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Winter problems on mountain passes – Implications for cost-benefit analysis

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A R T I C L E   I N F O

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A B S T R A C T

Cost-benefit analysis is a tool in government decision-making for determining the consequences of alternative uses of society's scarce resources. Such a systematic process of comparing benefits and costs was adopted in early years for transportation projects and it has been the subject of much refining over the years. There are still some flaws, however, in the application of the method. In this article we have studied the impact of weather conditions on traffic speed on low traffic roads often exposed to adverse weather. This is an issue not currently considered in the cost-benefit analysis of road projects. By using two analytical approaches—structural equation modelling and classification and regression tree analysis—the impact of the weather indicators temperature, wind speed, and precipitation on traffic speed has been quantified. The data relates to three winter months on the European Route 6 road over the mountain pass Saltfjellet in Norway. Increase in wind speed, increase in precipitation and temperatures around freezing point all caused significant decrease in traffic speed in the case studied. If actions were taken to reduce the impact of adverse weather on traffic (e.g. by building a tunnel through the mountain) this study indicates that the road users would gain a total benefit of approximately 2,348,000 NOK (282,000 EUR) each winter at Saltfjellet if all the weather related benefits were included. We argue that this is a significant number that is highly relevant to include in CBAs. This applies both to the CBAs of new transportation projects as well as when resources are allocated for operation, maintenance, and monitoring of the existing transport systems. Including the weather related benefits would improve the application of CBA as a decision-making tool for policy makers.

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1. Introduction

Mountain passes are often exposed to rough weather, especially during the winter. The Norwegian Public Roads Administration (NPRA) has identified strong wind, snow and driving conditions around freezing point as problematic for traffic on mountain passes (NPRA, 2012). The importance of these weather variables for traffic is supported by previous research on this topic (see e.g. Agarwal et al., 2005; Al Hassan and Barker, 1999; Cools et al., 2010; Nosal and Miranda-Moreno, 2014). Adverse weather[1] may impact driving conditions on mountain pass roads in several ways. First, the combination of wind and snow causes snowdrifts either because the wind moves snow already lying on the ground, or because there is wind and

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[1] In this context, adverse weather is defined as "atmospheric conditions at a specific time and place that are unfavourable to optimal traffic conditions" (El Faouzi et al., 2010).

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snowfall at the same time. Snowdrifts reduce visibility and block the roads (NPRA, 2012). Second, the wind speed is sometimes so great that there is a risk of vehicles being blown off the road. Finally, driving conditions around freezing point cause the roads to be slippery and the risk of accidents increases. It is challenging and costly to operate mountain passes during the winter because of the problems created by adverse weather. Sometimes the operating crews have to close the roads or traffic is led in convoys because it is not safe to allow the free flow of traffic (NPRA, 2012).

It is not only the operation of mountain passes that is costly; road users also experience increased travel costs because of problematic traffic conditions in adverse weather on mountain passes. There are costs related to delays and unreliable travel times, increased risk of accidents, and extra material costs due to the use of spiked tires and chains (Hagen and Engebretsen, 1999). Much research has been conducted addressing the problems with delays and unreliable travel times caused by adverse weather, and the conclusions are that these problems can be extensive and that people are willing to pay to avoid them (see e.g. Bates et al., 2001; de Jong et al., 2009; Li et al., 2010; Sikka and Hanley, 2013; Tseng and Verhoef, 2008). The extensiveness of the problem can be illustrated by the Oak Ridge National Laboratory study, which estimated the delay experienced by American drivers due to adverse weather conditions in 1999 to be 46 million hours (cited in Rakha et al., 2007).

All road projects in Norway are subject to cost-benefit analysis (CBA). The Norwegian Public Roads Administration (NPRA) states that the aim of the CBA is to systematically consider all relevant benefits and costs that a road project will impose on society (NPRA, 2006). Yet despite the harsh climate and the fact that many important road sections are exposed to adverse weather, adverse weather impact on traffic is not considered in CBAs of road projects. As mentioned above, research reveals that people are willing to pay for both travel time savings and reliable travel times (see e.g. Asensio and Matas, 2008; Bates et al., 2001; Carrion and Levinson, 2012; de Jong et al., 2009; Li et al., 2010; Sikka and Hanley, 2013). Travel time savings typically produce 60 percent of the traditionally quantified user benefits in the CBA of new road projects (Hensher, 2001). However, travel time savings related to the avoidance of delays and uncertainty caused by adverse weather is not included, and the value of increasing the reliability of travel times is often not included at all. In a recent study, Peer et al. (2012) show how travel time variability can be predicted for use in CBAs. They point out that in order to be able to include in CBAs the benefits associated with measures increasing travel time reliability, it is necessary both to know the extent of unreliability in the transport system today and the driver's valuation of unreliable travel times. This also applies to delays.

Thorough work has been done to put monetary values on travel time savings (NPRA, 2006), but to what extent adverse weather causes delays and unreliability at mountain passes is poorly covered. This makes it impossible to include these effects in CBAs, which again means that the net benefits of projects aimed at reducing the problems are valued too low, and projects may lose priority to other projects with higher net benefits. The building of a tunnel through a mountain in order to avoid a challenging mountain pass is an example of a project which would reduce the impact of adverse weather on traffic and hence result in both travel time savings and higher travel time reliability. Improvement of the road structure (location in the terrain, road width, curvature, etc.) is another example. Hagen and Engebretsen (1999) conducted a supplementary CBA of two tunnel projects located in the county of Nordland, Norway, and estimated an increase in cost-benefit ratio from 0.42 to approximately 0.90 when the weather-related benefits of travel time savings, increase in travel time reliability and reduction in material costs were included. The results were based on a stated preference study among the users of the road.

Maze et al. (2006) have identified three predominant and measurable dimensions of the weather's impact on traffic: traffic demand, traffic safety, and traffic flow relationships. Research has focused on all three dimensions for quite a while, and the interest for the topic has increased lately in the light of the growing awareness of climate change impact on the transport system (see e.g., Arana et al., 2014; Böcker et al., 2013; Hooper et al., 2013; Khaleghei Ghosheh Balagh et al. 2014; Khattak and De Palma, 1997; Khattak et al., 1998; Lam et al., 2008).

The aim of this study has been twofold. First, two analytical approaches—structural equation modelling (SEM) and classification and regression tree (CART) analysis—have been applied in order to be able to quantify how weather influences traffic flow (here represented by traffic speed) on mountain passes. Second, the results from the analysis have been used to quantify the economic consequences of the impact of adverse weather on traffic flow.

The use of speed as an endogenous variable in the analysis is supported by Koetse and Rietveld (2009), who identified speed choice as one of several possible behavioural reactions to adverse weather (for further details on behavioural reactions in transport, see de Dios Ortúzar and Willumsen (2011)). Difficult driving conditions caused by adverse weather represent only one factor determining speed choice. The literature has identified several other factors determining speed choice:

- speed limit, cost of fines, and the risk of being caught driving too fast (Rietveld and Shefer, 1998);
- individual characteristics of the driver, such as age, gender, and income (Rietveld and Shefer, 1998);
- information about the transport system and previously acquired knowledge and experience (Dia, 2002);
- perception of driving conditions and risk (Dia, 2002; Fuller, 2005);
- frequency and severity of accidents, characteristics of the road and type of vehicle (De Luca et al., 2012; Liu, 2007);
- costs of arriving late (Rietveld and Shefer, 1998).

Keeping task difficulty within selected boundaries has been suggested as a key sub-goal in speed choice (Fuller, 2005). Different levels of task difficulty are thought to be produced in the dynamic interaction between the determinants of task demand and driver capability (Fuller, 2005). Hence, in adverse weather drivers reduce vehicle speed to varying extents.

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