TRANSPORTATION POLICY AND ROAD INVESTMENTS

Thor-Erik Sandberg Hanssen* and Finn Jørgensen

Bodø Graduate School of Business, University of Nordland, NO-8049 Bodø, Norway

(*Correspondence, E-mail: thh@uin.no)

Abstract

This paper analyses which factors can explain the planned funding for 83 different stretches of roads in the Norwegian national road network during the ten-year period from 2010 to 2019. Previous studies have focused on the extent to which Norwegian politicians use the results of cost-benefit analyses when they prioritise various road projects. In contrast, we analyse how road characteristics, prior to the planning period (2009 and earlier), influence the amount of money to be spent on the roads. Broadly speaking, the multiple regression analysis shows that the technical characteristics of the roads and their environmental impacts do not have a substantial influence on the funding decisions. The most prominent explanatory factors seem to be the total traffic on the roads under consideration. Thus, our analysis does not support critics of the allocation of funding to Norwegian roads who claim that regional policy considerations largely decide the allocation of road funding. The opponents' critics, however, gain support from the fact that, due to frequent start-ups and stops in Norwegian road building, no economies of scale seem to exist. Another result worth noting is that roads located in constituencies that, relative to the number of inhabitants, are overrepresented in the Norwegian Parliament receive more funding. This does not necessarily mean that politicians are particularly concerned about the people in these constituencies but rather that they perceive high political returns for investing in these constituencies.

Keywords: Road funding, road quality, environmental influence, road importance, political returns

1. Introduction

How can the allocation of public funding to different stretches of roads be explained? Or, indeed, why do some infrastructure projects receive more funding than others? Several studies have sought to answer such questions, including the seminal work by (McFadden, 1976) and more recent ones by Mackay (2001), Lambrinidis et al. (2005) and Kemmerling and Stephan (2008). Focusing on the regional allocation of infrastructure investments, these studies have shown that population and population density, efficiency and redistribution criteria, a replication of previous investment decisions because of bureaucratic inertia, and the expected political return of the investments all play significant roles in the allocation of infrastructure investments. Nevertheless, the literature on the allocation of public investments is still considered limited (Kemmerling and Stephan, 2008; Tsekeris, 2011).

In Norway, econometric analyses of the factors influencing investments in transportation infrastructure have focused on the influence of cost-benefit analyses (CBAs), which is a seemingly reasonable approach given that appraisal by means of a CBA is a common method for evaluating public investment projects (Nyborg, 1998). However, these studies have found that the relationship between the results of cost-benefit analyses and investments is, at best, weak (Fridstrøm and Elvik, 1997; Odeck, 1996). The seemingly weak relationship between CBAs and investments has been explained by a reluctance among politicians to accept the normative premises of CBAs (Sager and Ravlum, 2005), and moreover, politicians would appear redundant if they were simply to accept the result of an expert technique (Nyborg, 1998). The apparent weak explanatory power of CBAs can also be explained by the fact that a CBA aims to maximise social welfare, but this is not the only objective of the transportation policy in Norway. The objectives of the Norwegian transportation policy are to "provide an effective, universally accessible, safe and environmentally friendly transportation system covering Norwegian society's transportation requirements and encouraging regional development" (Norwegian Ministry of Transport and Communications, 2009).

As there is nothing mechanical about the process of implementing public policies either in Norway or anywhere else (Blondel and Manning, 2002), this study is designed to test in depth how different factors influence the planned allocation of funding for transport projects. More specifically, we analyse how specific characteristics of different stretches of Norwegian roads influence their planned funding. The specific characteristics include (1) their importance for car drivers and businesses, (2) their quality, (3) their environmental impacts and (4) the characteristics of the constituencies in which the roads are located. The analysis is based on data of planned funding that terminates at the end of 2009 of 83 specified road stretches for the ten-year period 2010 to 2019 and characteristics of the same roads (explanatory variables) in 2009 and earlier. All analysed stretches of roads form part of the Norwegian National Road Network (NRN) and comprise approximately 90 per cent of all evaluated NRN projects for the actual period.[1]

The remainder of this article is organised as follows. Section 2 briefly presents an overview of the Norwegian national road network and the planning procedure prior to funding being allocated to different roads. Section 3 defines the variables and data used in the study. Section 4 outlines the econometric specification of the model estimated and presents and discusses its results. Lastly, the main results are summarised in section 5.

2. The Norwegian National Road Network and planning procedure

The Norwegian national road network

The Norwegian road network has a total length of approximately 93000 kilometres. The most important roads make up the Norwegian national road network (NRN) and are maintained by the national government. This network is approximately 10500 kilometres long and has 350 long bridges (>350 metres), approximately 450 tunnels and 18 ferry services (Norwegian Public Roads Administration, 2010). Although only 11% of the road kilometres in Norway are part of the NRN, NRN roads account for approximately 44% of all vehicle-kilometres travelled on Norwegian roads (Gustavsen, 2009). Together, the NRN and Norway's national harbours, railway hubs and airports constitute the national transportation network. The NRN is illustrated in Figure 1.

[1] We were not able to find the values of the explanatory variables used for all projects.

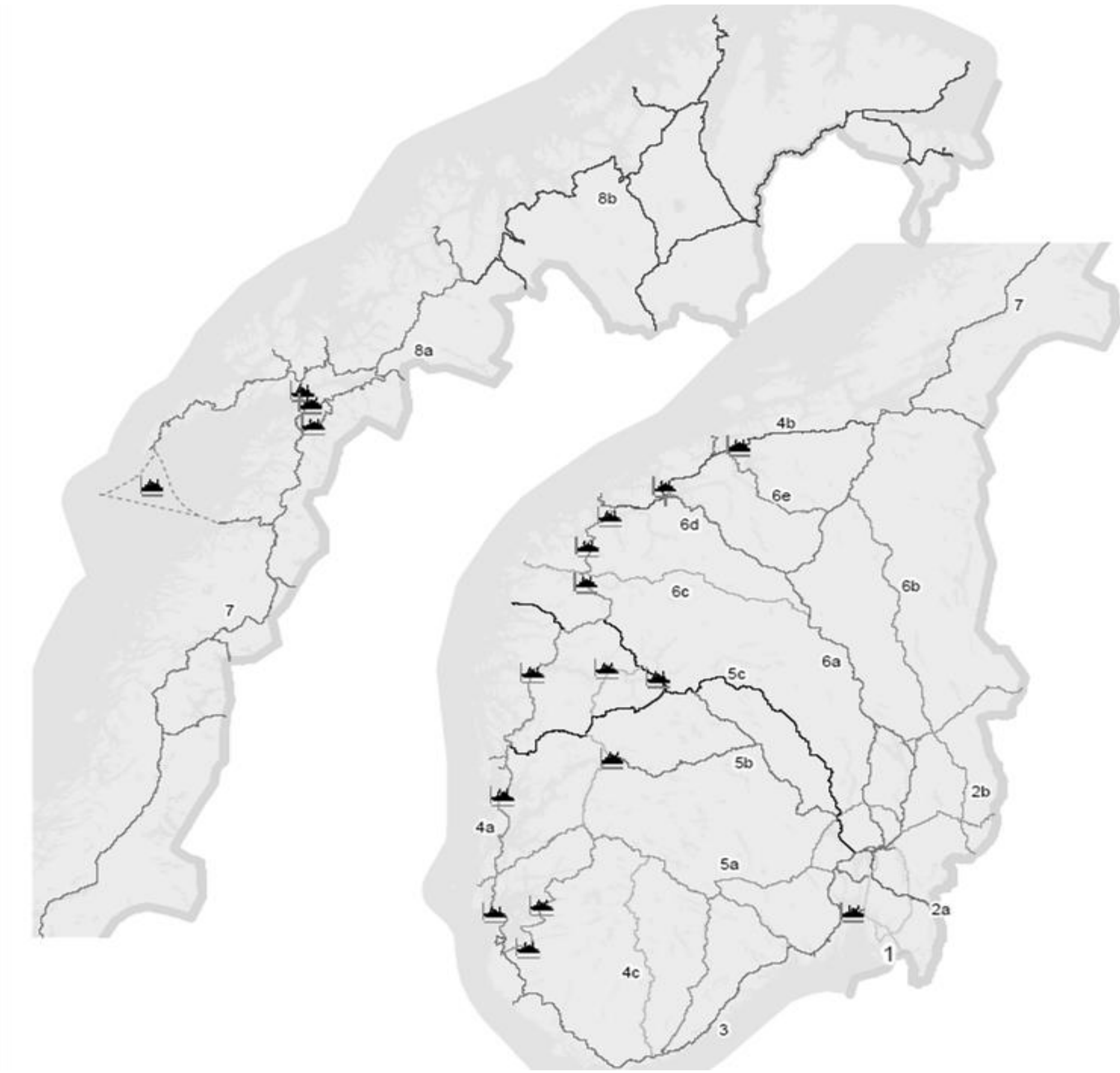

Figure 1 Map of the Norwegian national road network (www.vegvesen.no). (The numbers on the map mark the transportation corridor to which each road belongs. The locations of the ferry services in the NRN are marked by ferry illustrations).

The planning procedure for national road expenditures

The Norwegian government presents its transportation policy in the National Transport Plan (NTP). The plan is produced every four years, covers a period of ten years and aims to provide a hierarchical framework and technical basis for decision making (Norwegian Ministry of Transport and Communications, 2009).

The procedure to develop the plan begins when the government informs the Norwegian Public Roads Administration (PRA) about its policy objectives immediately after publishing the previous transportation plan. The regional offices of the PRA then provide a list of projects in their regions that can help to meet the policy objectives. Based on the priorities as determined by the regional offices and in cooperation with the Norwegian National Rail Administration, the Norwegian Coastal Administration and Avinor AS (the owner of the Norwegian airport network) a proposal for the next NTP is assembled and submitted to the government. After receiving and reviewing the stakeholders' comments, the government assembles the NTP and sends it to Parliament for ratification. The planning procedure is illustrated in Figure 2.

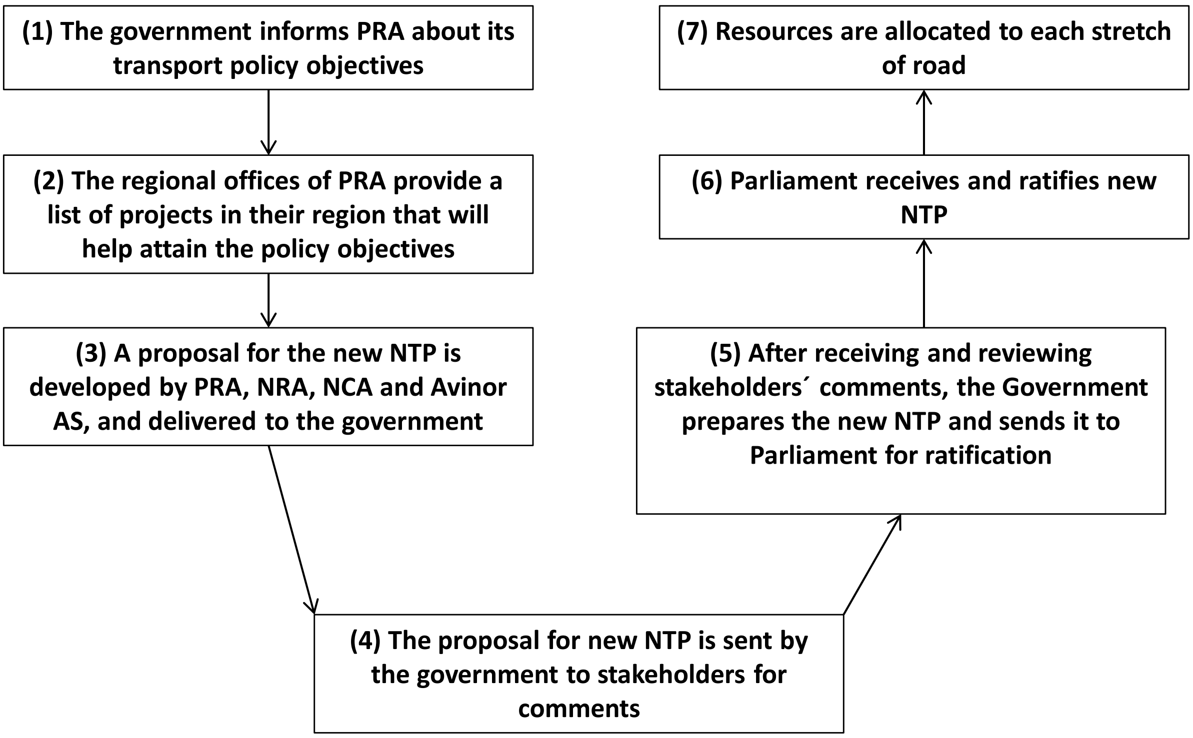

Figure 2 The planning procedure for the National Transport Plan of Norway (NTP). (The abbreviations used in the figure are PRA: Public Roads Administration, NTP: National Transport Plan, NRA: National Rail Administration, NCA: Norwegian Coastal Administration. Avinor AS own the Norwegian airport network).

Following ratification by Parliament, the Norwegian Public Roads Administration then prepares an action plan (Norwegian Public Roads Administration, 2010). This plan is the most important reference for how the policy objectives of the NTP are to be implemented. The last action plan for NTP 2010 to 2019 lists all planned expenses for each of the roads that were part of the Norwegian NRN as of January 1st, 2010.

It is important to note that even though the NTP is ratified by the Parliament, it is not a binding budget document (Welde et al., 2013). Road projects tend to reach the public agenda following local initiatives that gain momentum through the media (Haanæs et al., 2006). The result is that the funding priorities may change during the NTP period in question (2010 to 2019). Nevertheless, the selection of projects included in the NTP is the result of careful assessments conducted by the PRA (e.g., cost-benefit analyses) and the involvement from politicians on several different policy levels (Welde et al., 2013). Therefore, the NTP is the most reliable source of information with respect to the planned future spending on different stretches of roads. Oral information from the bureaucrats working with the NTP also affirm that the priorities of the NTP are, for the most part, implemented. Because the action plan prepared by the Public Roads Administration is based on the priorities as determined by the NTP, the members of Parliament constitute the decision makers in this context.

For the 2010 to 2019 planning period studied in this article, the government announced that to achieve the overriding transportation policy objectives, it intends to spend approximately NOK 220 billion[2] on the Norwegian national road network (the 83 stretches of roads).

3. Descriptions of data sources and variables

The data set used in this study is collected from The Norwegian Public Roads Administration (2010), the Norwegian National Road DataBase (NRDB) and the Norwegian Parliament (www.stortinget.no). A detailed description of the models' variables is provided herein.

[2] 1 NOK≈USD 0.17.

The amount of money allocated (*IN*)

IN is the dependent variable and the amount of money, measured in 2010–NOK, that is planned to be spent on repairs and improvements for each stretch of the 10500 kilometres of the national road network in the ten-year period from 2010 to 2019. The average amount to be allocated to each of the 83 stretches of roads is NOK 1302 mill, with a range from 2 mill NOK to 6953 mill NOK.

Road length (*RL*)

All other factors being considered equal, it is more costly to build and maintain longer roads. This is intuitive because more resources are needed to plan, build and maintain long roads. Therefore, we assume that there is a positive relationship between the money planned to be spent on a stretch of road and the length of that stretch of road. The average length of the 83 roads in our sample is 102 kilometres. The shortest road, located in the capital city of Oslo, is only 2 kilometres, and the longest road, located in the northern part of the country, is 655 kilometres.

Average traffic volume (*AT*)

Traffic volume is an important determinant influencing how Norwegian roads are built (Directorate of Public Roads, 2011b). That is, roads with a substantial amount of traffic are built according to higher engineering standards, and as such, these roads require more resources. Moreover, rutted roads are one of the most important triggers for road maintenance in Norway (Hjelle, 2007), and ruts develop more quickly on roads with high volumes of traffic. As a result, the expected lifetime for road surfaces varies from 6 to 13 years, depending on the traffic volume (Directorate of Public Roads, 2011a). Accordingly, we hypothesise that there is a positive association between money planned to be spent on road investments and maintenance, on the one hand, and average traffic volume, on the other hand.

As the numbers of trucks and light vehicles on different stretches of roads are highly correlated, it causes estimation problems when employing both as explanatory variables in the same regression model. Therefore, we introduce a compound measure of traffic volume on a stretch of road using two steps. First, the number of light vehicles (AT_L) and the number of trucks (AT_T) are estimated from unweighted averages of the numbers of these two vehicle categories passing all counter points on the stretch. The compound daily traffic volume measure (AT) on the stretch is then estimated using the following formula:

$$AT = AT_L + v \cdot AT_T$$

where v is the relative weight of a truck compared to a light vehicle. The estimated average weight of heavy vehicles in Norway is 17.2 tonnes (including load), while the average weight of light vehicles is 1.75 tonnes (including load). Consequently, $v = \frac{17.2}{1.75} = 9.83$. This means, for example, that an increase in the number of trucks by one unit leads to approximately the same increase in traffic volume as an increase in the number of light vehicles by 10 units. AT is, therefore, a compound measure of traffic using one light vehicle as a numeraire. The reason why v, and thereby AT, is estimated using the vehicles' relative weights as bases is because a vehicle's weight means more for road maintenance than its size.[3] The mean value of *AT* for the 83 stretches of roads in our sample is 16130 and ranges from a low of 1272 to a high of 68170.

Percentage predicted traffic growth (*TG)*

Before each investment period, Norwegian authorities forecast the expected traffic volume for that particular upcoming period. Forecasts are made for truck and light vehicle transports in each county (Avinor et al., 2007). The predicted percentage growth *(TG*) in traffic volume *(AT*) during the investment period on a particular stretch of road is estimated using the following formula:

$$TG = \frac{AT_L}{AT} \cdot TL_L + \frac{AT_T}{AT} \cdot TL_T$$

where TL_L and TL_T are percentages of expected growth in the number of light vehicles and the number of trucks during the investment period from 2010 to 2019, respectively. *TG* is, thus, a weighted sum of the percentages of growth in light vehicles and trucks using the proportions of light vehicles and trucks in 2009 as weights.

[3] The Norwegian Directorate of Roads measures the transport production of different ferry services in "light vehicle units" or "passenger cars units" using the relative size of different categories of vehicles as a starting point. This is because space is the limiting factor as far as the transport capacity of each ferry is concerned.

As the same public bodies are involved in investment decisions and traffic forecasts, it is reasonable to assume a positive relationship between planned road investments and traffic growth, i.e., decision makers will invest more on those roads they expect will experience the highest traffic growth during the investment period. The average predicted traffic growth is 12.2 per cent, i.e., traffic during the investment period will increase by 12.2 percent, with the sample ranging from -5.9 to 26.8 per cent.

The number of horizontal curves (*HC*)

Horizontal curves affect travel time and route choice (Lægran et al., 2004), and consequently, they affect the efficiency of road networks. Horizontal curves with a radius of less than 50 m are always considered bottlenecks for freight transportation in particular, whereas curves with a radius of less than 150 m can mean bottlenecks when combined with other factors (Norwegian Public Roads Administration, 2011).[4] Because it is an objective of the Norwegian transportation policy to develop an effective transportation system (Norwegian Ministry of Transport and Communications, 2009), we assume that money intended to be spent on a stretch of road is positively related to its number of horizontal curves with a radius of less than 150 m. The number of horizontal curves in 2009 with a radius of less than 150 metres ranged from 2 to 419, with a mean of 103 for the 83 stretches of roads.

Narrow road (*NR*)

Sections of Norwegian roads narrower than 6 metres have no yellow separation line and are defined as bottlenecks (Norwegian Public Roads Administration, 2011) that affect travel time and route choice (Lægran et al., 2004). In this study, we define *NR* as the number of road km that are narrower than 6 metres. Because the government aims to reduce the number of road km without a yellow separation line (Norwegian Ministry of Transport and Communications, 2009), we assume that planned road expenditures is positively associated with *NR*. On average, the stretches of roads in our sample had 3 km without a yellow separation line. Of the 83 roads, 36 had no sections narrower than 6 metres, while one road had more than 44 km of road narrower than 6 metres.

[4] A shorter radius means a sharper curve.

Avalanche problems (*AP*)

Problems associated with avalanches can be a source of uncertainty and anxiety for road users, and this can affect travel time, reliability and the choice of roads used for travel (Lægran et al., 2004). Moreover, Norwegian communities are often isolated after an avalanche. For these reasons, the Norwegian government announced that it will invest in avalanche protection (Norwegian Ministry of Transport and Communications, 2009). Hence, all other things being equal, the hypothesis of this paper is that more money is allocated to stretches of roads with high avalanche problems.

The measure for avalanche problems applied in this study is based on a model developed by the Norwegian Public Roads Administration (2008). All potential hazardous locations on each of the 83 stretches of roads were identified and given a value between 0 and 10. The higher the value, the more serious the avalanche problems at that location.[5] The variable used in this study is measured by the sum of the avalanche risk for all locations with an avalanche risk higher than 3. The value of *AP* in this sample ranges from 0 to 175, with a mean value of 21.

Speed limit (*SL*)

Higher speed limits reduce driver travel times. Consequently, all other things being equal, higher speed limits result in a more efficient road network. However, because there is a close relationship between the risk of being killed in an accident and speed, the speed limit is an important input parameter when Norwegian roads are being dimensioned (Norwegian Public Roads Administration, 2009). Therefore, it can be assumed that roads with high speed limits generally have higher engineering standards than roads with lower speed limits.[6] Two arguments, drawing in opposite directions, can be made with regard to how *SL* influence the amount of money planned to be spent on a stretch of road.

[5] The *AP* variable used is not a pure measure of avalanche risk, but it depends also on the inconvenience for the transport users if an avalanche occurs. For a thorough description of how the *AP* variable is defined, we refer to Norwegian Public Roads Administration (2008).

[6] Not all quality aspects of a road are taken into account by our previous stated variables, such as the road surface, the number and degree of hills and the proportion of its length that has safety barriers etc.

First, it could be argued that it is more costly to maintain the high engineering standards of a road with a high speed limit than a road with a low speed limit. However, on the opposite side is the argument that the engineering standards of a road with a high speed limit are already high. Consequently, there is less need to improve the engineering standards for these roads than for roads with lower speed limits. Thus, it is difficult to form a clear presumption regarding how the *SL* influences the amount of money planned to be spent on a road. The average length-weighted speed limit for the roads in our sample is 75 km/h, with a range of 50 km/h to 95 km/h.

Measure of safety (*FS*)

The measure of safety applied in this article is the absolute number of fatalities and serious injuries on each of the 83 stretches of roads between 2005 and 2010, i.e., in the five years preceding the planning period. In these years, the number of fatalities and serious injuries[7] on the actual roads ranged from 0 to 40, with a mean value of 7. Because it is a goal of the Norwegian transportation policy to reduce the number of fatalities and serious injuries by one-third by 2020 (Norwegian Ministry of Transport and Communications, 2009), the hypothesis of this paper is that roads with many fatalities and serious injuries receive more money.

Measure of subjective noise nuisance (*NN*)

Peoples' subjective noise exposure along every road in Norway has been estimated using actual traffic data, and the number of people living within each 5 dB noise interval (Gjestland, 2007). A mean subjective nuisance score for each 5 dB noise interval measured on a linear scale from 0 to 1 where 0 indicates no nuisance and 1 denotes extreme nuisance has been calculated. The nuisance index per interval is the product of the number of people living within the interval and the mean nuisance score for that interval. The total noise nuisance for each road (*NN*) is the sum of the nuisance indexes for all intervals along the road.[8]

[7] A serious injury is one that is life-threatening or has permanent health consequences.

[8] If, for example, 1000 people state a nuisance score of 0.2 and 2000 people indicate a nuisance score of 0.4 along a particular stretch of road, its *NN*-value is 1000 ((1000×0.2)+(2000×0.4)).

In Norway, it is a policy objective to reduce the total noise nuisance by 10 per cent from the 1999 level by 2020 (Norwegian Ministry of the Environment, 2007). Thus, our hypothesis is that there is a positive association between a road's noise nuisance and the amount of money intended to be spent on that stretch of road. The value of *NN* for the roads in our sample ranges from 0 to 9700, and the mean value is 726.

Representation in the Norwegian Parliament (*RP*)

There are 19 counties in Norway, which also compose the electoral constituencies, and the geographical size and population of the constituencies determine the number of seats each county holds in Parliament. The design of the electoral system takes regional policy considerations into account (Helland and Sørensen, 2009). As a result, remote and sparsely populated constituencies have more seats in Parliament relative to the number of eligible voters in these constituencies than do densely populated constituencies in central areas of the country. The idea that remote and sparsely populated constituencies should be overrepresented in the Parliament has been a guiding principle in the design of shifting electoral systems in Norway.

Politicians know that allocating nationally financed projects to their home districts is an effective way to win votes (Helland and Sørensen, 2009). Moreover, political parties benefit the most from winning additional votes in constituencies with a high number of seats in Parliament per eligible voter because fewer voters have to be persuaded for the party to win an additional seat in Parliament. Therefore, all other factors being equal, we hypothesise that more money is allocated to roads in constituencies with many seats in Parliament relative to the number of eligible voters. The number of seats in Parliament per eligible voter (*RP*) from the 19 constituencies in Norway ranges from 4.08×10^{-5} to 9.48×10^{-5} with an average value of 5.09×10^{-5}.

Summary of the variables

A summary of the variables is presented in Table 1 and Table 2. The first three explanatory variables (*RL, AT, TG*) indicate the present and future importance of the stretch of road such that the higher their values, the more important the stretch of road. The next four variables (*HC, NR, AP, SL*) indicate the standard of the road stretch such that higher values of *HC, NR* and *AP* and a lower value of *SL* means a lower standard. Higher values of *FS* and *NN* may be interpreted as more severe external costs being associated with the traffic on that particular stretch of road.

Table 1 Summary statistics of the data set.

Variable code	Definition	Mean	S.D.	Min	Max
IN	Planned road investments 2010 to 2019, mill. NOK	1302.5	1774.4	2.0	6953.0
RL	Road length in kilometres	102.3	115.2	2.1	655.1
AT	Average daily traffic volume	16130.3	15445.5	1271.6	68170.3
TG	Predicted percentage traffic growth	12.2	7.2	-5.9	26.8
HC	Number of horizontal curves with a radius less than 150 metres	103.2	94.3	2.0	419.0
NR	Kilometres of road narrower than 6 metres	3.0	7.1	0.0	43.7
AP	Index reflecting avalanche problems	21.5	38.7	0.0	174.5
SL	Average length-weighted speed limit (km/h)	75,0	7.0	50.0	94.6
FS	Total number of fatalities and serious injuries (2005 to 2010)	6.8	7.6	0.0	40.0
NN	Index reflecting noise nuisance	725.7	1312.9	0.0	9700.0
RP	Seats in Parliament per eligible voter (10^{-5})	5.1	1.3	4.1	9.5

Finally, a higher value of *RP* indicates that the particular stretch of road receives more attention from the politicians in Parliament due to the prospect of winning additional seats in Parliament. It is noted that the minimum values of *NR, AP, FS* and *NN* are zero, thus meaning that at least one stretch of road has no place where the road is narrower than 6 metres, has no avalanche problems, has no fatalities or serious injuries and causes no noise problems prior to the start of the investment period, respectively.

Table 2 shows that the highest correlation coefficients between the explanatory variables are between *RL* and *FS* (0.58), between *HC* and *NR* (0.58) and between *RL* and *HC* (0.56), all of which are statistically significant at the 5 per cent level. Generally speaking, *RL* correlates best with the other explanatory variables, while *NN* and *RP* are the least correlated. Later tests show that the correlations in Table 2 do not cause any estimation problems with respect to our model specification (see section 4).

Table 2 Pairwise correlation matrix of the explanatory variables.

	RL	AT	TG	HC	NR	AP	SL	FS	NN	RP
RL	1.00	-0.29*	-0.16	0.56*	0.47*	0.46*	0.28*	0.58*	0.11	0.32*
AT		1.00	0.34*	0.08	-0.17	-0.37*	0.10	-0.03	0.35*	-0.44*
TG			1.00	0.14	-0.00	-0.11	-0.11	-0.13	0.15	-0.32*
HC				1.00	0.58*	0.48*	0.19	0.40*	0.41*	-0.13
NR					1.00	0.46*	0.09	0.09	0.06	0.12
AP						1.00	0.09	0.17	-0.02	0.14
SL							1.00	0.28*	-0.05	0.13
FS								1.00	0.14	-0.01
NN									1.00	-0.21*
RP										1.00

*Indicates correlation coefficients statistically significant at 5 per cent level or better.

Selection of explanatory variables and cost-benefit analyses

Before we outline the a priori assumptions regarding the relationship between the money planned to be spent on each stretch of road (*IN*) and our selected explanatory variables, it is worth emphasising that these variables are chosen from a careful examination and observation of the political process leading to the priorities in the NTP (see section 2). Local politicians have great influence on the selection of the stretches of roads considered in the NTP and how they are prioritised. The politicians' priorities, to a large extent, are based on what they can observe and experience when using the roads themselves and when talking to local private car users and local businesses. Therefore, present and future importance of the stretches of road (the explanatory variables *RL, AT* and *TG*) and the present standard of these stretches (the explanatory variables *HC, NR, AP* and *SL*) largely determine the local politicians' priorities. The physical characteristics of the roads and their levels of traffic provide the politicians a better intuitive understanding of the effects of allocating money to the roads than the effects in monetary units presented in the cost-benefit analyses. Norwegian politicians - in particular the left wing politicians representing rural areas - have always been sceptical of cost-benefit analyses. Instead, they rely on traffic and technical information from the parties that are directly affected by the investment (Nyborg, 1998). Nyborg's findings coincide with the results of Welde et al. (2013) in that they conclude, as mentioned previously, that cost-benefit analyses seem to have minimal impact on the selection of projects included in the NTP. As Nyborg's work is based on interviews with members of the Norwegian Parliament while the latter work analyses actual choices presented in the NTP, these results together indicate that Norwegian politicians' wants are decisive with respect to the prioritisation of road projects.

Reduced time costs typically make up between 60% and 75% of the quantified user benefit of transport projects (Hensher, 2001; Welde et al., 2013). Consequently, our chosen explanatory variables *AT* and *TG* are major components in the cost-benefit analyses as investments in stretches of roads with high levels of traffic and traffic growth normally yield high benefit/cost ratios. This fact, in combination with our a priori assumptions that the amount of money planned to be spent on a particular stretch of road (*IN*), is positively associated with the values of *AT* and *TG* (see section 4), suggests that the amount of money allocated to different stretches of roads is positively correlated to their benefit/cost ratios. Thus, our hypotheses seem to be in conflict with Norwegian politicians' attitudes towards cost-benefit analyses. However, it is important to note that an increase in *IN* alone will reduce the benefit/cost ratio. The increase in *IN* may outweigh the benefits resulting from improving the standard of the roads. Hence, all other things being equal, investments in roads with low standards do not necessarily need to be more profitable or yield higher benefit/cost ratios than improving the standard of roads with good quality. Finally, we also hypothesise that parliamentary representation in the electoral districts where the roads are located (*RP*) influences the amount of money planned to be spent on them, thereby making the selection of the project less dependent of their economic viability.

Based on the above reasons, one can argue that there is no major conflict between assuming that the politicians place weight on our chosen explanatory variables and the fact that they only place minor weight on the cost-benefit analyses.

4. MODEL SPECIFICATION AND ESTIMATION RESULTS

The model

To analyse how the characteristics of the stretches of road influence the authorities' planned future spending on those stretches (*IN*), the following model is employed:

$$(1)\ \ LnIN = \beta_0 + \beta_{RL}LnRL + \beta_{AT}LnAT + \beta_{TG}TG + \beta_{HC}LnHC + \beta_{NR}NR + \beta_{AP}AP + \ \beta_{SL}LnSL + \beta_{FS}FS + \beta_{NN}NN + \beta_{RP}LnRP + \varepsilon$$

Equation (1) includes explanatory variables with negative and zero-value observations. Because the natural logarithm of negative and zero values are undefined, equation (1) includes only log-transformed explanatory variables with positive observations.

From Equation (1), it follows that $EL_iIN = \frac{\partial IN}{\partial i}\frac{i}{IN} = \beta_i, i = \{RL, AT, HC, SL, RP\}$ and $EL_jIN = \frac{\partial IN}{\partial j}\frac{j}{IN} = j \cdot \beta_j, j = \{TG, NR, AP, FS, NN\}$, where $EL_i\,IN$ and EL_jIN denote elasticity of *IN* with respect to i and j, respectively. Hence, the elasticities of IN with respect to i, $i = \{RL, AT \ldots\}$, are constant, whereas the elasticities of IN with respect to *j*, $j = \{TG, NR, ..\}$, increase proportionally with *j*. This means that the relationships between IN and i, $i = \{RL, AT \ldots\}$, are loglinear while the relationships between IN and *j*, $j = \{TG, NR, ..\}$, are semi-loglinear. Thus, an increase in i, $i = \{RL, AT \ldots\}$, by 1% will always change IN by β_i %, while an increase in *j*, $j = \{TG, NR, ..\}$, by one unit will always change IN by $100 \cdot \beta_j$ %. Thus, our model specification implies that the relative changes in *IN* when i changes by one percent, $i = \{RL, AT \ldots\}$, and when j changes by one unit, $j = \{TG, NR \ldots\}$, are independent of their own value as well as the values of the other explanatory variables. The absolute change in *IN* when one variable changes is, in contrast, dependent on the values of all explanatory variables in the model as outlined by the expressions of the cross derivatives stated below.

It follows from the hypotheses presented in Section 3 that the sign of β_{SL} is uncertain. The remaining independent variables are assumed to have positive impacts on planned road investments. Therefore, we assume that $\beta_{RL}, \beta_{AT}, \beta_{TG}, \beta_{HC}, \beta_{NR}, \beta_{AP}, \beta_{FS}, \beta_{NN}, \beta_{RP} > 0$.

From our model, it follows that the cross derivatives $\frac{\partial^2 IN}{\partial l \partial k} > 0$ and $\frac{\partial^2 IN}{\partial SL \partial k} \leq (>) 0$, $l, k = \{RL, AT, TG, NR, RW, AP, FS, NN, RP\ l \neq k\}$. This means that the marginal effect of each independent variable on money intended to be spent on each stretch of road is assumed to depend on the value of all ten independent variables included in the model. For example, the effect of the number of horizontal curves (*HC*) on the money planned to be spent on the road (*IN*) is assumed to increase when average traffic volume (*AT*) and the predicted traffic growth (*TG*) increase. All of these tacit implications of the model are reasonable. How marginal changes in $k = \{RL, AT, TG, NR, RW, AP, FS, NN, RP\ \}$ influence how the speed limit (SL) influences the amount of money planned to be spent on a road (the value of $\frac{\partial IN}{\partial SL}$) is, however, ambiguous.

Finally, it is noted that the money planned to be spent on a particular stretch of road for the period 2010 to 2019 (the dependent variable *IN*) does not influence the values of any of the explanatory variables. The explanatory variables describe the characteristics of the road prior to 2010. Hence, they are definitely exogenous, meaning that we have no identification problem (see, for example, Greene (2008)).

Model estimates and diagnostics

The multiple regression estimates for Equation (1), using 83 road sections selected from the national road network in Norway, are presented in Table 3.

Table 3 Multiple regression estimates.

Dependent variable: Road investments		
Explanatory variable	Coefficient	t-value
LnRL	1.054	2.71***
LnAT	1.436	4.49***
TG (traffic growth)	-0.031	-1.15
LnHC	0.115	0.69
NR	0.044	1.46*
AP	0.004	0.64
LnSL	-2.057	-0.83
FS	0.023	0.68
NN	0.0001	0.77
LnRP	1.932	1.73**
Constant	-6.6702	-0.65
Summary statistics	N = 83, R^2 =0.56, F-value 9.30	

Level of significance: * indicates p<0.10; ** indicates p<0.05; *** indicates p<0.01 (one-tailed).

Model diagnostics do not indicate serious problems with our model. The variance inflation factor (VIF) ranges from 1.25 to 5.69 with an average value of 2.36, which is well below the value of 10, the value at which one would begin to be concerned about multicollinearity (Hair, 1998).[9] Moreover, White`s tests for heteroscedasticity, combined with a visual inspection of the residuals versus the predicted values, do not indicate violations of the constant variance assumption. The Shapiro-Wilk test for normality shows that we cannot reject the assumption of normally distributed residuals. Moreover, the average residual value is approximately zero, and the residuals are not correlated with any of the independent variables. In conclusion, the properties of the model appear to be statistically valid, thus indicating that the results are credible.

The F-value shows that the model is significant at the 1 per cent level. The R^2 value of 0.56 (with an adjusted R^2 of 0.50) shows that the model explains 56% of the variance in intended road expenditures across the 83 stretches of road. The remainder of the variance in *IN* could, in part, be

[9] Note that the correlation coefficients between the transformed explanatory variables in the model will be different than those shown in Table 2.

due to deleted explanatory variables, such as lobbying and nearby investments in other types of transport infrastructure (e.g., rail stations, harbours etc.) and partly due to some misspecifications of the model. The signs of the coefficients support our a priori assumptions regarding the impacts of the independent variables on road investments. However, not all estimated coefficients are statistically significant at the 10 per cent level.

Further discussion of estimation results

The results in Table 3 give rise to several comments. First, two of the three variables that indicate the importance of the road stretch (*RL, AT*) have significantly positive influences at a 5 per cent level or better on the intended amount of money planned spent on the road. An increase in *RL and AT* by 1 percent increases the money intended to be spent on the road stretch by 1.05 and 1.44 per cent, respectively. It is worth noting that the elasticity of money to be spent on a road with respect to its length ($EL_{RL}IN = \beta_{RL}$) is approximately 1. This finding suggests that there are neither economies nor diseconomies of scale with respect to maintenance and investment in roads of different lengths in Norway. This result could be due to Norway's tendency to improve short stretches of roads at a time. Such procedures result in a more frequent initiation of start-up costs compared with a tendency towards improving longer stretches of road all at one time. Consequently, road builders cannot use the potential scale economies for maintaining and building longer stretches of roads. The relatively high elasticity of money spent on a road (*IN*) with respect to the average traffic volume (*AT*) ($EL_{AT}IN$) indicates that 1) politicians prioritise improving the quality of busy roads and 2) traffic volume is an important determinant of how Norwegian roads deteriorate and how frequently they require maintenance.[10] More surprising, and in conflict with our a priori assumptions, traffic forecasts (*TG*) are found not to significantly influence road investments. One possible interpretation of this result is that authorities and politicians regard the traffic forecasts as being so uncertain that they attach little importance to them.

[10] Our data does not enable us to divide between pure maintenance costs and investment costs.

Second, even though all the explanatory variables indicate that the quality of the road stretch (*HC, NR, AP, SL*) influences the money intended to be spent on it in the hypothesised direction, only the variable indicating the narrowness of the road (*NR*) contributes significantly. The estimated value of β_{NR} = 0.044 means that an increase in the number of kilometres in which a road is narrower than 6 m by one km leads to a 4.4 % increase in the money intended to be spent on it. The fact that only one of our four measures of a road's quality significantly explains the magnitude of money planned allocated to it, suggests that Norwegian politicians do not necessarily allocate the most resources to improving the roads with poorest quality. Previous studies have found that central governments tend to allocate transportation investments to districts where re-election prospects are uncertain (Tsekeris, 2011). The above points in the direction that decision-makers think extending narrow roads are the most visible measure, thus offering higher political returns than investments resulting in less winding roads, reduced avalanche problems, or higher speed limits.

Third, none of the variables indicating the external costs associated with traffic on the road (*FS, NN*) influence the intended money spent on it significantly. These findings are somewhat surprising, as previous research has found that both safety and noise nuisance are important factors in determining levels of resource allocation for roads (Odeck, 1996, 2010). One reason may be that traffic accidents (*FS*) are gradually being tackled in a more multi-disciplinary manner by planners, who involve engineers, public health organisations, police departments, educational authorities and social services departments (Hamer, 2004). Consequently, several important measures to improve road safety are financed over other budgets, e.g., stricter enforcement of speed limits, developing positive attitudes for road users in schools and traffic safety research. Also, the insignificant influence on road funding of the noise nuisance variable (*NN*) suggests that, in recent years, the government has considered low-cost measures, such as stricter noise limits for vehicles and tyres, lower speed limits, and the reduced use of studded tyres, to be more appropriate solutions for reducing noise problems than noise-reducing pavements or acoustic barriers.

Fourth, Table 3 shows that parliamentary representation in the electoral district where the road is located (*RP*) influences the amount of money planned spent on the road significantly. A one per cent increase in the number of seats per eligible voter from the district in which the road is located leads to a 1.9 per cent increase in intended expenditures on the road. Based on the design of the electoral system in Norway, sparsely populated constituencies are, as previously mentioned, overrepresented in the Parliament. The fact that more money is allocated in roads located in constituencies overrepresented in Parliament indicates that, other things being equal, more money is intended to be allocated to roads located in sparsely populated areas.

5 Concluding remarks

The main objective of this paper is to analyse how the characteristics of 83 stretches of the Norwegian national road network prior to 2010 influence the amount of money the Norwegian authorities intend to spend on the roads in the ten-year period from 2010 to 2019. This analysis is performed with an econometric model using data related to the Norwegian national roads.

The main conclusion is that the Norwegian government intends to spend more money on long-distance stretches of roads and on those stretches that are heavily trafficked, that is, the most important roads as far as the number of vehicle kilometres produced is concerned. The fact that forecasted growth in traffic on different stretches of roads does not influence the amount of money to be spent on them indicates that the decision makers have little confidence in their own forecasts.

Moreover, the government does not necessarily prioritise investing in the most dangerous and least environmentally friendly roads. Although planned investments are higher for roads with long narrow stretches, our data do not support the hypothesis that more money is planned for investment in roads with poor curvatures or severe accidents or roads that generate severe noise problems. Many Norwegian politicians and bureaucrats in urban areas argue that too much emphasis is placed on regional development at the expense of the roads’ importance for people and industry in general when funding for different road projects is allocated. The above conclusions do not support these claims.

However, our data do suggest that more money is intended to be invested in roads located in regions overrepresented in the Norwegian Parliament. Because of the electoral system in Norway, the regions overrepresented in Parliament tend to be rural and sparsely populated. This does not necessarily mean that policy makers are particularly concerned about regional policy. An alternative and more cynical interpretation is that politicians invest more money in roads in regions overrepresented in Parliament because the expected political return is higher as fewer voters in these regions need to be persuaded for the politician to win a seat in Parliament.

A main critique of the Norwegian procedures for road investments gains support from our analysis. We find that an increase in the length of the road stretch by X per cent increases the money planned for that stretch by approximately X per cent, this indicating no economies of scale in the Norwegian road building industry. This could be due to the authorities' tendency to improve only parts of designated stretches at a given time, thus causing the frequent initiation of start-up costs.

Finally, our results – similar to all empirical studies – have weaknesses due to erroneous data reports and the validities of the explanatory variables. In particular, the ways by which we define the quality of a stretch of road (using variables *HC, NR, AP, SL*) and the external costs or environmental problems caused by the traffic(using variables *FS and NN*) are open to debate. In addition, our compound measure of the level of traffic (*AT*) is questionable. Moreover, the data set does not enable us to differentiate between necessary maintenance costs granted to a stretch of road and money given to improve the standard of the road. Thus, additional money intended to be allocated to busy roads may be due to necessary maintenance cost increase along with the level of traffic and not due to the authorities wishing to improve their standard. Hence, the money planned for a particular stretch of road for the period 2010 to 2019 (*IN*) is an imprecise indicator of the authorities' preferences with respect to future road priorities.

Additionally, actual explanatory variables for money allocated to particular stretches of roads, such as fixed spatial effects and transport infrastructure specific to each of the constituencies in which the roads are located and the effects of the characteristics of neighbouring constituencies, are omitted.

The gross domestic product (GDP) per capita and income distribution for the population in the areas where the roads pass through may also be relevant explanatory variables. We find it difficult, however, to operationalise these things accurately as available data (for example, GDP per capita) are at the county level while many of the roads in question run through many counties. It is also difficult to develop firm a priori assumptions about how many of the explanatory variables influence road funding. An airport, for example, can produce complementary or alternative transport services to a road leading to that airport, thus influencing the funding of the road positively and negatively, respectively.

Despite the above limitations, this paper presents a first attempt to determine how the prior characteristics of different stretches of the Norwegian national road system influence how much money politicians and transport planners intend to spend on these stretches of roadway during the next ten-year period.

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