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Impact of main road investments in Bergen and Oslo

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Abstract

When the toll rings around Bergen and Oslo were established in 1986 and 1990, respectively, they were part of a major scheme to speed up road investments. In Oslo twenty percent of the revenue has been allocated to public transport investments.

The paper studies the impact of these major investments in road and public transport infrastructure on mainly on car travel and travel behaviour. The investment schemes are regarded as relatively successful viewed against of the aims of the investments and their historical setting. The transition from an old fashioned surface network of main roads to a modern highway system with extensive use of tunnels, has contributed to reduce congestion and environmental problems. Further, benefits for off-peak traffic have been large because of increased travel speed. Oslo, being three times bigger than Bergen, has still congestion problems whereas Bergen has hardly any. However, for the future, a continued road building strategy might prove less advantageous than before. For both cities urban sprawl appears to be the major challenge ahead.

0 Background, purpose of the study

The Norwegian Public Road Administration assigned Institute of Transport Economics to perform an evaluation of the effects of the main road investments in the two biggest cites in Norway – Oslo and Bergen. The study deals with several aspects (traffic, public transport, safety, environment, urban sprawl, transport industry satisfaction etc). This paper focuses on impacts on traffic and travel behaviour.

Firstly, the paper describes the important features of the investment schemes and a short discussion of literature on induced travel. Emphasis is placed on the funding mechanisms (toll ring, government co-funding) and on description of the investment packages. Secondly, the effects for car travel are investigated. We look at developments in traffic volume, distribution of traffic in time and space, travel time, modal split etc. At the end other aspects are briefly touched upon, before conclusions are drawn.

1 The Bergen and Oslo toll rings and infrastructure investment schemes

Oslo is the capital of Norway and the Oslo region[1] has slightly more than 1 million inhabitants. It is located to the southeast of Norway. Bergen is located on the western coast and Bergen region[2] has around 340 000 inhabitants (facts on the cities and the investment scheme are give in table 1).

In Norway there is more than 70 years experience in using road toll payment as a financial instrument for building bridges and tunnels. Up to 1980, less than 5 % of the total road investments came from toll revenues. Today about one third of the national road investment budget is based on toll fees. The urban toll rings are important contributors to this budget.

The tolling tradition was one background for the toll rings in Bergen and Oslo. More important though, was congestion problems in both cities and especially in Bergen. Moreover, increased car ownership, urban growth and a national road investment profile that benefited remote regions contributed to a common understanding among planners and local politicians that infrastructure investments had to be sped up. The toll ring was not a major issue in Bergen, whereas in Oslo there was a big dispute before an agreement was reached.

In *Bergen* a specific road investment scheme was established as part of the toll ring scheme. The toll ring was situated very close to the city centre with no or few possibilities to avoid the ring while going from one part of the city to another. The period of operation was originally from 0600h to 2200h, Monday to Friday. Today it has changed to 24 hours a day, Monday to Saturday. Only motorists driving into the CBD area are tolled. A single ticket was originally 5 NOK and is now 15 NOK (€1.9). The investment agreement was favourable to the Bergen community. Toll revenues amounted only to 25 % of the total investment scheme and were matched by the same amount of extraordinary national funding. For the period 1986-1997 the total road investment scheme in Bergen was 2.5 billion NOK (1996-prices). The Bergen toll ring was based on manual collection/inspection, but an automatic system (Autopass) was introduced in 2004.

[1] Oslo and Akershus county.

[2] Bergen and 11 surrounding municipalities.

Main investment projects in Bergen were principal roads into town from west and north, some improvements to the south, and a large road intersection connecting the three transport corridors of the city (see annex 1). The northern corridor was finished in the period 1988-1990. The western corridor was finished in 1993 (outer part) and 1999 (inner part). The southern corridor has been subject to improvements throughout the whole period from 1990-2003. A new investment program has replaced the old one from 2003 and on-ward. The new program has put more emphasis on environment and public transport than the old road investment scheme.

In *Oslo* twenty percent of the investment scheme was allocated to public transport investments (like reserved bus lanes and metro lines and terminals). The toll ring was located 5-8 km from the city centre forcing all car drivers to pass the toll ring while going from one part of the city to another. Only motorist driving into the city area are tolled, and the period of operation is 24 hours all days. A single ticket was originally 10 NOK and is now 20 NOK (€2.5). The toll ring offers electronic fee collection, where cars have on-board units. The share of manual and coin box collection in Oslo has decreased from 40 % in 1991 to app. 20 % today. From 2004 electronic fee collection was harmonised in Norway. All toll roads use the "Autopass" system.

Seasonal passes in both Oslo and Bergen were available. Toll revenues amounted to 55 % of the total investment scheme in Oslo, while government co-funding covered the remaining 45 %. For the period 1990-2001 the total road investment scheme in Oslo was 11 billion NOK (1996 prices).

Important investment projects in Oslo were a road tunnel close to CBD, connecting western and southern/ eastern part of the city, and tunnels from north and east into the city. Other main investments were large improvements on the outer ring road (Ring 3) and some road projects in the neighbour county of Akershus (annex 2).

Studies of the traffic impacts of the toll rings indicate about 3-5 % traffic reduction in Oslo the first year and 5-7 % in Bergen (Ramjerdi 1995, Larsen 1988). In 2003 87 000 and 245 000 cars passed the toll ring daily (one way) in Bergen and Oslo, respectively.

Table 1. Central figures Oslo and Bergen

	Oslo	Bergen
Population (1000), municipality	522	238
Population (1000), region	1011	340
12 year investment (billion NOK, 1996)	11	2.5
Toll ring established	1990	1986
Initial toll fee, private car, NOK	10	5
2004 toll fee, private car, NOK	20	15
Number of passing cars daily (1000)	245	87

2 Road capacity and induced traffic – theory and methods

Many studies indicate some level of induced traffic connected to increased road capacity (Goodwin 1996, SACTRA 1995, ENO 2002, Cervero 2003). Induced travel may be defined as increased travel caused by a decrease in the general cost of travel (ENO 2002). Traffic effects of increased population, employment or income are thus excluded. It can be measured as an elasticity of demand.

Induced travel may take several forms (new trips, route diversion, mode switch, increased trip length, changed timing of travel). Effects may be estimated with respect to travel time, generalised travel cost or road capacity, and may also be estimated at a program/regional level or at a project level (ENO 2002). The former do not include route diversion.

Further, induced traffic related to single projects is more likely to occur in outer parts of the city, as traffic in the city centre is generally suppressed by congestion and parking restrictions. Effects are usually larger in the long run than in the short run, since the major mechanism, land use changes, takes its time. However, it is difficult to determine the role of road investment on urban sprawl, in growing cites.

Based on theoretical calculations and literature reviews, Goodwin (1996) gives an average value for the elasticity of traffic volume with respect to travel time of about –0.5 in the short term and –1.0 in the long term. On average increased road capacity give an additional 10 % base traffic in the short term and 20 % in the long term. Goodwin's estimates are in the higher end of elasticity intervals given by ENO (2002).

Cervero (2003) points at city size, congestion level and the quality of the public transport system as important explanatory factors of the level of induced traffic. In an international context the cities of Oslo and Bergen are relatively small. City size and congestion level may be related, but not always. Bergen, being a much smaller city than Oslo, experienced huge congestions problems during the mid 1980s. At the time, delays were larger than in Oslo.

At a certain phase of the development of road systems in cities, there is a transition from old-fashioned streets to a "modern" road network with extensive use of tunnels and crossings with overpasses. The transition implies increased road quality and higher travel speed. The increased road quality may itself induce traffic, since almost ¾ of the traffic runs outside peak-hours with no capacity restrictions. At later phases of development, road quality improvements may diminish, leaving increased road capacity as the only remaining effect. In the Oslo and Bergen investment packages, road quality improvements constitute an important part of the benefits.

There is always the counter-factual problem. What would have happened if road investments were not sped up? First we may assume that urban growth and income growth would still continue, leading to increasing demand (figure 3, E_0 to E_2) and increased congestion and cost of travel. A new road might improve the situation, but due to increased demand travel costs might be even higher than in the initial situation (compare the 0- and 2-situation in figure 3).

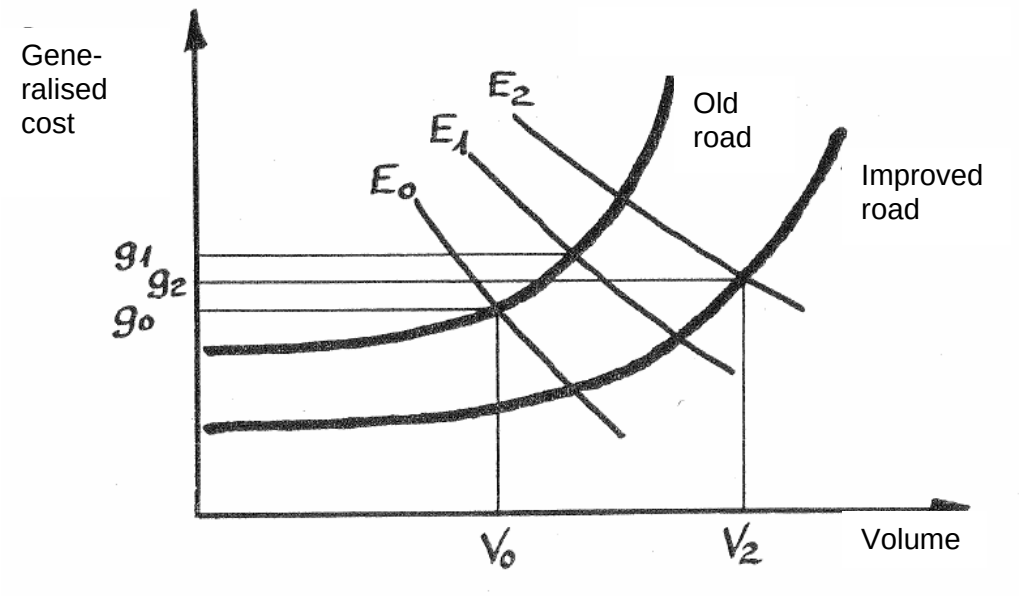

Figure 1. Changes in demand and road network over time (Mannheim 1979).

In our case, the formulation of a hypothetical road network would be speculative. The evaluation thus simply compares the before and after situations. However, considerations to (external) demand side changes are being made.

The analysis is based on following data:

- Road investment data (no capacity data).
- Traffic statistics and counts (car traffic and public transport)
- Travel surveys
- Measurement of travel times along corridors
- Population, employment and income data

3 Overall traffic development

During the 1990s the *Oslo* region experienced traffic growth in line with national growth rates (+ 1.9 % per year) in spite of a much stronger increase in all the drivers of mobility like population, employment and income. This leaves little room for significant induced effects of road investments on car traffic, even though Oslo's share of national road investments increased from 11 % before the investment package to 23 % after. Our interpretation is that the total volume of car traffic, only to a minor extent is influenced by the investment program. One must also consider that rush hour travel times were not imrpoved during the period.

Bergen experienced a higher traffic growth than Oslo during the 1990s (+2.7 % growth per year). There are several reasons for this:

- The city and the region had been a laggard with respect to car ownership (previously limited utility of car ownership due to missing fixed links to surrounding islands and communities)
- The congestion problems were severe, but have more or less been solved
- Urban sprawl took place beyond the surrounding mountains
- The local government put low priority to public transport

In light of above arguments, it is almost surprising that Bergen did not experience even higher growth rates.

Table 2 Growth in traffic, population and employment in the regions of Oslo and Bergen 1980-2002. Percent.

	Bergen	Oslo	Norway
Population			
1980-1990	6.0	7.1	3.8
1990-2002	12.6	13.7	7.1
Employment			
1980-1990	7.0	13.0	5.4
1990-2002	13.4	15.4	10.4
Private cars			
1980-1990	34.3	26.1	30.8
1990-2002	35.9	21.4	17.8
Traffic[1]			
1980-1990	56.0	40.0	44.0
1990-2002	39.0	24.5	25.2

1. Vehicle kilometres.

4 Traffic development in corridors and local vs main roads

Looking at parts of the city, traffic growth in outer parts of *Oslo* was stronger than in the inner parts, as expected on basis of the literature. The surrounding county Akershus experienced a traffic growth of 2.5 % per year in the period 1990-2002, whereas Oslo had a growth of only 1.1 % per year. However, due to urban sprawl Akershus also experienced a much stronger increase than Oslo in the drivers of mobility, such as jobs and population. Especially the number of jobs in Akershus grew fast during the period 1990-2002 (27.4 % vs 9.6 % in Oslo). On the basis of the data available in this study, we have not been able to determine the role of road investment on urban sprawl, as scarce land resources and high prices on land will always tend to shift the growth of the city outwards. However, research mentioned above suggests an interaction between urban sprawl, increased car ownership and main road investment.

Both in Oslo and Bergen growth rates in main transport corridors have been studied. Due to topography both cities have three distinct major transport corridors. In both cities, the findings indicate that employment and population growth seem to have a greater influence on traffic development in corridors than increased road capacity.

In *Oslo* traffic has increased most to the northeast where congestion is low. However, the corridor also experienced a huge growth in jobs. In addition, in 1998, the new main airport of Oslo was moved from the 8 km west of the city to 45 km northeast. The southern corridor also experienced a large increase in traffic, even though congestion was, and is, severe. Employment and population growth are the main reason for traffic growth. The western corridor has by far experienced the lowest increase in traffic due to the “lost” airport, weak employment growth and severe congestion problems.

Table 3. Growth in traffic and jobs by corridor in Oslo. Percent.

Corridor	Traffic at the city border 1990-2002	Jobs 1990-2000
West	8	15
Northeast	35	40
South	35	31

In Bergen traffic growth was strong in all corridors. To the north and west, this was due to improved roads, as congestion in the before-situation was heavy, but delays have now diminished. Urban sprawl and a change in commuting pattern in the western corridor from ferry to car commute, did also contribute to the traffic growth. To the south, road investments have been moderate and congestion is unaltered. Still, the traffic increase is as strong as in the other corridors, due to land use development (offices, shopping centres, population growth).

When it comes to *route choice*, there are some distinct effects of road investments. In Oslo, traffic growth occurred on the improved main roads both in the toll ring and at the city border (2.1 % yearly growth), while there was no growth on local roads. Closer to the city centre, traffic statistics indicate a reduction of 20 % in traffic on local roads crossing a inner ring road (Ring 2).

In *Bergen*, there was no increase in traffic entering the city, while traffic through and around the city centre increased by 7 % per year during the 1990s. Further, in the southern corridor where there is a choice of routes, traffic volumes decreased on local roads, while there was a strong increase on the principal road. Thus, the goal of diverting traffic away from where people lived or stayed was to a large extent achieved.

5 Congestion and timing of travel

Reduced congestion was a main goal of the investment packages. In *Bergen* travel times have clearly been reduced. In the northern corridor delays were nearly 45 minutes on average during the morning rush hour and about 30 minutes in the afternoon. In the western corridor road delays were about 30 minutes both during the morning and evening rush hours. Both approach roads are now without delays after the building of a four-lane expressway. The results indicate that in a rather small city like Bergen it has been possible, at least for a period, to completely solve congestion problems by road investments. However, there are now indications of increasing congestion in the northern corridor.

In the southern corridor delays have been slightly reduced. In the southern corridor new congestion problems have also arisen around newly developed industrial areas close to Bergen airport.

Table 4. Rush-hour traffic delays (minutes) in Bergen.

	North	West	South
Morning, 1984	45	30	16
" 2002	1-2	0	11
Afternoon, 1984	30	30	10
" 2002	1-2	0	6

In *Oslo* travel times have been measured on a yearly basis on 18 routes since 1990[3]. Over time there are only minor changes in travel times and delays. In total, there is a small improvement in average speed during the morning rush hour, but no significant changes in the afternoon. Increased road capacity thus seems to have counterbalanced the growth in traffic with a small positive margin. The continuous struggle between traffic growth driven by urban and economic growth, and road capacity is illustrated by figure 4. By 1995 many larger road projects were finished. In the years 1995-1997 there was a period of strong traffic increase driven by an economic upswing. Around 2000 a new bulk of projects was finished, improving the situation for a short while.

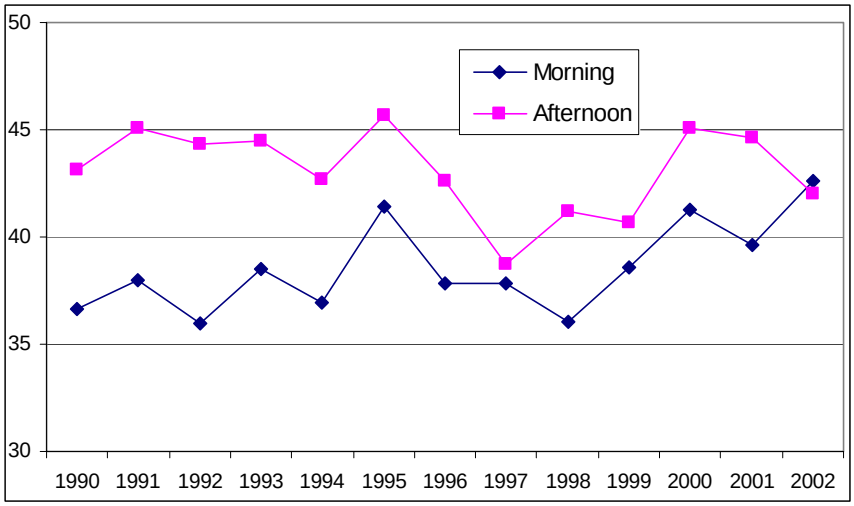

Figure 2. Average travel speed (km/h) for peak traffic in Oslo. 1990-2002.

Improvements have occurred along the outer ring road (Ring 3). To the north, average travel speeds are also relatively high. To the south, delays have increased due to population growth. To the west, the situation is relatively unchanged. Delays here are still the largest in the region. A peak-hour round trip from west has in total an average of 30-40 minutes delay, depending on the route.

The investment scheme strategy has been to complete projects from the inner parts of the region and outwards. This strategy seems to have been rather successful. Road sections 10-15 km from the city centre have the largest delays, whereas traffic flows with more ease in the inner parts.

An important aspects in both cities, has been increased *road standard* and raised speed limits. These improvements have affected the ¾ of the traffic that runs outside rush hours. Car travel is now conceived as more convenient and predictable. In Oslo, off-peak travel time along the outer ring road (Ring 3, 18 km) has been reduced from 18 to 14 minutes. In Bergen, the tunnels have, in addition, contributed to shorter travel distances. Some routes have become 2-3 km shorter. As the city road network now has undergone a transition to modern highway network, further improvements will not have the same effect on off-peak travel times.

Changes in the *departure times* are most likely to occur if congestion is altered. Since there were only minor changes in travel times and delays in Oslo and the southern

[3] Registration on 10 working days in September each year. Departure times varied (15 min intervals).

corridor of Bergen, no significant changes in departure times were discovered. However, on the northern corridor of Bergen, where congestion originally was severe, there are clear changes in departure times on working days. Here, the spread over the day shows more distinct rush hour peaks after the road investments. The share of traffic carried out during the rush hour 7-9 in the morning and 15-17 in the afternoon increased from 30 % to 37 %. This finding suggests that there is some amount of "suppressed" traffic on the shoulder of the peak hours that might switch back to the central rush hour if road conditions are improved. Even though the switch back of this traffic pattern might reduce the effects of increased road capacity on average speed, the length of the peak period might still be reduced.

6 Travel behaviour

Travel surveys were available in both cites. In Oslo a postal survey was undertaken in 1989 just before the opening of the toll ring. A national telephone survey with an extra sample for Oslo was carried out 2001. In Bergen there were telephone surveys from 1992 and 2000.

In Bergen, car travel seems to increase at the expense of walking, cycling and public transport. There seems to no clear link between where road investments are undertaken and where changes in public transport market share occur. There is one exception, from the west, where ferry was used for going to Bergen city, there is a marked change to more car travel after a new bridge was built.

In Oslo walking and cycling is excluded from the analysis since there seems to be a considerable amount of underreporting of such trips in the 1989 postal survey. Looking just at motorised transport, there is a small shift towards more car travel. The public transport share in the region is reduced from 27 % to 23 %. These figures correspond almost exactly with traffic statistics on the city border.

As in Bergen, there seems to be no clear link between where road investments are undertaken, and where changes in public transport market share occur. However, car travel clearly seems to get increasing importance in the outer parts of the city (figure 3). Further, the share of trips within the outer parts of the region (outside the toll ring), is greater than before (from 45 % to 55 % of all motorised trips). Thus, urban sprawl seems to act as a structural change that lead to increased car travel. To what extent road investments contribute to speed up urban sprawl is difficult to tell.

Figure 3. Public transport in Oslo region by area, 1989 and 2001. Per cent of total motorised transport.

During the 1990s there has been a decline in the number of *public transport passengers* in all of the larger Norwegian cites. Bergen has experienced a larger decrease than other cities due to reduced subsidies and as a consequence increased fares and reduced supply (vehicle km). In fact, the negative trend in Bergen seems to be fully explained by trends in fares, supply, petrol prices and income. The subsidy level in Bergen is now less than 10 % of costs, implying that public transport appears as a sheer commercial activity. The fact that the negative trend is almost fully explained by reduced supply and higher fares, may indicate that road investments only to a small extent affects public transport, due to limited competition between public and car transport.

Oslo, on the other hand, has experienced a better development than expected by taking into account the developments in prices, supply and income. Improved public transport quality probably played an important role. Main improvements achieved through the investment program have been reserved bus lanes and fully connected metro services. Compared to Bergen, Oslo has a rather extensive public transport system.

7 Other aspects

Freighters are generally satisfied with the investment packages, especially in Bergen, were delays are significantly reduced. There are still some accessibility problems at major freight terminals in Oslo.

Some transport operators in Oslo have moved their terminals way out of the city centre (20-30 km), stating that enough space and the value of land were the main location factors. But even if the quality of the road network is not mentioned explicitly, it is obvious that a developed trunk road system is a prerequisite for effective distribution of goods in the region from such remote locations.

The road accident risk has been reduced both in Bergen and Oslo, but the risk reduction is slightly smaller than the national average.

Traffic is diverted to main roads, and many main roads are constructed as tunnels. Thus large, densely populated areas are relieved from environmental problems caused by road traffic. Noise reduction is the most important element.

8 Conclusion - overall judgement of the road investment packages

The toll rings around Bergen and Oslo have been part of major schemes to speed up road investments. The main goal was to reduce *congestion*. This goal has more or less been reached in Bergen. Probably the small size of Bergen, only 340 000 inhabitants in the region, makes it easer to cope with congestion. In Oslo, which is three times bigger than Bergen, congestion levels are relatively unchanged in spite of massive investments.

Still, the absence of improvements in peak-hour congestion levels in Oslo is not necessarily an indication of failure. The region has experienced rapid population and employment growth during the 1990s. Our conclusion is that increased road capacity has counterbalanced the growth in traffic with a small positive margin. Alternatively, a slow pace of investment could have lead to excessive congestion levels. This especially true if the willingness to endure congestion increases with increased income level (Stopher 2004), or there is some positive utility connected to commuting (Ory and Mokhtarian 2005). In that case, congestion levels could hypothetical become very high.

The 12-year period analysed represent a relatively short time period. Sooner or later traffic growth will catch up with investments. Even in Bergen there are now signs of increasing congestion. Anyway, important benefits of the investments have been a transition from an old-fashioned surface network of main roads to a modern highway system. Travel speed outside peak-hours, which concerns ¾ of the traffic, is increased. Further, extensive use of tunnels, has contributed to reduce environmental problems.

When it comes to the question of *induced traffic*, the evidence is mixed. In Bergen, where congestion problems are relieved, traffic growth clearly seems to have been stimulated by road investments. The main mechanism seems to be increased car ownership. In the Oslo region, where congestion is unaltered, the amount of induced traffic seems to be of less significance, given the strong growth in drivers of mobility.

The difference in car travel growth rates between Bergen and Oslo may also have some relation to greater emphasis on public transport in Oslo than in Bergen, both with respect to the content of the investment program and with respect to subsidy level.

However, due to limited competition between car and public transport, emphasis on public transport might affect the development of public transport more than car traffic. For public transport in Oslo, it is concluded that qualitative improvements, like reserved bus lanes and fully connected metro services, have played an important role. In Bergen, public transport has lost ground due to reduced public transport supply and increased fares.

In Oslo, it seems that employment and population growth to greater extent than increased road capacity explain growth rates in traffic corridors. In Bergen both road investments and employment and population growth more or less equally explains traffic growth rates in corridors.

Given the growth pressure in Oslo and Bergen and a traditional national road investment profile that have benefited remote regions, a forced pace of infrastructure investment in Oslo and Bergen seems to have obtained several objectives. This understanding has also filtered through to the public, as a high and increasing share is in favour of the toll ring, especially if the investment scheme also includes public transport.

However, for the future, a continued road building strategy might prove less advantageous than before, since benefits will be more linked to increased capacity than increased travel speed off-peak. For both Bergen and Oslo, urban sprawl appears to be the major challenge ahead in order to take the pace car traffic growth.

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Annex 1. Road investments in Bergen

Annex 2. Road investments in Oslo