes and the traffic flow is obstructed by the accidents.

There is limited research on the seasonal variation in risk of accidents, although research has revealed that rain and snowfall cause increased total crash rates mainly due to increase in less severe accidents (see e.g., Andrey et al., 2013; A. J. Khattak et al., 1998; Knapp et al., 2000; Koetse and Rietveld, 2009; Seeherman and Liu, 2015). For areas such as the one studied and similar mountainous areas with cold and snowy weather, the effect of adverse weather on crash rates may last the whole winter season causing a different road

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accident pattern compared to other locations. By estimating and comparing the risk and severity of accidents for different types of vehicles, the accident patterns of the vehicles groups in each season are revealed. Knowledge of which is scarce in the existing literature.

Cost-benefit analysis is a frequently used governmental decision-making tool for determining the economic consequences of alternative infrastructure projects. In order to evaluate the consequences of various safety measures, the social costs of road accidents are estimated. The problem of vehicle combinations blocking the winter roads is the subject of great attention each winter in Norway and has been further actualized with the increased globalization of transportation, with drivers from the southern parts of Europe entering Norway with limited knowledge of and skills necessary to handle the difficult winter driving conditions (NPRA, 2013; Royal Norwegian Ministry of Transport and Communications, 2014). Attempts to quantify the costs of delays, however, are limited, implying that the benefits of taking measures to reduce the frequency and duration of these accidents are underestimated.

Most countries, including Norway, follow the recommendations of the COST 313 project (Alfaro et al., 1994) regarding which cost categories to include when studying the social costs of road crashes (NPRA, 2014; SWOV, 2014). These include medical costs, the cost of lost production, material costs, settlement costs and intangible costs (loss of quality of life), but not delay costs. The policy focus in most countries has been on reducing the frequency of severe accidents causing serious injuries or fatalities because the social costs of these are high. With this study, we also want to emphasise the significance of the delay costs of accidents. Not with the intent of undermining the importance of reducing the frequency of severe accidents, but rather to show that in certain circumstances it may be appropriate to prioritize measures to reduce the frequency of less severe accidents as well.

Increasing congestion in urban areas has increased researchers' interest in studying the cost of delays due to accidents (see e.g. Adler et al., 2013). In their study of road accidents in Flanders, Raemdonck et al. (2010) conclude that these types of costs are significant. This has led the Netherlands to include congestion costs as a sixth category of accident costs in their recommendations (SWOV, 2014; Wit and Methorst, 2012).

This study is conducted in a rural area. The existing literature on delay costs of accidents has largely been conducted in urban areas afflicted by recurrent congestion. There are special features of transport in rural areas, however, that make it equally relevant to examine delay costs in this setting. First, there is limited access to alternative transportation routes (Laird and Mackie, 2009). There are only two alternative routes to Ev6 connecting the southern and northern parts of Norway. One goes through Sweden. However, this route has two border crossings and results in a long detour to avoid an obstruction on the Ev6 through Nordland. The other alternative route runs along the coast and is associated with poor road quality and interruption by several ferries. This is also a long detour. A second aspect to consider is the characteristics of the transport on the road section in question. The road section in this study is an important transport corridor for fresh fish, which is particularly dependent on short and reliable travel times (Hanssen and Mathisen, 2011). It is clear that accidents blocking the roads have significant consequences for the transport of perishable goods such as fresh fish. A third factor is that the rescue crews' response and clean up times after traffic accidents may be longer in rural areas than in urban areas because rescue crews may be spaced quite far apart, possibly resulting in longer periods of road closures and obstructions.

Finally, the characteristics of the road are also important for the magnitude of the effect of an accident on traffic flow. Many parts of the studied road section are steep, narrow and winding. This means that it may be difficult for other road users to pass the accident location during post-accident clean up, in which case it will take longer for the traffic flow to normalize after the accident. The road characteristics also cause variation in speed among drivers; e.g., heavy vehicles will often have problems maintaining speed on roads with a high gradient, particularly in combination with winding roads, and some drivers will lower their speed in order to cope with the difficulty of driving on narrow and winding roads (Fuller, 2005). This will hold back all traffic because of the scarcity of opportunities for safe overtaking on winding roads. According to Bogaerts et al. (2004), the robustness of a road is determined by the rest-capacity of the road, the availability of alternative routes, the speed of incident management, information to road users, and the level of road maintenance (Bogaerts et al., 2004). Considering the discussion above in relation to this definition, the robustness of Ev6 Nordland is low.

Each context will have its own combination of characteristics related to climate, topography, demography, and so on. Therefore, it is important to conduct the studies in various context. According to Böcker et al. (2013) concerns related to adverse weather effects on travel behaviour in rural areas with arctic climate have received little attention. Although the results from this study cannot be directly transferred to other contexts, there are rural areas with cold winter weather and/or mountainous topography such as the Alps, the Snow Belt states in US, and areas in Canada, which may benefit from the knowledge produced in this study. Our approach to estimate the often disregarded delay costs due to accidents is particularly useful in this respect.

The remainder of this article is structured as follows: in Section 2, the theoretical background of the analysis is presented. In Section 3, the case and data are described. The results are presented and discussed in Section 4. Lastly, the main results, some concluding remarks and implications are summarized in Section 5.

2. The risk of accidents and the associated social costs

2.1. The risk of accidents

A road traffic accident is a stochastic event with frequency and severity determined by three groups of factors: (1) the characteristics and behaviour of the drivers (age, driving experience, driving speed, level of concentration and attitudes towards risk); (2) factors related to the vehicle (size, type, and vintage); and (3) external physical factors such as weather conditions, lightening, road characteristics and the level of traffic (Høye et al., 2012; Koster and Rietveld, 2011; Maibach et al., 2008). The surface of the road section studied is largely covered by snow and ice during the winter, and wind and snow often create difficult driving conditions. In addition, the lighting is poor due to the dearth of daylight hours and scarce artificial lighting on long stretches of the road. The risk factors are further reinforced by large parts of the road being narrow, winding and of a steep gradient. Summing up, it is reasonable to assume that the risk of accident is higher in winter than in summer.

Freight transport drivers in general are expected to be better trained and have more experience in driving under both normal and adverse weather and are thus generally more capable drivers and more able to handle difficult driving tasks than private motor vehicle drivers (Fuller, 2005). However, two factors indicate that heavy vehicles may have higher risk of accident in winter than private motor vehicles. First, the combination of narrow, winding roads with steep gradient are particularly challenging to handle for large vehicles. Second, a significant amount of the heavy vehicles on the road stretch are foreign (22%), many from southern parts of Europe, with vehicles less well equipped and drivers less trained and experienced with handling difficult driving conditions on Norwegian winter roads.

The risk of accident on a particular stretch of road (R) is here defined as the number of accidents per million vehicle kilometres driven in accordance with e.g. Høye et al. (2012) and the Norwegian Public Road Administration's (NPRAs) guidelines (2008). The regis-