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Do Planners Get it Right? The Accuracy of Travel Demand Forecasting in Norway

Morten Welde[1]
Norwegian Public Roads Administration, Oslo, Norway; Norwegian University of Science and Technology, Trondheim, Norway

James Odeck[2]
Norwegian University of Science and Technology, Trondheim, Norway

This paper deals with the accuracy of travel demand forecasts among Norwegian road projects. We use data collected from tolled roads and toll free roads. The results reveal that while traffic forecasts of tolled schemes are fairly accurate, traffic forecasts among toll free roads have a higher degree of inaccuracy and are generally underestimated. An explanation for the observed discrepancy between estimated and actual traffic among toll free roads is that road planners may have ignored the existence of induced traffic and that the standard national traffic growth rates used in the transport models has been too low. For tolled roads, an explanation for the higher degree of forecast accuracy is that planners over the years have been scrutinized to provide careful estimates. Our recommendation is that traffic forecasts provided by planners should constantly be subjected to scrutiny by independent consultants before being presented to the decision makers. Aspects that need to be specifically examined include: (1) the extent to which a road project may lead to induced traffic, (2) the extent to which transport models accommodate appropriate factors and, (3) the extent to which forecasts made address uncertainties by providing confidence intervals of estimates.

Keywords: Traffic-forecast accuracy, toll roads, toll free roads

1. Introduction

Risk and uncertainty are issues of increasing concern in transport planning, and it is generally acknowledged that inaccurate travel-demand forecasts represent a major source of risk in the planning of infrastructure projects. International experience suggests that bias, or deliberately skewed forecasts, may play a role in the planning of road-infrastructure projects and that risks are often downplayed.

[1] P.O. box 8142 Dep, NO 0033, Oslo, Norway, T: +4797730031, E: morten.welde@vegvesen.no
[2] NO 7491, Trondheim, Norway, T: +4748025940, E: james.odeck@ntnu.no

The over- or underestimation of traffic levels can have severe implications. Traffic forecasts are used to determine the capacity of transport infrastructure, and inaccurate traffic forecasts can therefore result in inefficient and inaccurate sizing of the road. Accurate forecasts are also important from a socioeconomic point of view. All road projects in Norway and most other countries of Western Europe are subjected to traditional cost-benefit analyses, which rely heavily on the accuracy of the forecasts being used. If traffic levels turn out to be significantly lower than estimated, this can affect total benefits derived from time savings, reduced accidents or lower vehicle-operating costs. In the case of traffic underestimation, the capacity relief on the congested links could turn out to be lower than planned. This may distort the social viability of such projects and result in non viable projects being implemented. The end result may be inefficient resource allocation.

For toll projects, the implications of inaccurate forecasts are even more serious. Whether a road project can (completely or partly) be financed using tolls or not depends largely on the traffic level (i.e., the number of paying vehicles). Thus, in addition to the consequences for toll free roads, toll roads on which traffic levels fail to meet expectations also risk financial default. Furthermore, toll roads are often financed through non-recourse loans that are secured against future toll revenue only and with no other collateral. Bondholders and lenders should therefore require proposed toll roads to be subjected to a thorough risk assessment before investing in projects where the repayment of loans relies on precise traffic estimates.

Over the years, several toll projects have experienced financial difficulties due to traffic shortfalls, cost overruns and/or increased interest rates. The Ålesund Tunnels project in Norway experienced payment difficulties soon after opening in 1987, and the main creditor, Sunnmørsbanken, eventually collapsed. Despite a restructuring of the loans, the project was, in effect, bankrupt. The debt continued to increase, and when the project finally was terminated in October 2009, the remaining debt was still some € 165 million, which had to be covered by the government. To date, however, it is the only Norwegian toll project that has gone into default. With over 100 projects financed by tolls, the success rate of Norwegian tolling must hence be considered high. Internationally, the Hungarian M1/M15 represents a well-known example of overestimation. The project opened on time and within budget, but the traffic soon turned out to be only about half of what was projected. As the concessionaire relied solely on the traffic revenue, guarantees from both the shareholders and the state had to be drawn, and eventually, the concession was nationalised and toll rates halved. The shareholders suffered substantial losses and received no compensation (Joosten, 1999). More recently, the M6 toll road outside Birmingham, UK, is now being used by less than half the number of vehicles for which it was intended, and haulers have called for the road to be subsidised to ease congestion on the main M6, which has no tolls (BBC, 2008).

The aim of this study is to provide new evidence on the magnitudes of traffic forecast inaccuracies using Norway as a case study. We provide explanations for the accuracies and inaccuracies and, based on these explanations, give recommendations for improving road-forecast practices. The differences in the forecast accuracies between toll and toll free road projects are specifically examined.

The paper is organised into the following sections. Section 2 discusses the forecast uncertainties on toll roads versus toll free roads. Section 3 presents the data and methodology used in the analysis. In Section 4, the results are presented, and in Section 5, some conclusions are drawn.

2. Forecast inaccuracies for toll roads vs. toll free roads

The practice of financing new infrastructure through user fees is increasing worldwide. For roads, cost recovery through tolls is becoming ever more common as total tax revenues are often insufficient to cover the requisite infrastructure investments. Traffic forecasting is a complex issue, and adding tolls to the calculation normally increases the uncertainty of the forecasts. Road users respond to tolls in various ways, not all of which are rational, and the models used to forecast traffic are not necessarily designed to incorporate these reactions.

The financial viability of a toll project relies heavily on the number of paying vehicles passing through the toll stations, and overestimation of traffic can potentially have severe financial implications. Thus, it is expected that planners treat toll projects with a higher degree of caution and, even if uncertainties in the estimates cannot be eliminated, use conservative traffic estimates to avoid overly optimistic forecasts.

Forecast inaccuracy is not necessarily a problem. If the errors for various projects are randomly distributed around the true mean, there is a possibility that they would cancel each other out for a given project portfolio. When the forecasts are systematically biased, however, with averages significantly different from zero, perhaps due to over optimism or downright dishonesty on the part of the planners, the problem should be taken more seriously. Whereas transport models can be improved through increased computing power, improved data quality and other factors, deliberate human error is much harder to completely avoid.

The concept of optimism bias or risk denial has been the focus of several studies by Flyvbjerg (2005) and Flyvbjerg et al. (2005, 2006). Based on the data from transport projects around the world, the authors concluded that planners in the transport industry do a poor job of estimating demand. For roads, the actual traffic was found to be, on average, 9.5% higher than forecasted. The actual and forecasted traffic differed by more than ± 20% in over half of the road projects in the sample. Based on these rather disappointing results, Flyvbjerg suggested that planners and decision makers should take traffic forecasts, especially rail forecasts, which do not properly deal with uncertainty with "a pinch of salt" (Forster, 2006, p. 9). Furthermore, Flyvbjerg used these results to make allegations regarding the professional honesty (or dishonesty) of the planners and argued that the end result was often that the most misrepresented projects were built rather than the best ones (Flyvbjerg, 2007). This was opposed by Osland and Strand (2010), who found no general support for the theory of strategic misrepresentation and argued that there are other mechanisms at work that could better help to explain the variations in the forecast accuracies that were often observed.

It is often assumed that planners have become better at predicting traffic levels due to improvements in transport models and computing power. Flyvbjerg et al. (2006) did not support this proposition. In fact, the opposite seems to be the case for Danish road projects, as forecasts there seem to have become more inaccurate over time. Odeck et al. (2009), however, reached different conclusions. By investigating the accuracies of the national and regional traffic forecasts, they found that the forecasts have become more accurate since 2001, when the regional and national transport models were improved. Although their findings relate to forecasts at the macro- and regional levels rather than project-specific forecasts, it is still of interest to compare their results with ours.

Traditionally, the studies of forecast accuracy have been based on toll free roads. With the use of toll financing increasing, however, toll projects have come under increasing scrutiny, especially from credit-rating agencies that routinely gauge the financial viability of such projects on behalf of potential investors. Perhaps the first comprehensive study of toll road traffic-estimation performance was conducted by the investment bank JP Morgan (1997), revealing that 13 of the 14 newly implemented US toll roads displayed traffic levels below forecasts. In four of the projects, the opening-year traffic was 30% below what was expected. The bank concluded that traffic-forecasting inaccuracy represents one of the major sources of risk in toll road projects. The credit-rating agency Standard & Poor's (S&P) have performed risk studies of the traffic forecasts in toll projects since 2002 (Bain and Wilkins 2002; Bain and Plantagie 2003; Bain and Plantagie 2004; Bain and Polakovic 2005) and reported consistent findings. Their conclusions were that toll projects throughout the world suffer from extensive optimism bias and error. The performance of the projects studied ranged from actual traffic being only 15% of the forecasts to actual traffic exceeding forecasts by more than 50%. From the perspective of potential investors, these results are alarming. Even worse, it is likely that Standard and Poor's sample, like the other samples of misleading forecasts, was biased because the toll facilities with a higher credit quality were over-represented. The worst cases of traffic underestimation were probably not included in the sample. As stated by Bain and Polakovic (2005, p. 68): '(…) very poorly performing assets will remain under-represented in the sample and the results derived from our case studies are likely to be flattered in comparison with average, global toll road forecasting performance'. Forecasts for complex road schemes with intricate traffic patterns are hence likely to be vague or non existent, making follow-up studies more difficult.

The concept of demand ramp-up is often considered to be an argument against using the first whole year of operation as the basis for measuring the inaccuracy in forecasts because the demand for travel often depends on variables that might take years to spread through the system. It may thus take a few years before a new road reaches its full traffic potential. In the S&P 2005 study, however, Bain and Polakovic (2005) investigated the concept of demand ramp-up and found no such effect, as there was no systematic improvement in the traffic forecasting accuracy after Year 1. The underestimation of the traffic in Year 1 was likely to persist during Years 2-5, meaning that the forecasts did not become more accurate over time. Similar conclusions were reached by Fitch Ratings (George et al., 2003), who found the actual performance in US toll projects to be heavily skewed downward. However, unlike the other studies mentioned above, George et al. found clear evidence of ramp-up and that traffic tended to gravitate back towards and even exceed the original forecasts over time.

Given these rather disappointing results, one might ask why the toll-financing share of total road financing annually increases if traffic revenues regularly fail to meet expectations in the first critical years of operation. A probable reason is that a high proportion of user-financed projects actually do meet expectations. Mauchan and Bates (2007), of the transport-planning consultants Steer Davies Gleave (SDG), studied 15 privately funded toll projects and found that the forecasts showed a distribution around the expected value, with no evidence of optimism bias. In fact, for the majority of the projects, the traffic was within 5% of forecasts, which in many ways is extraordinarily accurate. Their sample was small, however, and even included seven shadow-toll projects, making them, in effect, toll free projects, so the transferability of the results may be limited. Users do not pay at the point of use in shadow-toll projects, and including such projects in a toll road sample could be considered dubious. However, Bain (2009b) argued that shadow-toll projects share the same error characteristics as traditional toll projects because of the private financing mechanism. The SDG study showed, however, that no general conclusions can be drawn regarding the accuracy of traffic forecasts for toll roads and that research in the industry would benefit from a more case-specific approach, focusing on one country or region at a time. However, the general impression of toll-project forecasting accuracy is of overestimation. Further examples from the US, Spain and Australia (TRB, 2006; Vasallo, 2007; Li and Hensher, 2009 – cited in Bain, 2009b) have all suggested consistent over optimism and/or optimism bias of toll road traffic forecasts.

Studies of forecast accuracies in toll roads versus toll free roads have been rare to date. However, Bain (2009a) provided a comparison of toll and toll free roads based on the data from the S&P studies referred to above and the sample presented in Flyvbjerg et al. (2005). The comparison showed that the toll roads and toll free roads suffered from the same uncertainties. The forecast distributions for the two categories of roads were similar (the same error) but centred around different means; this is a sign of potential bias. The traffic on toll roads was found to be generally lower than the forecast, whereas the traffic on toll free roads was found to be higher than the forecast. The consequence of a similar distribution is that the observed bias can be corrected for, and the potential for error and economic losses can be reduced. Thus, there is no evidence to support the theory that forecast error is reduced when drivers are not required to pay tolls. Næss et al. (2006) reached the same conclusions with similar forecasting accuracy in terms of the absolute error between the two classes of roads.

The studies cited above show that while traffic on ordinary road projects often turns out to be higher than the forecast, toll road traffic is generally overestimated. What these studies have in common though, is that the data often have been collected from secondary sources and from different countries on different continents. Some observations even date back decades. Given that different countries inevitably have different planning traditions and tools and place different emphasis on forecasting accuracy, we argue that the conclusions reached should be interpreted with care. A data set from one country and one data source only would, in our opinion, yield much more reliable results due to the greater opportunity for quality control of the data. Accordingly, the focus of this study is the accuracy of travel-demand forecasts for Norwegian road projects.

3. Data and methodology

3.1 Data

The data for this study consisted of observations from 25 toll projects and 25 toll free road projects in Norway. The data from toll projects are often more available and generally of better quality than for other road projects because all toll projects require a specific approval from the Norwegian parliament. The parliamentary bill in which the project is presented includes all financial assumptions, including the forecasts for the average annual daily traffic through the toll stations. The critical test for traffic forecast accuracy is thus how the actual traffic relates to what was presented to decision makers at the time of the decision to build. The Norwegian Public Roads Administration (NPRA) collects data annually on the traffic levels, costs and revenues in all toll projects throughout the country. The data set includes 12 fixed-link crossings (bridges and tunnels), 11 ordinary highway projects and 2 toll cordons. The tolling in the projects started in the years 1990 to 2007. In projects where the traffic patterns were difficult to forecast, the data are often unavailable. This is consistent with the sampling bias that was observed in the studies mentioned above.

Although our sample consisted of relatively few observations, we still consider it to be representative of the population. During the years 1990 to 2007, 33 toll projects were implemented. Thus, our sample comprised 76% of the total projects in the analysed period. The criteria on which the sampling was based were data availability and quality. We acknowledge that using the projects where data was not available or of a sufficiently high quality for inclusion in the data set would increase the precision in the various property estimates of the population. However, due to the high sample/population ratio and the fact that the quality of the observations was considered to be very high, we still expected to be able to draw some valid conclusions regarding the accuracy of the forecasts in the Norwegian toll road industry.

An important distinction between toll projects and toll free projects is that paying traffic will always differ from (and be lower than) ordinary traffic because of various discounts and exceptions. However, given that the information on the fare and discount system was known before the start of the project, we still expected planners to be able to estimate their effects with a reasonable degree of accuracy.

For the toll free projects, the data situation was somewhat more complicated. Although these projects are approved by parliament in the same way as the toll projects, less data are presented to the decision makers, and the quality of post opening data are generally less reliable. However, the parliamentary bill includes the net present value (NPV) estimated in the cost-benefit analysis (CBA) that relies heavily on the forecasted traffic levels. To find the original estimates, we thus had to consult the original CBAs in which the NPV estimates presented to the decision makers were found. The previous CBAs were not stored in a single database, and even when the estimates were present, they were often on an overall level, so access to the original detailed calculations was necessary. In the Norwegian case, impact assessment, including CBA, is carried out by use of the EFFEKT software. This was a rather demanding process and required collecting data from several sources. The next step was determining the actual traffic. The NPRA collects traffic data from 9,000 sites on all roads based on permanent and temporary monitoring. Among these, 600 sites are so-called Level 1 sites where the traffic is counted continuously. Unfortunately, no system is in place that requires traffic data to be automatically collected on new roads. This means that traffic data were not available for several new roads and could not be included in our data set. We were nevertheless able to find 25 toll free roads where both reliable estimates and actual traffic levels were available. The data were from the years 2001 to 2007 and consisted primarily of projects outside the major urban areas. We often found that less emphasis was placed on traffic forecasts for small road projects such as the straightening of curves. The sample thus consisted mainly of larger projects.

3.2 Methodology

To estimate the accuracy of the traffic forecasts, we compared the actual traffic with forecasted values:

$$U = ((X_a - X_f) \times 100) / X_f$$

where U is percent inaccuracy, X_a is the actual traffic and X_f is the forecasted traffic. With this estimation, perfect accuracy is indicated by zero, and for example, -20% would imply that the actual traffic was 20% lower than expected. For forecast values, we used the estimated traffic in the first calendar year of operation. This is normally presented in the parliamentary bill where the decision to approve the project is made. This means that if a project opens for traffic in August, the basis for comparison would be January to December the next year. In addition, we examined Years 3 and 5 to test whether any improvement in the forecast accuracy occurred over time. One might argue that focusing merely on the first year of operation does not allow for the long-run nature of many forecasting models. However, the principles of discounting suggest that the first years of operation are crucial for both financial and social viability. If a toll project with a pay-off period of 15 years fails to meet revenue expectations in the first five years, the risks of default increase considerably, even if the forecasts become more accurate in, for example, 8–10 years.

It is probably unreasonable to expect planners to be able to predict values with perfect accuracy, especially for projects with complex traffic patterns. However, no acceptable level of forecasting accuracy is defined, and it must thus be regarded as an empirical matter. For construction costs, the

Ministry of Transport and Communications requires cost estimates to be in the range of ±10%; with no specific requirement for demand-forecast accuracy, we used this as a benchmark and regarded the demand estimates that were within ±10% of the actual traffic to be within an acceptable range.

4. Results

The purpose of this study was to assess divergences between the forecasted and actual traffic for toll and toll free projects and to investigate whether there were differences in the forecast accuracies for the two types of projects. In this section, we present the results of our findings.

4.1 Forecast accuracy: Toll roads

As with the international studies referred to above, we found the forecasted traffic on Norwegian toll projects to be higher than the actual traffic. However, with the actual traffic being 2.5% less than forecasted on average, the scale of overestimation was much less than that revealed in the studies in other parts of the world. Summary statistics for the forecast inaccuracies with the Norwegian toll projects are presented in Table 1.

Table 1. Summary statistics for forecast inaccuracies for toll roads.

	Statistic
Number of cases	25
Mean	-2.5
Std. error of mean	4.4
Standard deviation	22.0
Minimum	-35.2
Maximum	45.0

These results appear to be encouraging. A mean of -2.5% was well within what we defined as an acceptable range. However, a closer look at the data revealed that a majority of the projects experience traffic overestimation, as in the international studies reported above. Additionally, 24% of the projects had over 20% less traffic than expected. Clearly, a traffic overestimation of up to 35% in the first whole year of operation can potentially have severe financial implications for the viability of a project. There is a significant risk that projects with traffic shortfalls of this magnitude could experience financial difficulties that necessitate loan refinancing, a prolonged payment period, increased tolls or a combination of alternatives. Luckily, the Norwegian economy has been blessed with the rare combination of high economic growth and low interest rates for some time. If this were to turn into a recession with increasing interest rates and demand shortfalls, as seen in the late 1980s and early 1990s, the risk of default would increase considerably. The standard deviation was 22%, indicating a rather large variation between the projects. Table 2 provides the distribution of projects by percentage inaccuracy.

Table 2. Distribution of projects by percentage inaccuracy.

	Number of projects	Percentage
Projects with overestimation larger than -20%	6	24.0
Projects with overestimation 0 to -20%	10	40.0
Projects with underestimation 0 to +20%	5	20.0
Projects with underestimation larger than +20%	4	16.0
Total	25	100.0

A histogram showing the distribution of these observations is provided in Figure 1.

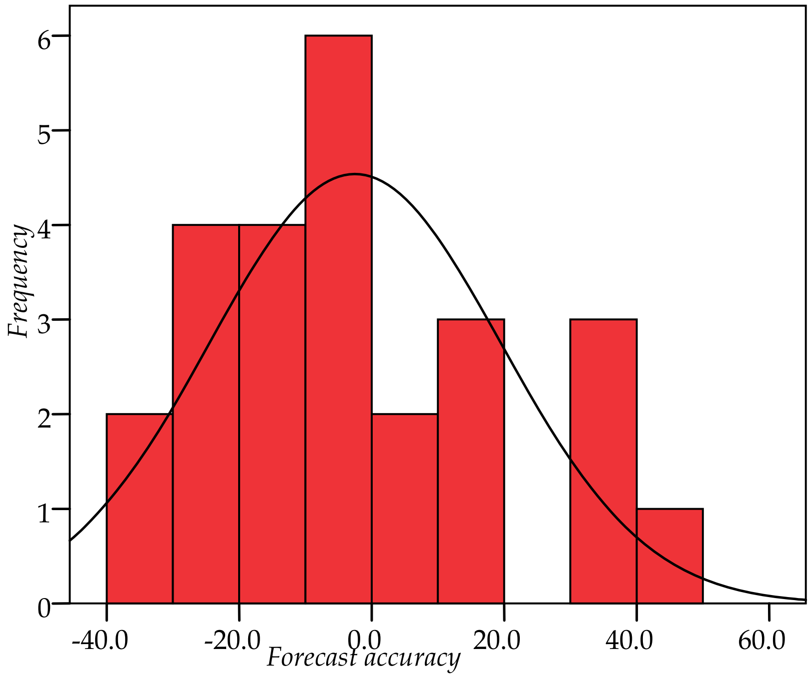

Figure 1. Inaccuracies of the toll road traffic forecasts.

Figure 1 reveals a curve that is close to a normal distribution. A Kolmogorov-Smirnov test of normality ($D(25) = 0.159$, $p > 0.15$) confirmed that the forecasts for the traffic levels in the Norwegian toll projects were normally distributed around the mean or that the assumption of a normal distribution was not rejected. A *t*-test for deviation from zero revealed a test statistic of -0.57 and a significance value of 0.58, which meant that the mean forecast inaccuracy was not significantly different from zero and that we could not conclude that the underestimation was more common than overestimation for the Norwegian toll roads.

From a credit perspective, it is worrying that the majority of the forecast errors for Norwegian toll projects were overestimations. However, a toll project can sometimes struggle to reach its full traffic potential in the first whole year after opening. This could potentially mean that the overestimation is more severe in Year 1 than in subsequent years and that the traffic better fits the forecasts as time progresses. The international evidence of ramp-up has been inconclusive, as different studies have shown different results. However, as shown in Table 3, even though the number of observations decreased over time (*N* = 22 in Year 3 and *N* = 19 in Year 5), there were signs of ramp-up in the Norwegian toll projects.

Table 3. Demand ramp-up.

Year since opening	*Mean inaccuracy*	*Std. dev.*
Year 1	-2.5%	22.0%
Year 3	-2.1%	20.0%
Year 5	2.3%	23.2%

Although the traffic in Year 1 was overestimated, it increased over time, and after five years, the average traffic exceeded the original forecasts. Although the financial implications of forecast error in Year 1 might be severe, there is less need to worry if the traffic soon increases to or even exceeds the necessary levels. This is contrary to Bain's (2009b, p. 37) claim that "…projects that under perform in their early years may never catch up with their original forecasts in later years". In our sample, among the 13 projects with an overestimation greater than the sample mean, four exceeded their original forecasts, five exhibited traffic growth that may well soon put them in the above-forecast figures and four continued to under perform at Year 5. From a financial perspective, the failure to meet revenue predictions in the first five years of operation is, of course, potentially alarming, but our results nevertheless provide a more nuanced picture than that painted by Bain.

4.2 Forecast accuracy: Toll free roads

For the toll free roads, for which we had 25 reliable observations from the last nine years, we noted that the traffic was, on average, *higher* than forecasted. The mean underestimation was 19.0%, but the range was large, from -14.6% to +76.1%. This was consistent with the pattern observed by Flyvbjerg et al. (2005) and Næss et al. (2006). Only six projects had traffic levels below the forecasts, and 13 projects exhibited traffic overestimation above the sample mean. In seven projects, the actual traffic was over 30% higher than predicted. This is clearly unacceptable. We would expect the forecast accuracy to be higher for toll free roads, but this was not the case for the Norwegian roads. The picture that emerged was that the traffic forecasts for the toll free Norwegian roads were skewed to the right. The summary statistics for the toll free roads are presented in Table 4.

Table 4. Summary statistics for the forecast inaccuracies for toll free roads.

	Statistic
Number of cases	25
Mean	19.0
Std. error of mean	4.1
Standard deviation	20.5
Minimum	-14.6
Maximum	76.1

Despite a high standard deviation, we found that the mean was significantly different from zero at the 99% level ($t(24) = 4.64$, $p < 0.05$). Thus, we concluded with a high level of certainty that the traffic on toll free Norwegian roads has been underestimated. The spread in the distribution was alarmingly high, which indicated a high level of general error. The shape of the distribution, as illustrated in Figure 2, indicated that the observations were normally distributed around the mean but with a slight positive skew (Kolmogorov-Smirnov: $D(25) = 0.098$, $p > 0.20$).

As illustrated by the standard deviations for both classes of roads, the internal variations with both the toll and the toll free projects were huge. However, the difference in the means between the two categories of roads was -21.5, and a *t*-test of the difference revealed that the difference in the mean forecast accuracy between the two categories was highly significant and not a result of coincidence ($t(48) = -3.58$, $p < 0.01$).

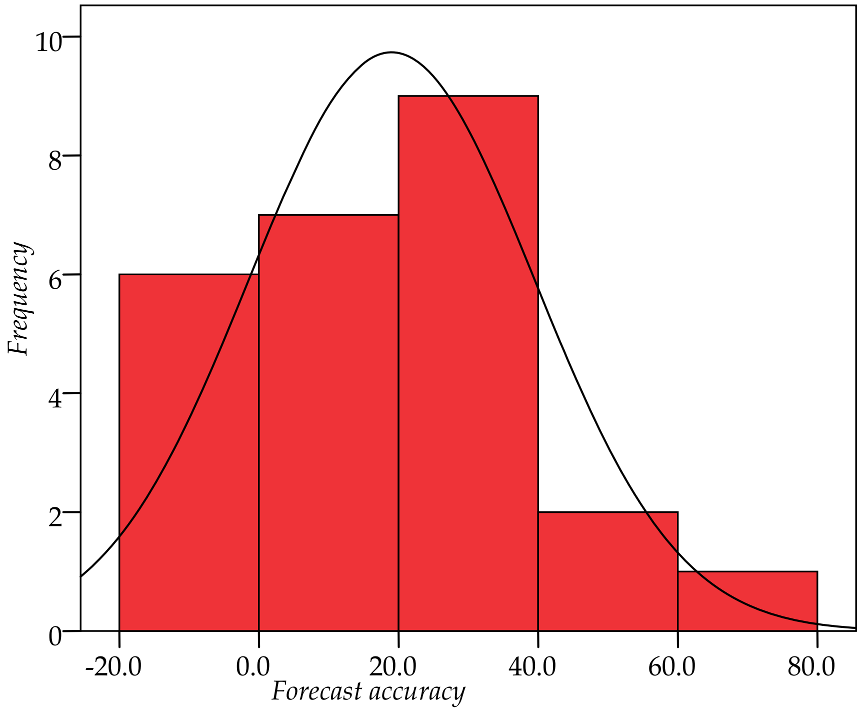

Figure 2. Forecast inaccuracies for the toll free roads.

4.3 Do planners get it right?

Our results suggest that the Norwegian transport planners should not be satisfied with the accuracies of their forecasts. On average, the planners do *not* get it right even if the toll road forecasts were, on average, within an acceptable range. Here, the results presented by Flyvbjerg (2005) and Bain (2009a) were confirmed because the toll road forecasts were more accurate than the forecasts for the toll free roads and because the countries with more toll road experience produced more accurate forecasts. However, the ranges that both the toll roads and toll free roads forecasts fell within were alarmingly high and should be a cause for concern.

The traffic on toll free roads was significantly higher than forecasted. This is worrying and would be doubly disturbing in a situation where the road capacity was limited and where the motivation for new road construction was to relieve congestion. But this is usually not the case in countries where the congestion is still limited to the peak-period traffic in the large cities. The higher traffic levels will often, as argued by Kjerkreit and Odeck (2009), lead to a higher NPV than originally estimated. However, this is obviously not a satisfactory situation in the long term. If the traffic is generally underestimated, then this could lead to inefficient resource allocation or the implementation of the wrong projects and a shorter relief period from congestion for the roads in urban and congested areas.

Transport models for the Norwegian roads sector have improved since 2001, when regional transport models replaced a wide range of locally developed models, and Odeck et al. (2009) claimed that the forecasts have since improved. Today, the traffic on ordinary toll free roads is estimated through the use of national transport models for trips longer than 100 km and regional transport models for trips shorter than 100 km. Both models are traditional four-step models based on the fixed-trip matrix approach. Induced traffic is thus not taken into account. The traffic on toll roads, however, is estimated using elasticity models where the effects of tolls are calculated specifically. Hence, there are two different models used, one for toll roads and one for toll free roads.

The use of the regional transport models has made it possible to identify the factors that lead to inaccurate forecasts. If the distributions of the forecasts between regions are similar, it is easier to isolate the cause of the error if the forecasts have been based on the same models than if different models have been used. Thus, it was interesting to test whether the assumption of increased accuracy after the introduction of regional transport models holds true using the data to which we had access. The toll road sample included 13 projects implemented in the years 1990 up to and including 2000 and 12 projects implemented in the years 2001–2007. For the toll free roads, we had 13 projects from 2001 to 2004 and 12 projects that opened for traffic in the years 2005–2007. Table 5 shows the differences in the mean accuracy for the two time periods for the two road categories. The number of observations is so low that caution should be taken when interpreting the results, but there appears to have been little or no improvement in the forecast accuracy over time either for the toll roads or for the toll free roads. However, the weaknesses in the Norwegian transport-demand models were first identified in the work leading up to the National Transport Plan for the years from 2002 to 2011, and because the planning process for roads often takes years, it has not been until very recently that we can expect to see real improvements caused by the improvements in the transport models.

Table 5. Traffic-forecasting inaccuracies over time.

Road category/opened for traffic	*Mean inaccuracy*
Toll roads 1990–2000	-2.7%
Toll roads 2001–2007	-2.2%
Toll free roads 2001–2004	18.6%
Toll free roads 2005–2007	19.4%

The concept of induced traffic is often used to explain traffic levels in excess of what was originally predicted. A study by Goodwin (1996) found the traffic in 151 UK highway schemes to be 10% higher on average than the forecasts in the short term and 20% higher in the long term. Thus, the forecasts for these projects were not able to fully include the extra traffic created by the network improvements leading to retiming, redistribution, mode shifting or change of frequency. Goodwin also suggested that the addition of the capacity itself, regardless of the changes in the travel time, could help explain the increases in traffic flow. However, the changes in traffic brought by the improvements in the pleasantness of travel, such as a smoother ride from better surfaces, remains an under-researched area (Goodwin and Noland, 2003).

Traditionally, transport planning has been based on the traffic levels and independent of the supply conditions and the quality of the road network. The growth demand has been largely attributed to economic factors such as income, population growth, the prices of petrol and other input factors. This is normally referred to as the fixed-trip matrix approach and is still in use in Norwegian road planning (except for the straight-crossing projects). Because the traffic on toll free roads is generally higher than forecasted, there are indications that this approach should be abandoned and that the induced traffic should be dealt with explicitly.

Another potential explanation for higher traffic levels than estimated is the long period of economic growth that Norway has experienced over the last decade. Because transport is a derived demand, forecasting traffic relies on the forecasts of a range of other parameters (Boyce and Bright, 2003). Thus, if the income estimates in the transport models are underestimated, traffic may also be underestimated. The same pattern was observed during the 1990s, when the average national traffic growth over the years 1992–2002 was higher than all the forecasts that had been produced (Larsen et al., 2004). The recession early in the decade was followed by an economic boom that was accompanied by strong traffic growth. De Jong et al. (2003) distinguished between input uncertainty, or difficulties in producing good forecasts for transport model input variables, and model uncertainty. Because Norway has experienced unprecedented, strong economic growth over the last decade, there are clear indications that while more emphasis has been put on improving the transport models, the main causes of the observed error are input error rather than model error. This fits well with the observations of Larsen et al., who found the standard national traffic growth rate, which has been a mandatory input in the transport models, to be too low.

Strategic behaviour and bias are often cited when no other explanations for forecast inaccuracy can be found. Wachs (1987, 1989) argued that because planners are concerned with having their projects financed and built, they deliberately produce overly optimistic forecasts for both capital costs and traffic. Because governments operate under budget constraints, the projects compete with each other for funding. Planners could thus be tempted to underestimate costs and overestimate benefits to meet a specific benefit-cost ratio (BCR) cut off. Although intuitively appealing, we do not necessarily agree that this serious allegation can be used as a general explanation for traffic-forecast inaccuracy. First, our results showed no evidence of such behaviour, which in itself was an indication that these forces are not occurring in Norway. Second, as the traffic on ordinary roads was underestimated, the benefits were also underestimated and not overestimated, all other things being equal (Kjerkreit and Odeck, 2009). In uncongested conditions, traffic in excess of what was forecasted will increase the overall benefits, and planners will thus have little to gain from underestimating the traffic, as this would mean presenting projects with a lower NPV than what they later turn out to produce. In fact, the funding for Norwegian road projects does not always rely on a positive BCR at all. Odeck (1996, 2010) studied whether Norwegian decision makers' ranking of road projects was explained and/or positively influenced by a positive BCR. Contrary to expectations, he found that the BCR was not a significant explanatory variable for the selection of projects and that more emphasis was placed on non monetised impacts. The projects with a positive BCR were sometimes not put on the priority list at all, whereas the projects with a negative BCR were sometimes given a very high ranking. Nilsson (1991) found similar results in Sweden. Although clearly unsatisfactory from a socioeconomic point of view, placing less emphasis on socioeconomic profitability and monetised impacts could reduce the risk of optimism bias in producing the traffic forecasts.

We do acknowledge, however, that the bidding process by which the toll road contracts are awarded may play a role in explaining the optimism bias. As argued by Flyvbjerg (2005), Vasallo (2007) and Bain (2009b), awarding toll road contracts based on a bidding process where the bidder with the highest revenue projections or the lowest capital cost projections wins could reward over optimism rather than accuracy. Here, the Norwegian framework for toll financing provides an alternative framework that might reduce the risk of overoptimistic forecasts. Norwegian toll projects are initiated locally, usually because much-needed road investments cannot be realised in the near future within the government budget. The proposal is then evaluated by the NPRA, who closely scrutinises all major assumptions before it is forwarded to the Ministry of Transport, which prepares a bill to be tabled in Parliament. The project might have a positive or a negative NPV, but all toll projects are stress-tested for financial robustness to ensure that the risk of financial default is low, even in worst-case scenarios. Once passed by Parliament, the operation of the toll road is managed by a non profit toll company operating as a financial vehicle on behalf of the NPRA, which remains the ultimately responsible party for the project (for a detailed presentation of the organisational framework of Norwegian tolling, see Welde and Odeck, 2009). Although the system is not without its flaws, there is less incentive for appraisal optimism than in alternative frameworks, and the system of quality control and the emphasis on conservative estimates has so far prevented any major financial scandals in the Norwegian toll road industry.

The absence of any major scandals due to inaccurate traffic forecasts should not, however, lead us to conclude that this is not an area that warrants continuous attention. The huge variation in forecasting accuracies continues to be a major source of risk in the planning of Norwegian road projects. However, merely pointing out the problem will not make it disappear. The increasing range of international studies focusing on this issue has apparently not contributed to any major improvements in terms of forecasting accuracy. However, the knowledge generated from studies such as this will hopefully facilitate learning and lead to improvements in the forecasting methodologies. Furthermore, we strongly suggest that that the fixed-trip matrix approach (i.e., assuming a zero elasticity of demand) be abandoned for all road projects, as this is very likely a cause of the poor estimation of traffic levels and, ultimately, total economic benefits. In addition, because the process of project bidding or requiring projects to pass a certain BCR threshold to receive financing clearly increases the risk of deliberate over optimism, a system where NPV/BCR is only one input variable in the decision-making process should be considered. It would be interesting to see if countries that apply alternative appraisal frameworks, such as Multi-Criteria Analysis suffer from the same inaccuracies as countries where the decision makers' preferences are more determined by the outcome of the traditional cost-benefit analysis. Finally, the signs of good practices should act as encouragement and as an incentive for further research into why some projects are more successful than others.

5. Conclusions

In this study, we examined the accuracy of traffic forecasts made in the Norwegian road sector. Two types of road projects were studied and compared: (1) toll roads and (2) toll free roads. This distinction was made because the consequences of inaccuracy with toll projects are considered to be more serious because they may lead to financial difficulties and the bankruptcy of toll companies.

We found that the traffic forecasts in the Norwegian toll projects have been fairly accurate. A likely explanation is that the planners over the years have been scrutinised and pressed to provide careful estimates for these projects. The results prove that the planners have been careful, but the number of projects where the actual traffic was significantly below what was forecasted suggest that the toll-project traffic forecasts should continue to be closely scrutinised. However, the variation in the forecast accuracies was high, and we suggest that the results from this study be used to identify the causes of why some projects have performed better than others. For the toll free roads, the results showed a clear underestimation of the traffic. Some of the projects studied had underestimations so great that there is reason to suspect that the projects may have experienced induced traffic for which the planners failed to account. This underestimation may have lead to inefficient resource allocation. Thus, the decision makers may have been misled into foregoing projects that were beneficial in favour of less beneficial ones.

The results from the Norwegian road sector are slightly better than some of those presented in studies from other countries, especially for the toll roads, where the actual traffic was, on average, very close to the forecasted traffic. Even though the number of projects with traffic levels significantly different from the forecasts was high, the mean forecast accuracy and the relatively high share of projects with traffic levels close to perfect accuracy is a source of some encouragement.

Our findings should be of interest to planners and policy makers in Norway and elsewhere. First, the planners need to reconsider their traffic-forecasting models, at least for the toll free projects, to ensure that all relevant factors are captured and forecast inaccuracy thus reduced. Second, the issue of induced traffic in particular must be considered. The Norwegian models for traffic forecasts do not consider induced traffic explicitly, and this may well be a reason why underestimation is prevalent. Third, with the high uncertainty revealed in such a crucial variable as the traffic level, presenting decision makers with single-point estimates for the NPV might potentially be misleading. This suggests that the presentation of social surplus through the NPV should be done through a confidence interval illustrating the inherent uncertainty in a project evaluation. Finally, the care taken when estimating traffic in toll projects demonstrates good practice but, even here, there is a potential for improvement.

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