

concept

Petter Næss, Gro Holst Volden,
James Odeck and Tim Richardson

Neglected and under- estimated negative impacts of transport investments

Concept report no. 54



transport
concept

Petter Næss, Gro Holst Volden,
James Odeck, Tim Richardson

Neglected and under- estimated negative impacts of transport investments

Concept report no. 54

Concept report no. 54

Neglected and underestimated negative impacts of transport investments

Petter Næss, Norwegian University of Life Science

Gro Holst Volden, Norwegian University of Science and Technology

James Odeck, Norwegian University of Science and Technology

Tim Richardson, Norwegian University of Life Science

ISSN: 0803-9763 (print version)

ISSN: 0804-5585 (web version)

ISBN: 978-82-93253-65-5 (print version)

ISBN: 978-82-93253-66-2 (web version)

© The Concept research program. The publication may be quoted freely with attribution.

ABSTRACT:

This study aims to call attention to the fact that there may be neglected or underestimated *negative* impacts that are not taken into account in the cost-benefit analyses of transport investments. These negative impacts differ in type. The report discusses four main categories of negative impacts that are normally neglected or underestimated: i) Disadvantages pertaining to the construction period, ii) neglected environmental impacts, iii) induced traffic, urban sprawl, and negative implications, and iv) underpricing of environmental assets. The report briefly discusses various measures.

DATE: December 2017

PUBLISHER: Ex Ante Academic Publisher
The Concept research program
Norwegian University of Science and Technology
7491 NTNU – Trondheim
www.ntnu.no/concept

Responsibility for the information in the reports produced on behalf of the Concept research program is on the commissioned party. Views and conclusions is on account of the authors and not necessarily identical to the views of the Concept research program. All contributions are reviewed in a peer review process.

The report series

The Concept research program is based at NTNU and conducts research into the development and quality assurance of large investment projects in Norway. This is interdisciplinary research within the fields of project management, public finance, political science, economic analysis and evaluation. The report series presents research findings within the fields covered by the program and is approved as a level-1 scientific publication channel by the Norwegian Association of Higher Education Institutions. The primary target group is researchers within the respective fields and professionals in the public sector and in reporting institutions.

Editorial staff

Knut Samset, Professor, NTNU, editor

Gro Holst Volden, Research Director, Concept research program

Morten Welde, Researcher, NTNU

Editorial board

Tom Christensen, Professor, University of Oslo

Petter Næss, Professor, Norwegian University of Life Sciences

Nils Olsson, Professor, NTNU

Ingeborg Rasmussen, General Manager, Vista Analysis

Jørn Rattsø, Professor, NTNU

Tore Sager, Professor, NTNU

Arvid Strand, Researcher 1, Institute of Transport Economics

Heidi Ulstein, Partner, Menon Business Economics

Vibeke Binz Vallevik, Head of Group, DNV GL

Bjørn Otto Elvenes, Associate Professor, NTNU

Preface

This study was initiated in a response to the public debate about the *wider economic benefits* of transport investment projects. An understanding seems to have emerged among stakeholders, planners, consultants, and some researchers, that some components are usually omitted in cost-benefit analyses (CBA) of transport investment projects, which are *positive* and *potentially large*. Although we accept the theoretical possibility of wider economic benefits, we see a need to balance the picture and focus on some weaknesses in the cost-benefit analyses that lead to underestimating or even ignoring *negative* impacts.

Our initial ambition was to define and discuss the *wider economic costs*, interpreted as the worsening and/or increase in market failures in secondary markets, to directly counterbalance the wider economic benefits discussion. However, we soon realized that this definition would be somewhat narrow, and that we need to discuss other, related weaknesses as well, some of which originate in the transport markets themselves or are due to systematic underpricing. Therefore, we ended up with the broader term *neglected and underestimated negative impacts*. It is the sum of these impacts of different origins that led us to argue that the cost side of the analysis may be considerably underestimated. These negative impacts are not necessarily new or unrecognized by researchers, but they are rarely mentioned in the public debate about the shortcomings of cost-benefit analyses.

The study was funded by the Concept research program at the Norwegian University of Science and Technology, and was carried out jointly with researchers at the Norwegian University of Life Sciences. We would like to thank the project reference group, including Professor Arvid Strand and Senior Research Economist Harald Minken, both from the Institute of Transport Economics, and Professor Svein Bråthen, Molde University College, Specialized University in Logistics, for their valuable comments on an earlier draft of this report.

Our hope is that the report will contribute to the debate about how the cost-benefit analysis methodology should be developed further.

Trondheim,

December 2017

Table of contents

<i>Preface</i>	4
<i>Sammendrag</i>	7
<i>Summary</i>	13
<i>1. Background and overview</i>	19
1.1. Introduction	19
1.2. Cost-benefit analysis and transport investments.....	20
1.3. Wider economic benefits?.....	24
1.4. This study – highlighting the neglected and underestimated negative impacts.....	27
<i>2. Disadvantages pertaining to the construction period</i>	32
<i>3. Neglected environmental costs</i>	37
<i>4. Underestimation of induced traffic</i>	41
4.1. Short-term induced traffic.....	41
4.2. Long-term induced traffic.....	44
4.3. Implications for external effects on health, safety and the environment.....	45
<i>5. Urban sprawl and implications</i>	48
5.1. Urban sprawl as a phenomenon	48
5.2. Negative impacts of infrastructure-induced urban sprawl.....	51
5.3. Additional local infrastructure investments	55
5.4. Reduced quality of public transport	56
5.5. Negative impacts on lifestyle and public health	58
5.6. Sociocultural negative impacts	59
5.7. Lock-in effects, from freedom to necessity	61
<i>6. Underpriced environmental assets – greenhouse gas emissions</i>	62

6.1. Road projects and the climate.....	63
6.2. When there is no ‘correct’ price	65
6.3. The additional problem caused by discounting	67
7. <i>The distribution of the neglected and underestimated negative impacts</i>	<i>69</i>
8. <i>How can the neglected and underestimated negative impacts be handled?.....</i>	<i>73</i>
9. <i>Conclusions</i>	<i>80</i>
<i>References</i>	<i>82</i>
<i>Appendix 1: Common critique against the cost-benefit analysis.....</i>	<i>97</i>
<i>Appendix 2: A critical view on the wider benefits.....</i>	<i>102</i>
<i>Appendix 3: Improvements in the model systems – status Norway.....</i>	<i>112</i>

Sammendrag

Undervurderte negative virkninger av transportinvesteringer

Transportinvesteringer gjennomgår vanligvis en omfattende utrednings- og analyseprosess, hvor ikke minst nytte-kostnadsanalysen står sentralt og får mye oppmerksomhet. En har lang tradisjon for bruk av nytte-kostnadsanalyser i transportsektoren, og utviklingen av metodikken over tid har ført til at stadig flere virkninger prissettes og tas inn i transportetatens veiledere – både i Norge og andre land. Likevel er det klart at ikke alle virkninger, verken innenfor eller utenfor transportmarkedene, håndteres fullt ut i analysene.

Utgangspunktet for denne studien var det pågående debatten om såkalt “mernytte” av transportinvesteringer. Dette har fått mye oppmerksomhet, både i akademia, og ikke minst blant interessenter, planleggere og konsulenter. Mernytte er positive virkninger, utenfor transportmarkedene (dvs. i sekundærmarkedene) som i hovedsak skyldes markedssvikt og som ikke er implementert i den ordinære nytte-kostnadsanalysen. Det kan for eksempel handle om at en ny vei binder sammen arbeidsmarkeder og dermed øker arbeidernes produktivitet. I senere år har en rekke studier blitt finansiert, for å forsøke å kvantifisere mernytten av ulike transportprosjekter. Vår vurdering er at selv om vi anerkjenner den teoretiske muligheten for mernytte, så bør en være forsiktig med å ukritisk anvende funn fra andre land i en norsk kontekst, hvor både befolknings- og næringsstrukturen er annerledes. Mye taler for at de mernyttegevinstene man har beregnet i enkelte studier i Norge, kan forklares ved at analysen forutsetter at *folk ikke kan flytte* til områder med større arbeidsmarkeder. Forskningsmiljøene har imidlertid til dels svært ulike syn på både eksistensen av, og størrelsen på, disse virkningene, i Norge og andre land.

Målet med denne studien er ikke å argumentere imot eksistensen av mernytte, men å rette oppmerksomheten mot det faktum at det også finnes *negative* virkninger som systematisk neglisjeres eller underestimeres. Noen av disse utgjør en direkte motsats til mernytten, i den forstand at de finner sted i sekundærmarkeder og skyldes markedssvikt (i den grad det finnes «markeder» for dem i det hele tatt – i noen tilfeller går markedssvikten ut på at det ikke

gjør det). Andre oppstår i transportmarkedene selv eller skyldes systematisk underprising. Vi dekker således et bredt spekter av tema (noen vil kanskje si for bredt), som til sammen gir et bilde av hvordan også kostnadssiden i analysen systematisk undervurderes. Selv om hovedfokuset er på kostnadssiden, er skillet mellom «kostnad» og «negativ nytte» ikke alltid åpenbar, og noen av svakhetene vi peker på indikerer også at nyttesiden er overvurdert. Vi mener at en slik systematisert, samlet fremstilling er nyttig i den videre diskusjonen av bruk og utvikling av nytte-kostnadsanalyser.

Rapporten diskuterer følgende fire hovedkategorier av negative virkninger som vanligvis neglisjeres eller underestimeres. Virkningene gjelder for transporttiltak generelt, men diskusjonen tar utgangspunkt i et typisk veiutbyggingsprosjekt som vil bedre kapasiteten inn og ut av en større by.

Ulemper i anleggsperioden

De fleste transportprosjekter tar flere år å gjennomføre. Ulemper i byggefasen kan omfatte både trafikale forstyrrelser i eksisterende nettverk, lokal støy og forurensning, midlertidige landskapseffekter, ulemper for lokalt næringsliv, og innvirkningen på små lokalsamfunn av en tilstrømming av arbeidere som jobber på prosjektene. Av disse er det særlig de trafikale ulempene som antas å kunne slå sterkt ut på prosjektets beregnede lønnsomhet. Mer generelt tilsier logikken i en nytte-kostnadsanalyse, hvor effekten av diskontering har stor betydning, at en kan gjøre en stor feil ved å ignorere virkninger i denne fasen. Når slike virkninger ignoreres gir det heller ikke noe incentiv til å velge gjennomføringsmodeller som har færre slike ulemper enn andre. Vi finner det vanskelig å forstå hvorfor ulemper i anleggsperioden ignoreres i gjeldende modellverktøy, og vanligvis nevnes de heller ikke blant ikke-prissatte virkninger.

Neglisjerte miljøvirkninger

Negative eksterne virkninger på natur og miljø kan åpenbart være vanskelig å prissette. Men implikasjonen av dette er at virkningene enten inkluderes bare delvis (man tar med noen aspekter ved problemet som kan kvantifiseres, og anser dermed virkningen som “kvittert ut” i analysen), eller man ser helt bort fra den. Et eksempel er utslipp av mikroplastpartikler, som inkluderes i den prissatte analysen i den grad de skaper *lokale* miljøproblemer, mens effekten av biltrafikken på det marine miljøet i global målestokk ikke er med. Videre gjelder for flere av miljøvirkningene, ikke minst utslipp av klimagasser, at det kun er virkningene relatert til den kortsiktige trafikkveksten som (i beste fall)

dekkes, og ikke den langsiktige veksten som følge av endret arealbruk (se også neste punkt). Andre kilder til utslipp, som for eksempel utslipp fra produksjon av nye kjøretøyer, er gjerne ikke med i det hele tatt.

Når det gjelder landskapsvirkninger og effekter relater til omdisponering av areal, så er dette gjennomgående svakt håndtert i gjeldende rammeverk. I den grad de inkluderes, er det gjerne i et kortsiktig perspektiv. Den såkalte ikke-prissatte delen av analysen kan være omfattende, men fokuserer i hovedsak på de umiddelbare virkningene ved åpning av den nye veien.

Nyskapt trafikk, byspredning og negative implikasjoner

Det er godt dokumentert at nyskapt trafikk som følge av økt veikapasitet ofte blir undervurdert. Det betyr at også de eksterne effektene som følger direkte av trafikken blir underestimert. Riktignok er norske transportmodeller bedre enn mange andre til å håndtere nyskapt trafikk i et korttidsperspektiv, men på lang sikt vil trafikken ventelig fortsette å vokse som følge av endringer i lokaliseringvalg, arealbruk og forringet kvalitet på kollektivtilbudet. Dette har nær sammenheng med fenomener som regionforstørrelse og byspredning. Det skjer såfremt det ikke iverksettes sterke virkemidler for å motvirke en slik utvikling.

Mennesker har en tendens til å øke sin mobilitetsradius fremfor å bruke gitte tidsbeparelser til arbeid eller andre formål som ikke er å reise. Enkelt sagt, i en ny likevekt med økt veikapasitet bruker man gjerne like lang *tid* på reising som før, men man reiser lengre. Når de tiltenkte tidsgevinstene på denne måten byttes eller omdannes til andre typer nytte, oppstår en rekke negative effekter som den enkelte aktør ikke tar hensyn til:

- økt kø og trengsel på veiene
- ulykker (kan være redusert per km, men totalen kan likevel øke som følge av veksten i total reiselengde, hensyn tatt til både hovedvei og sideveier)
- negative effekter på livsstil og folkehelse
- negative miljøeffekter av ulike typer
- dårligere kvalitet på kollektivtilbudet og/eller økte kostnader for kollektivselskapene, som må utvide tjenestene geografisk og får færre stordriftsfordeler¹

¹ Downs–Thomson paradokset sier at når offentlig transport konkurrerer med bilen i et område med mye kø, vil veiprosjekter som øker kapasiteten på veien, medføre en ny

- kostnader for lokale myndigheter som følge av behov for mer spredt infrastruktur som vann, kloakk, elektrisitet og lokalt veinett
- nedsiden av et arbeidsmarked og produktmarkeder med sterkere konkurranse er nedleggelse av «nærbutikken», økt sannsynlighet for ledighet blant personer med noe lavere arbeidsproduktivitet, og etter hvert tap av lokale skoler og annen service. Små steder mister mange av sine kvaliteter når de blir forsteder for nærmeste storby.

Så lenge denne type virkninger ikke prises, vil de ikke tas hensyn til, heller ikke i utgangssituasjonen, og et veiprojekt kan forsterke en uønsket utvikling mot desentralisering.

I rapporten diskuterer vi også innelåsingseffekter relatert til byspredning. Spredt bebyggelse representerer irreversible kostnader som påvirker folks livsstil i stor grad. På lang sikt blir det å reise langt for å nå sine daglige og ukentlige gjøremål, ikke bare en mulighet, men en ren nødvendighet for mange.

Underprising

Prisene på miljøeffekter brukt ved nytte-kostnadsanalyse av transportprosjekter er generelt lave i Norge. På samme måte er de faktiske prisene på utslipp (i form av skatter og avgifter) lave. Spesielt kan de være langt unna å reflektere nasjonale myndigheters ambisjoner om å ivareta miljøhensyn og nå ambisiøse mål og forpliktelser. Dette virker som et paradoks, og prisen på klimagassutslipp er et ekstremt tilfelle. Vi skal være forsiktige med å hevde at prisene er «feil», siden en objektivt riktig pris på klimagassutslipp knapt er mulig å beregne. Men generelt ligger de gjeldende prisene lavt i forhold til det som er diskutert i litteraturen. Implisitt verdsetting indikerer at «riktig» karbonpris avledes av målene – dvs. at jo strengere mål, desto høyere pris. I virkeligheten brukes en blanding av ulike verdsettingsteknikker og –prinsipper om hverandre.

I tillegg til lav kronemessig pris på klimagassutslipp og andre miljøvirkninger, kommer det at bruken av en diskonteringsrente reduserer betydningen av slike (ofte langsiktige) virkninger ytterligere. Det gjelder selvfølgelig alle langsiktige virkninger, både positive og negative, men det at alvorlige miljøkonsekvenser for fremtidige generasjoner ignoreres blir gjerne sett på som en fundamental

likevekt med færre brukere av kollektivtransport, og redusert kvalitet for begge transportformene.

svakhet ved nytte-kostnadsanalysen. Logikken om at individer foretrekker penger nå fremfor senere, kan ikke brukes til å forklare at velferden til dagens generasjoner skal telle mer enn velferden til neste generasjon. Noen vil si at dette er et fordelingsmessig spørsmål, som ikke kan løses innenfor rammeverket av en nytte-kostnadsanalyse. Men det er heller ikke vanlig å løfte frem generasjonskonflikter hva gjelder tilgangen til miljøgoder i en separat analyse av fordelingseffekter.

Hvordan kan disse virkningene bedre ivaretas?

Virkningene vi har pekt på er av ulike typer. Noen er håndgripelige, andre vil trolig aldri kunne prissettes i kroner. Noen skyldes empiriske svakheter ved metodikken, andre må forklares ved teoretiske eller til og med etiske/normative svakheter. Vi vil derfor ikke anbefale en enkelt løsning, men heller kort diskutere ulike forbedringstiltak som kan supplere hverandre.

For det første bør en undersøke potensialet for forbedringer i transportmodellsystemet, ikke minst slik at det er mulig å fange langsiktige effekter på både arealbruk, demografi, økonomi og transport. En nyere type modeller som kan være relevant er såkalte LUTI-modeller (Land Use and Transport Integration models).

Videre er det et potensial for å forbedre den økonomiske verdsettingen av virkninger som i dag enten ikke inngår eller er sterkt underpriset. Det må samtidig nevnes at selv om riktig prising i nytte-kostnadsanalysen er viktig, så er selvfølgelig riktig prising i markedene det aller beste. I Norge har for eksempel Grønn skattekommisjon anbefalt at avgiftene på utslipp bør settes høyt nok til at innenlandske utslippsmål nås, og at subsidiering av tiltak med negative miljøvirkninger bør oppheves (som for eksempel skattefradrag ved pendling).

Andre svakheter er mer fundamentale og kan tale for forsiktighet ved ukritisk bruk av nytte-kostnadsanalyse alene som beslutningsunderlag. Det er vel kjent at et lønnsomt prosjekt ikke nødvendigvis er miljømessig bærekraftig, eller sosialt akseptabelt. Det finnes andre analysemetoder som kan brukes som alternativ eller supplement, som Sustainability Impact Assessment, eller flermålsanalyse. Det er også i prinsippet mulig å beskranke nytte-kostnadsanalysen på ulike måter, for å sikre en akseptabel situasjon miljømessig for neste generasjon.

Det vil uansett være virkninger som ikke kan eller bør forsøkes prissatt, derfor bør en også se på en mulig utvidelse av den ikke-prissatte delen av analysen. Minimumskravet må være at ikke-prissatte virkninger beskrives og vurderes i et tilstrekkelig langsiktig perspektiv. Her kan en trekke på metoder og tilnærminger fra ulike fagområder.

Det må presiseres at denne studien er konseptuell, og formålet har i hovedsak begrenset seg til å peke på en del virkninger som neglisjeres eller underestimeres systematisk innenfor den gjeldende norske analyserammen og med gjeldende praksis. Vi har ikke gitt noe anslag på størrelsen av de ulike virkningene, men anbefaler sterkt at det gjøres empiriske studier for å forsøke å kvantifisere omfanget av problemet. Vi har heller ikke gått langt i å foreslå løsninger, noe det antakelig vil være svært ulike oppfatninger om, både innenfor og utenfor de fagmiljøene som jobber spesifikt med nytte-kostnadsanalyse. De fleste av momentene vi tar opp er nevnt i litteraturen tidligere og således ikke «nye». Verdien av denne studien er derfor først og fremst det at vi gir en samlet fremstilling av og en påminnelse om forhold som akademikere og praktikere innen nytte-kostnadsanalyse bare i varierende grad har vært opptatt av opp igjennom årene. I en tid hvor debatten om analysemodellen i stor grad handler om hvordan en kan implementere mernytte, så ønsker vi å balansere bildet, og oppmuntrer andre forskere til å gjøre det samme.

Summary

Transport investment projects normally go through an extensive appraisal and planning process. Commonly it is the cost-benefit analysis that attracts the most attention. There is a long tradition of using this type of analysis in the transport sector, and the methodology has improved so that an increasing number of impacts is monetized and included in the appraisal guidelines in Norway and other countries. However, not all effects within the transport market or beyond it are handled perfectly.

The point of departure for this study was the ongoing debate and the strong emphasis among stakeholders, planners, consultants, and academics, on the *wider economic benefits* that are currently not systematically included in the cost-benefit analysis framework. One example of wider benefit would be that a new road links two separate labour markets and thereby increases people's productivity at work. In recent years, a large number of studies have been funded to search for and simulate possible wider economic benefits in all types of transport projects. While appreciating the theoretical possibility of such wider economic benefits, applying findings from other countries to the Norwegian context is problematic, since the population base and trade structure is different. The research community in Norway and elsewhere are strongly divided regarding the existence and magnitude of such wider economic benefits. In our view, there is much to suggest that a large share of the calculated wider benefits in Norwegian studies can be explained by the mere assumption that *people cannot move* to areas with larger labour markets.

Nevertheless, the aim of this study is to call attention to the fact that there may *also* be neglected or underestimated *negative* impacts, which generally differ in type. Many of the issues that we discuss in this report are certainly due to market failure and take place in secondary markets (or rather, missing markets, for environmental goods), but others originate in the transport markets themselves or are due to systematic underpricing. While our main focus is on the cost side of the cost-benefit analysis, the distinction between "cost" and "negative benefit" is not always clear, and some of the issues that we discuss here do also indicate that benefits may be overestimated. Hence, we cover a

wide range of topics (too wide, some might argue), since we believe that it is useful to systematize these shortcomings and bring them collectively into the discussion about the cost-benefit analysis.

In this report, we discuss the following four main categories of negative impacts that are normally neglected or underestimated.

Disadvantages pertaining to the construction period

Most transport infrastructure projects take years to implement. Difficulties in and around the construction period can include consequences for traffic on existing networks, local noise and pollution due to construction activities, temporary landscape impacts, disadvantages for local businesses, and social disruption of neighbourhoods due to the influx of a temporary population of people working on the projects. Of these, the consequences for traffic (in terms of negative time savings, or time losses) are assumed to have the largest economic impact on the project's net present value. More generally, any disadvantages that occur early in the life-cycle of a project could have a major impact on the estimated net present value, due to the effect of discounting. It may be difficult to understand why such effects are disregarded altogether in the current framework. In most cases, they are not even mentioned among the non-monetary set of impacts.

Neglected environmental impacts

Negative effects on the environment may be difficult to quantify and give a price tag. The implication of this may be that some effects are only partly included (certain aspects or dimensions can be quantified and others cannot) and some are disregarded altogether. One example is emission of microplastic particles, which are included only to the extent that they are a problem for the *local environment*, whereas the impact of car traffic on maritime environments at a global scale is not included. Another example is greenhouse gas emissions (GHGs), where only emissions due to short-term traffic increases are included (at best), but not the long-term effects due to land use changes (see also next section). Moreover, some sources of emissions, such as emissions from the production of new vehicles, are rarely included at all.

Additionally, land-conversion related impacts and landscape impacts are poorly handled in the current framework. The non-monetary part of the cost-benefit analysis may be extensive and detailed, but tends to take a rather short-term perspective focusing on the immediate effect once the road opens.

Induced traffic, urban sprawl, and negative implications

It is well documented that extra traffic growth *induced* by a new or extended road is often underestimated. This implies that not only may the positive effects in terms of time savings be overestimated, but any external effects of traffic will be underestimated too. Admittedly, the Norwegian transport models are better than many others at handling induced traffic in a short-term perspective. However, in a long-term perspective, traffic will increase even more (unless strong measures to prevent it are implemented) due to changes in location patterns, land use, and public transport service levels. This is closely related to the phenomena often referred to as ‘regional enlargement’ and ‘urban sprawl’. People tend to expand their radius of action rather than using travel time savings for work or other non-travel purposes. In doing this, individuals do not take into account the disadvantages for others, such as:

- congestion
- accidents (not necessarily increases per km travelled, but increases in the total distance travelled)
- negative effects on lifestyle and public health
- negative environmental effects of various types (noise, emissions to soil and air)
- reduced quality of public transport and/or increased expenses for operators, who have to expand their services geographically while at the same time not being able to exploit economies of scale to the same extent when more people choose cars over public transport²
- expenses for local governments, due to the need for more local infrastructure such as water pipes, sewers, electricity lines, and access roads
- the downside of a ‘tougher labour market’ and the loss of local schools and stores. Small communities may lose some of their qualities.

As long as these negative side-effects of traffic are not correctly priced, traffic will generally be inefficiently high and cities inefficiently decentralized, even in the no-build alternative, and the new project may worsen the market failure.

² The Downs–Thomson paradox states that in the case where public transport competes with the car in a congested area, the road capacity increase will lead to a new equilibrium with fewer people using public transport and the quality level will be reduced for both modes of transport.

We also discuss the ‘lock-in effect’ related to urban sprawl. The physical entities of sprawling built environments represent large ‘sunk costs’ and they affect people’s lifestyles to a large extent. In the long term it may not only be possible but also necessary for people to travel over longer distances to perform their daily and weekly activities. Thus, mobility as freedom would turn into mobility as a necessity.

Underpricing

The prices used for environmental effects in transport project cost-benefit analyses are generally low in Norway, as are the actual prices (taxes, etc.) faced by polluters. The prices on environmental goods are far from reflecting our politicians’ concern for the environment and the ambitious goals adopted, particularly for the reductions in greenhouse gas emissions. We are reluctant to claim that the prices are ‘wrong’, since a ‘correct’ cost of carbon does not exist, and in reality a mix of different valuation techniques and principles are being used. However, we note that most valuation principles discussed in the literature give a higher price than the one currently used. Implicit valuation indicates that the carbon price should be derived from international agreements or domestic political targets. Thus, the stricter the target, the higher should be the price.

In addition to the low monetary value set for greenhouse gas emissions and other environmental impacts, the importance of long-term environmental consequences is significantly downplayed due to the discounting rules. This problem goes to the heart of the more fundamental critique against the cost-benefit analysis. While there is a logic behind the assumption that a person prefers to receive money now rather than the same amount in the future, the same logic cannot be applied to explain why the current generation’s consumption of a public good (such as a stable climate) is worth more than future generations’ consumption of the same good.

Some might claim that the problem of intergenerational inequity is one that cannot be solved within the framework of the cost-benefit analysis, but should rather be considered a distributional effect in order to be assessed in a supplementary analysis in the same way as intergenerational inequity problems. If this is true, it is a paradox that this is rarely done.

How can these impacts be identified and assessed?

The neglected and underestimated negative impacts discussed in this report are of very different types, some of which are tangible and others are entirely intangible. Some may be explained by empirical weaknesses while others are related to theoretical or even ethical/normative weaknesses of the cost-benefit analysis. We therefore do not recommend one particular measure that should solve all problems, but rather discuss various measures that could supplement each other.

Firstly, one should look at the potential for improvements in the transport model system, not least so that they can include effects on land use and long-term induced traffic. One recent development that may be relevant is the Land Use and Transport Integration (LUTI) models.

Furthermore, there is potential for improvement in the economic valuation of impacts, particularly with respect to the environmental effects, which currently are not included or are underpriced. It should be noted that correct pricing *in the markets* (i.e. reflecting the social marginal cost) would be the first-best solution. In Norway, the Green Tax Commission recommended that taxes on emissions should be high enough to reach domestic emission reduction targets, and subsidy schemes with negative climate effects must be abolished (such as tax reductions for commuters).

Other weaknesses are more fundamental, and imply that the cost-benefit analysis should not always be applied, at least not alone. There is generally no guarantee that a 'profitable' project is acceptable from a sustainability perspective, and some might therefore argue that the cost-benefit analysis should be replaced or supplemented by the Sustainability Impact Assessment, Multi-Criteria Decision Analysis, or something else. Alternatively, the cost-benefit analysis may be constrained, for example with respect to the kind of environmental situation that can be accepted for future generations.

It is not possible to quantify all of the discussed impacts, and even less possible to monetize them. Therefore, extensions and improvements in the non-monetary part of the analysis are also needed. The minimum requirement should be that they are assessed in a long-term perspective (the new long-term equilibrium, after any land-use changes). If one looks beyond the cost-benefit analysis, there is a broader field of different frameworks and approaches that we could learn from.

It should be noted that this is a conceptual study, for which the ambition has been limited to identifying impacts that are neglected or severely underestimated in the current Norwegian framework and practices. We have not performed an empirical investigation of their relative importance, which would be an interesting topic for future research. One should not be surprised if the neglected and underestimated negative impacts outweigh any wider economic benefits.

1. Background and overview

1.1. Introduction

Transport investment projects normally go through an extensive appraisal and planning process involving multiple stakeholders and different levels of government. In this process, often the cost-benefit analysis receives the most attention. The cost-benefit analysis is used to determine whether an investment or other intervention is profitable (i.e. whether the population's net aggregate willingness to pay for it is positive) and to provide a basis for ranking alternative schemes. In the transport sector, there is a long tradition of using cost-benefit analyses to inform decision-makers about the value for money of new infrastructure investments, and the method has been codified in official guidelines in a number of countries, including Norway.

Development in the cost-benefit analysis methodology has led to an increasing number of impacts being monetized and included in the appraisal guidelines. However, not all effects within the transport market or beyond it are handled perfectly. In particular, the cost-benefit analysis is not a general equilibrium model, and transformations of the impacts to other markets are not specified. Since the publication of the influential SACTRA report *Transport and the Economy* (SACTRA, 1999),³ great attention has been given to market imperfections that may cause the full benefits of a transport investment to not be captured by the cost-benefit analysis. The wider benefits are understood as indirect benefits in secondary markets such as product markets, labour markets and property markets, where the improved mobility has reduced a market failure. This is now the subject of extensive ongoing research, often funded by local public planners and stakeholders. In Norway, where most road and rail projects have a negative net present value, new hope has arisen among project

³ SACTRA was first and foremost influential for practical work, while the theory was developed earlier (see for example Jara-Diaz (1986) for an important theoretical contribution).

promoters that the wider economic benefits are going to justify their otherwise unprofitable projects.

This report is an attempt to balance the public debate, by compiling and discussing some neglected and/or underestimated *negative* effects in standard cost-benefit analyses. In the long run, people do not generally save time and use it for other purposes, but rather travel longer distances. This leads to more induced traffic, which in the long term is amplified by land use changes in the form of urban sprawl and associated social and environmental problems, which are not taken into account by the individual. Many such neglected and underestimated negative effects have long been recognized by researchers within transport economics and/or other disciplines. It has also been recognized (including in the SACTRA report) that the wider impacts may also be negative. However, there is a long way to go before the neglected or underestimated negative effects are given the same attention as the positive ones in the public debate, and to our knowledge they have not been systematized and brought collectively into the discussion of the missing impacts in cost-benefit analyses to date.

In the remaining part of this chapter we give a brief introduction to cost-benefit analysis and its application in transport investments in Norway,⁴ as well as the ongoing discussion about the wider *benefits*. Thereafter, we present our definition of the neglected and underestimated negative impacts, and outline what we believe to be the most important of these impact categories.

1.2. Cost-benefit analysis and transport investments

What is cost-benefit analysis?

Cost-benefit analysis is a way of systematically organizing information about the consequences of public sector resource use, involving the valuation, to the extent feasible, of all positive and negative effects of a scheme for the domestic population. (For an introduction, see Boardman et al. (2011) which is a good textbook. For a recent update on cost-benefit analysis in Norway, see NOU 2012:16). The fundamental principle, which is grounded in an acceptance of consumer sovereignty, is that the value of an impact is what the

⁴ The Norwegian methodology, public guidelines, and application have similarities with those in other countries (see Welde et al. (2013), for a comparison between the Norwegian and Swedish cost-benefit analysis transport appraisal methods, and Mackie et al. (2014) for a comparison across a larger group of countries).

population as a whole would be willing to pay to achieve it. The cost should reflect the value of the resources or inputs devoted to the project in the best alternative use. Future impacts are converted into a present value using a discount rate that may be interpreted as a required rate of return. If the total discounted willingness to pay for all benefits emanating from the project exceeds its total discounted costs, the project will be defined as profitable in economic terms.

In a situation with perfectly competitive markets, the price tags to be used in a cost-benefit analysis are the market prices. More commonly, market prices need to be adjusted for taxes and various forms of market failure. When the activity of a person or an enterprise has impacts on the welfare or profitability of others, the price should be corrected to account for such externalities. Different valuation techniques exist, such as stated preference interviews, when people are asked about their hypothetical willingness to pay for a good (Navrud, 2016).

There is a long tradition of the use of cost-benefit analysis in the transport sector. Over time, the method has grown increasingly comprehensive, and an increasing number of effects are being included as monetary effects in the model. By the early 1970s, time savings and accident costs were included in cost-benefit analyses in several countries, and throughout the subsequent decades, major developments were also made in the pricing of local environmental costs and other non-market effects. More recently, the framework has also included health effects and greenhouse gas emissions (Sager, 2013). A crucial input to the estimation of consumer impacts is the estimated traffic flows. Transport models are frequently used to perform these estimations, and since the information and communications technology revolution in the 1980s, transport models have become increasingly complex and have made it possible to analyse transport schemes involving large geographical areas.

The Norwegian framework for assessing transport projects

In Norway, a standard transport project cost-benefit analysis today consists of four main components, as described by Minken and Samstad (2005) and the Norwegian Public Roads Administration (NPRA, 2014) (these are gross impacts, and may offset each other when the net present value is computed – the ‘inclusive method’):

1. Consumer impacts

2. Producer surpluses
3. Budgetary impacts on the public sector
4. Impacts on society at large

Consumer impacts normally affect the project benefits most. By consumers, we mean the various users of the transport infrastructure. Travel demand is assumed to be a function of generalized cost, which includes time costs, fuel expenses, tolls, bus tickets, and other out-of-pocket expenses, as well as felt disadvantages that transport users face. Regularity and punctuality, and crowding and/or comfort on public transport may be included if data exist, which is normally not the case. Increased consumer benefits may be due to reductions in the generalized cost and/or induced additional travel. Changes caused by a transport scheme are computed by using the 'rule-of-a-half' for approximating the area below the demand curve. The change in the consumer surplus is computed for all affected submarkets (e.g. different modes, purposes, routes, and times of the day) and summed.

Producer surpluses include, for example, profits for system operators responsible for public transport, parking, and road toll collection.

Budgetary impacts include the investment cost, maintenance and operation costs, and other expenses for the government, including tax income and subsidies disbursed.

The last component consists of external effects on the environment, health and safety, the residual value of the infrastructure, and the cost of public funds. The change in accident costs is based on accident rates (fatal, serious, or slight casualties) by type of road and level of traffic, and the economic values are derived from the value of a statistical life (VSL). Effects on noise and the environment follow from computed changes in traffic flows, and include several types of local air pollution and greenhouse gas emissions (but far from all types of environmental disadvantages).

The monetary values from all categories are summed and the discounted net present value per Norwegian budget kroner is computed by using a discount rate of 4%, to be reduced after 40 years (however, in most cases the period of analysis is 40 years).

The framework also includes five non-monetary components, all of which are related to nature and the environment: 1) changes in the landscape image, 2) local environment and possibilities for outdoor activities, 3) biodiversity, 4)

cultural heritage, and 5) natural resources. These non-monetary effects are 'valued' by experts on a scale ranging from -4 to +4. These impacts are compiled and an overall assessment of them is made. This should be taken into account when a conclusion is reached as to whether the scheme is worth the investment.

The NPRA guidelines state that 'other impacts' should also be described, although not included as standard. These other impacts include: 1) wider economic benefits (see Section 1.3. below); 2) distributional effects, with respect to, for example, geography, population groups and business; and 3) effects on specific regions, assessing for example their access to labour and to other relevant markets, effects on tourism, changes in the region's attractiveness, and effects on land use.

What is not included

It should be noted that cost-benefit analysis as a decision basis for public investments is criticized from many perspectives. A summary of the general critique, not only related to the transport sector, can be found in Appendix 1, and we discuss some aspects of it throughout this report.

The cost-benefit analysis framework used for transport investments in Norway is fairly comprehensive. The two most recent consumer effects included are pedestrians'/cyclists' 'fitness effect' and changes in their 'felt safety' (albeit only included for schemes that are targeted at these groups). Valuation of impacts not traded in markets is based on best practice valuation methods. The results of a large Norwegian valuation study have been summarized by Samstad et al. (2010). The underlying transport models are best practice too. However, models are simplified representations of reality and they cannot include everything. Minken (2012) summarized the most important shortcomings that he found in the Norwegian transport models and cost-benefit analysis framework. These shortcomings included the need for real price adjustment of impacts (which has since been included for time savings in the newest version of the NPRA guidelines), the need for a longer period of analysis and improved computation of residual values (also now corrected), better treatment of regularity, inclusion of disadvantages in the construction period, impacts on the supply of public transport, better prognoses for maintenance and operation, and not least, the need to see transport systems together with other markets such as the labour market, housing and/or real estate market and land use. It should also be added that the prices used for the environment

are generally low in the Norwegian framework, and that some important effects on landscape and natural and heritage assets remain as qualitative descriptions in the framework and are, in practice, assessed only in a short-term perspective, being interpreted as ‘the immediate effect once the road opens’.

It is not clear whether the sum of the various shortcomings pulls toward a more positive assessment or more negative assessment of the desirability of a project proposed. However, there has certainly been pressure from those with an interest in transport schemes being profitable to correct the methodology with respect to some shortcomings while not mentioning others. One example is the lobby organization for new highways, Opplysningsrådet for Veitrafikken, which states that virtually all Norwegian road projects are erroneously assessed as unprofitable because they do not include the benefits of improved regularity or the wider benefits, and that time savings are given a too low value. The most discussed and currently most researched topic, with many studies being funded by municipalities and stakeholder groups who are hoping to get ‘their’ project approved, is the *wider economic benefits* that could potentially be generated in secondary markets. This is therefore the topic of the next section.

1.3. Wider economic benefits?

As already mentioned, the wider economic benefits of transport investments is a hot topic with numerous studies carried out in the last few years. We also see that it influences cost-benefit analysis practice: using the database for major public projects under the Ministry of Finance’s Quality Assurance scheme⁵, we found that among the 87 transport sector cost-benefit analyses performed in the period 2007–2015, almost half (46%) included a general discussion of the wider benefits that could potentially be added to the net present value, whereas only 14% of the cost-benefit analyses mentioned well-known negative impacts that might be undervalued, such as disadvantages in the construction period or intergenerational equity problems.

In Appendix 2, we present the theoretical foundation for the wider benefits and some attempts to measure them, and discuss in a critical perspective how

⁵ For more information on the database, Trailbase, see the Concept research program’s website www.ntnu.no/concept/datainnsamling

realistic it is that such effects exist in a Norwegian context. A short summary is given below.

The cost-benefit analysis is a partial equilibrium model, focusing on the direct effects within the transport markets (and trying to capture external effects on the side), but otherwise assuming that secondary markets are perfectly competitive. However, if market failures in secondary markets are severe *and* the transport investment considerably reduces their adverse effects on the economy, there may be a value that is additional to the transport-user benefits computed in the cost-benefit analysis.

The main type of wider economic benefits discussed in the literature is productivity improvements due to agglomeration and cluster effects. Urban areas are more productive than rural areas. An investment in transport infrastructure that increases the *effective* size of a city, for example by allowing more people to commute to the city centre, may in theory generate such positive external effects beyond what are taken into account by individual travellers. Examples of influential contributions to this literature are the publications by Venables (2007) and Graham (2007). However, it has proven difficult to measure any causal relationship between city size and productivity, and even more difficult to document an effect of a particular infrastructure investment. A number of different models have been developed, particularly in the UK, to *simulate a potential* effect based on a wide range of assumptions. The results seem to vary greatly. Many of the assumptions are, in our view, highly dubious, not least when reiterated and used in a Norwegian context. As noted by Harald Minken in his presentation at the NPRA seminar on the wider benefits of the Coastal highway route E39 ('Ferry-free E39') project, held in March 2016, a considerable share of the calculated wider benefits can probably be explained by the mere assumption that *people cannot move* to areas with larger labour markets; this is equivalent to an assumption that all the space within the city is already occupied and the only way to increase effective urbanization is through commuting. Most studies also disregard user fees or tolls, congestion, and any negative productivity changes in other regions that 'lose' their workers. All such limitations have been mentioned in the literature, but seem to be ignored in the public debate and in practical calculations⁶. In reality, one would probably find that many people adapt to the improved transport infrastructure

⁶ For example, Venables (2007) noted that his analysis failed to examine the effects on crowding and other negative externalities, and he made it clear that such effects will reverse the wider economic benefits.

by *moving out of the city centre* and commuting to the same jobs as they had before. Metz (2008) investigated the general development in people's travel habits, and found that while the average travel time has remained constant at approximately one hour per day for decades, the average distance travelled per day had increased dramatically over time. It is reasonable to assume that the marginal utility of this increased mobility and the new possibilities it gives to consumers is high in the beginning, but then diminishes. In such a case, the long-term productivity effects of steadily increasing peoples' mobility, may not be positive at all.⁷ In the long run there are the other, clearly negative, effects, such as those on climate change and the environment, which we discuss in later chapters in this report.

Another type of potential wider benefit that is often mentioned relates to the increase in production caused by increased labour supply. Workers who enjoy travel time savings are assumed to increase their working hours, and some may change from not working to entering the labour market. The additional income received by the worker will be taken into account by him or her and included in his or her demand for transport, but there may be a wider benefit in terms of the additional tax income. These effects could potentially be large in a society with high income taxes. However, they rest heavily on the assumption that workers actually realize time savings, and that they can and will spend some of it to increase their working hours. This suggestion does not hold in the long run if potential time savings are translated into longer travel distances, as shown by Metz (2008).

A third type of wider benefit often mentioned in the literature is when a transport investment triggers competition in some markets and thereby improves market efficiency. For this effect to be relevant, there must be sheltered sectors with elastic demand and a high level of market power in the ex-ante situation, and transport cost must constitute a considerable share of each producer's total cost in the affected markets. This effect thus depends on the local context and is highly uncertain, and even less documented empirically than the others.

As we have already indicated, we doubt the empirical relevance of the wider benefits in a Norwegian context, with a scattered population and already long

⁷ Metz and other have argued that one should not measure travel-time savings in the first place, since they are only hypothetical and at best are short term effects, but should rather focus on the real and long-term impacts.

travel distances. A transport scheme may well have positive impacts on the local economy and on employment. However, as a general rule, most such impacts are mirrored by corresponding, but reverse, impacts elsewhere in the country. They are therefore not wider benefits, but merely distributional effects. Furthermore, it should be noted that any wider benefits will normally be correlated with direct consumer benefits. Thus, if the computed consumer benefits are low, it is unlikely that the wider benefits will be significant. (Admittedly, there may be exceptions. Laird and Mackie (2014) studied four transport schemes in remote rural areas in Scotland and found large wider benefits in some of them – particularly in terms of competition effects, cf. the third type mentioned above). There is much to suggest that the wider economic benefits of Norwegian transport investment projects are relevant only in very special cases, such as game-changer projects, opening up for completely new possibilities, when they integrate areas that were previously separated, but *not* located far from each other, or when each area has *a large economic mass*, with *large differences in productivity*.

1.4. This study – highlighting the neglected and underestimated negative impacts

For the purpose of this report, we define the neglected and underestimated negative impacts as follows.

The negative real impacts of a transport infrastructure project that are often neglected or significantly underestimated in cost-benefit analyses

Our definition is somewhat broader than the one normally used to define the wider economic benefits, where attention is devoted to the indirect effects of the investment in secondary markets. Instead, we see ‘neglected and underestimated’ as a counterweight to ‘ordinary’ impacts, understood as impacts normally included in Norwegian cost-benefit analyses. This is a more pragmatic definition, which also allows us to include neglected or underestimated *direct* effects.

The main categories of neglected and underestimated negative impacts discussed in this report are:

- **Disadvantages pertaining to the construction period**

Following the logic of the cost-benefit analysis, when any impacts that take place in the short term count more than impacts in the long term, the

economic consequences of months and sometimes years of construction work implying worse, not better, accessibility, may be considerable. It is difficult to understand why this effect, which should be possible to quantify, is completely disregarded in traditional cost-benefit analyses. In addition, the construction period will entail intangible effects in terms of, for example, disruption to neighbourhoods, noise, and visual changes. This is the topic of Chapter 2.

- **Neglected environmental impacts**

Many of the neglected negative impacts discussed in this report are environmental impacts. Some such impacts may be difficult to measure, quantify, and give a price tag, and the implication is often that they are disregarded in the cost-benefit analysis. Similarly, the simplistic and very short-term handling of some environmental effects in the non-monetary part of the analysis is equivalent to ignoring such effects in the long term. This is the topic of Chapter 3.

- **Induced traffic, urban sprawl, and negative implications**

Extra traffic growth induced by a new or extended road is often underestimated. This implies that the consumer benefits, as well as any wider benefits, may be overestimated, *and* the external effects of traffic will be underestimated. These include, for example, impacts on the environment, public health, and culture, not least when land use changes in the form of urban sprawl are taken into account. Urban sprawl will also generate expenses for local governments in terms of new local infrastructure (which will reverse any additional tax income due to increased labour supply), and to system operators who must expand their services geographically while at the same time not being able to exploit economies of scale to the same extent when more people choose transport by car over public transport. Furthermore, any negative effects in terms of a tougher labour market and the loss of local shops and schools should also be included in the analysis. Small communities may lose some of their qualities. In this study, we go beyond the traditional cost-benefit analysis literature, and identify and discuss impacts normally associated with other disciplines, such as sociology, psychology, human geography, ecology, and environmental philosophy.

The neglected and underestimated negative effects related to induced traffic are discussed in Chapters 4 and 5.

- **Underpricing**

Lastly, we question the monetary valuation of environmental effects. It is a paradox that the environmental effects in cost-benefit analyses are typically very small or negligible (Welde et al., 2013)⁸ when our politicians at the same time have adopted ambitious goals for reductions in greenhouse gas emissions. The price tags used to value environmental effects (greenhouse gas emissions in particular) are thus inconsistent with the shadow prices that may be derived from political goals. This is the topic of Chapter 6.

The neglected and underestimated negative impacts in the framework

Based on Bull-Berg et al. (2014), we distinguish between real economic impacts (i.e. impacts that affect the net economic benefit of the investment) and other societal considerations, as shown in Figure 1. The cost-benefit analysis focuses on the real economic impacts, which can be either positive or negative, and either direct or indirect. Direct effects are defined as those taken into account by consumers and producers in the transport markets, whereas indirect effects are those that take place in secondary markets. All impacts can, at least in principle, be measured in monetary or non-monetary terms (not shown in Figure 1).

The neglected and underestimated negative impacts discussed in this report (i.e. the four main categories listed above) are shaded grey in Figure 1. We have tried to indicate whether the various categories are mainly direct or indirect effects, but it is not always clear where to draw the line. For example, when it comes to the implications of induced traffic and urban sprawl, some impacts are at least partly taken into account by the actors in the transport markets (such as the risk of accidents and effects on people's own health), whereas others are probably not (such as most environmental effects⁹). Similarly, the problem of underpricing is relevant for both direct effects and indirect effects.

⁸ Generally, the main benefit component in transport cost-benefit analyses is consumer benefits (primarily time savings), which on average represent 75% of total benefits. This is followed by the component reduced risk of accidents, which accounts for approximately 15%, whereas the importance of the environmental impacts is much lower and often negligible (Welde et al., 2013).

⁹ Some environmental effects may be partly taken into account, such as noise and local air pollution.

In Figure 1, we also indicate how induced traffic caused by land use changes is expected to affect negatively the consumer benefits and any alleged wider benefits (see the arrows).

Other societal considerations, such as intergenerational and intergenerational distributional effects and achievement of political objectives should also be discussed and presented with the cost-benefit analysis. In this report, we therefore also discuss the distributional effects of the neglected and underestimated negative impacts (Chapter 7). Admittedly, the distinction between real economic effects and distributional effects is not always as clear as shown in Figure 1, and similarly it is not always clear whether the shadow price of a political objective should be included in the cost-benefit analysis.

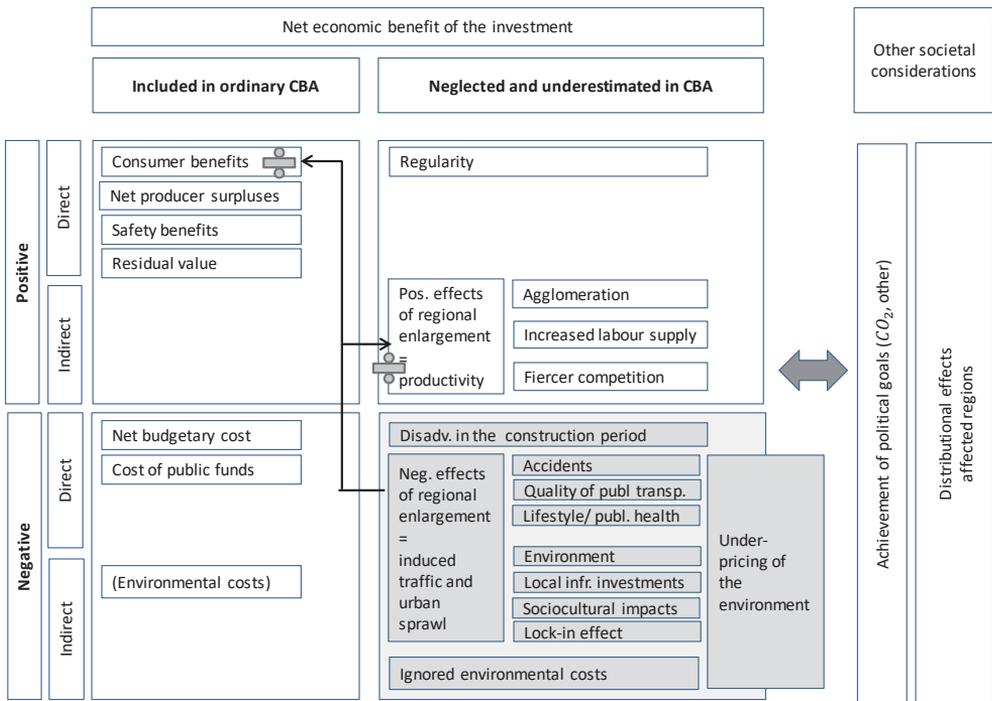


Figure 1. The neglected and underestimated negative impacts discussed in the report

In Chapter 8 we discuss some possible ways to ensure that the neglected and underestimated negative impacts are included in project appraisal. Some of the impacts discussed in this report might be referred to as empirically based

weaknesses, which could, at least in principle, be solved by investing in more or better data, and further developments in the existing models or valuation methods. Other impacts are, however, due to theoretical or more fundamental weaknesses of the cost-benefit analysis, being based on a set of strict assumptions, which makes it less suitable for handling, for example, political objectives, future generations, and market imperfections in secondary markets. These problems may be solved in various ways, such as the development of other (general equilibrium) models, constraining the cost-benefit analysis, extensions and improvements in the non-monetary part of the analysis, or complementing (or even exchanging) the analysis with other tools such as, for example, Sustainability Impact Assessment or Multi-Criteria Decision Analysis.

It should be noted that this is a conceptual study, in which our ambition has been limited to identifying impacts that are neglected or severely underestimated in today's practice. We have not performed an empirical investigation of their relative importance, which would be an interesting topic for future research. Furthermore, although we discuss briefly some possible ways to handle the neglected and underestimated negative impacts, we do not conclude the report with a clear recommendation of specific methods to be used.

2. Disadvantages pertaining to the construction period

Disadvantages in and around the construction period can include consequences for traffic on existing networks, local noise and pollution due to construction activities, energy use and related greenhouse gas emissions resulting from the construction process (e.g. tunnel boring), temporary landscape impacts during construction (e.g. stone tips, barracks, and fences), disadvantages for the local businesses affected by the construction works, and social disruption of neighbourhoods due to the influx of a large temporary population of people working on the infrastructure project. Of these, the consequences for traffic (reductions in consumer benefits) are assumed to have the largest economic impact on the project's profitability. (One can of course not rule out the possibility that some of these effects may also be positive, for example the effects for local businesses, but this is not our focus here).

Compared with the literature on the environmental impacts of transport activity, literature about the disadvantages for transport infrastructure during the construction period is rather limited. The few relevant publications found on the Internet when searching for 'construction period impacts transport' appear to be manuals for project evaluation and project planning issued by public authorities, particularly in the USA (e.g. The Interorganizational Committee on Guidelines and Principles for Social Impact Assessment (1994) and California Department of Transportation (not dated)). Disadvantages pertaining during the construction of transport infrastructure appear to be an under-focused topic in academic research.

Figure 2 shows the construction period impact categories that the California Department of Transportation require infrastructure construction operators to assess and for which, if relevant, to propose mitigation measures. Some of the impact categories mentioned in the list will also often be permanent impacts.

However, the categories shown in Figure 2 refer only to effects for which the duration is limited to the construction period.

<p>Community Impacts</p> <ul style="list-style-type: none"> • Neighborhoods and Businesses • Construction-period Safety and Security • Construction Employment • Community • Safety and Security <p>Transportation Effects During Construction</p> <ul style="list-style-type: none"> • Traffic Disruptions • Construction Vehicle Traffic • Parking <p>Additionally, if relevant</p> <ul style="list-style-type: none"> • Marine Operations • Marine Traffic 	<p>Construction-period Visual Changes</p> <p>Construction-period Air Quality</p> <p>Construction-period Noise and Vibration</p> <ul style="list-style-type: none"> • Construction Noise • Traffic Noise During Construction • Construction Vibration • Explosives <p>Hazardous Wastes</p> <p>Water Resources and Water Quality</p> <p>Natural Resources</p>
---	---

Figure 2. Categories of temporary effects during construction activities identified by California Department of Transportation. Source: California Department of Transportation (not dated)

Regarding the impact categories related to the construction process per se, *disruptions in the traffic system* might occur for road projects, rail projects, and other transport infrastructure projects. Insofar as the capacity of the existing infrastructure of a category is affected (e.g. due to temporary lane closure on a road), such disruptions can lead to changes in people's choices of travel modes, and to 'disappearing traffic' (Cairns et al., 2002), in a way similar to the induced traffic resulting from capacity increase after the opening of a project. In many cases, disruption during the construction process has resulted in lower-than-expected congestion (Cairns et al., 2002; Tennøy et al., 2016). However, this depends on whether alternative routes and travel modes are available, and on the extent to which it is possible for those who travel to make their trips at a different time of the day (i.e. outside the peak period) or simply drop some trips. The movement of bulldozers, tractors, excavators, and other contractor's vehicles on the roads during the construction process represents an additional source of disruption. For public transport projects, disruption during the construction period (e.g. the construction of an additional track on a railway) can make some passengers shift to using cars or

to other public transport connections, similar to the changes that may appear among car travellers during road construction. Remaining passengers who have to rely on alternative, temporary public transport services such as 'bus for train' often experience increased travel times. Traffic-related impacts during construction processes are complex and may be difficult to predict, but they should nevertheless be discussed and taken into consideration in project evaluations.

During construction projects, the activities of transport infrastructure normally entail *local noise* and *pollution*. Noise and air pollution are likely to emanate from blasting, hammering machines, bulldozers, excavators, heavy trucks, and other vehicles. Pollution of soil and water is also common the construction process. To varying degrees, such impacts are mentioned in environmental impact assessments (EIAs) of transport infrastructure projects (Nielsen, 2000), but are included to a lesser extent in the cost-benefit analyses.

The construction process also entails energy use and related greenhouse gas emissions. Such energy use and emissions can be quite substantial. How large a share of the energy use and greenhouse gas emissions that the construction process accounts for depends to a great extent on the geographical context of the project. For intercity two-lane roads and other types of road building schemes in rural areas, the contribution to CO₂ emissions and energy use stems mainly from the construction process. This is especially the case if long tunnels have to be constructed. For two-lane roads in smaller towns and urban settlements, the construction process normally accounts for 25-50% of the total increase in energy use and CO₂ emissions resulting from the project, while induced traffic accounts for the remaining percentage. For a third example, namely the expansion of an existing four-lane road in a metropolitan area with two additional lanes, the contribution of the road project to energy use and CO₂ emissions is mainly due to induced traffic, whereas the construction process itself accounts for some 6–12% (given a 'normal' share of bridges and tunnels included in the project) (Strand et al., 2009). For railway projects, the construction process accounts for a very high share of the lifetime energy use and CO₂ emissions, depending somewhat on the assumptions made about locomotives which are driven by hydroelectric power. For example, an environmental assessment of proposals for new high-speed intercity railways from Oslo to Bergen and Oslo to Trondheim concluded that it would take 35 years and 37 years respectively to 'pay back' the CO₂ emissions from the construction process, even if the proposed high-speed lines succeeded in

replacing all flights and goods transport by truck between Oslo and the two destinations (NRA/Jernbaneverket, 2012).¹⁰

The construction period normally also entails *temporary landscape impacts* in terms of, for example, stone tips, barracks, fences, and access roads for machinery. The surroundings, especially along access roads, also often acquire an ‘untidy’ and muddy appearance. From the perspective of landscape aesthetics, such changes are usually perceived by most people as negative. Often, the temporary installations are present for many years, thus influencing the view and the general landscape perception of local residents and tourists for a substantial period.

Finally, *social disruption of neighbourhoods* may occur due to the influx of a large temporary population of workers involved in the infrastructure project. This will probably not be an important impact for urban infrastructure projects, but for construction works in small rural communities, the influx of infrastructure workers can be experienced as quite overwhelming for the local population. If significant immigration occurs, the new residents may generate a strain on community infrastructure. Responding to the temporary increased demands on school, health facilities, housing, and other social services may be difficult for some communities (Interorganizational Committee on Guidelines and Principles for Social Impact Assessment, 1994). The influx of a large construction workforce can also cause social stresses due to changing patterns of social interaction (Interorganizational Committee on Guidelines and Principles for Social Impact Assessment, 1994), especially because there is usually a strong gender imbalance among those working on transport infrastructure projects, with the vast majority of workers being male.

The social impacts of a large temporary workforce in a local community are not necessarily always negative, and some residents may experience the

¹⁰ With regard to energy use and greenhouse gas emissions during the construction period, since 2015 these effects have been included in the current version of the cost-benefit analysis model used by the public road authority in Norway (NPRA, 2015), albeit with a low price. By contrast, in the model used by the national rail authority, no calculations of the cost of greenhouse gas emissions from the construction period are made. The authority assumes that such costs are fully captured by regulations and taxes. If the environmental effects are assumed to be considerable, they should be described qualitatively (NRA, 2011).

workforce as a refreshing and exciting new presence. However, some residents may find the changes disrupting, and to the extent that the construction process leads to strain on local infrastructure and social services or to stress resulting from changing social interaction patterns, these consequences should be included among the ‘neglected and underestimated negative impacts’.

3. Neglected environmental costs

In this chapter we identify and briefly discuss the environmental impact categories that we consider to be least well handled (which normally means totally neglected) in the cost-benefit analysis. The empirical knowledge about the ways in which such effects are actually dealt with in project evaluation is rather limited. Generally, there is a need for more research on the quality of the assessments of non-monetized effects and the extent to which such effects exert any influence on the decisions about projects.

We find it useful to present this list of neglected environmental impacts in one place, but it should be noted that there is considerable overlap with other chapters in this report, since underestimation of traffic (discussed in Chapters 4 and 5) and underpricing (discussed in Chapter 6) are both key reasons why environmental effects are underestimated. However, in this chapter our main focus is on impacts that are not included in the framework, either in quantitative terms or in qualitative terms.

Here, it should also be noted that the routine of assessing projects one by one can result in the neglect of accumulated environmental load from a larger number of projects. According to Norway's Nature Diversity Act, Section 10, any pressure on an ecosystem should be assessed on the basis of the cumulative environmental effects on the ecosystem, both now and in the future (Ministry of the environment, 2009). The impact of a new road or stretch of railway on, for example, a species of moss may be acceptable, but the sum of acceptable impacts may lead to extinction in the longer run. Such long-term and cumulative effects are not included in the cost-benefit analyses and thus belong to the neglected negative environmental impacts.

As explained in Chapter 1, the standard cost-benefit analysis includes the component 'impacts for society at large', which comprise some environmental costs in terms of noise and emissions to air. More specifically, the following impacts are included with a price tag: noise, particulates (PM10 and NO₂), NO_x emissions, and greenhouse gases (NO_x, CO₂, and N₂O). In addition, five

non-monetary components, all related to nature and the environment, are included: changes in the landscape image, local environment and possibilities for outdoor activities, biodiversity, cultural heritage, and natural resources. However, as noted above, the interpretation of the non-monetary impacts seems to be ‘the immediate effect once the road opens’ implying that any medium and long-term effects in these categories are ignored.

Greenhouse gas emissions resulting from road construction

Greenhouse gases are at the top of our list of underestimated environmental effects. As illustrated in Figure 3, changes in greenhouse gas emissions due to road construction can result from

- a) changes in emissions per kilometre that persons or goods are transported by the respective mode of transport (short-dashed arrows)
- b) changes in the number of kilometres that different types of vehicles travel (non-dashed arrows), resulting from
 - changes in how far persons and goods are moved
 - changes in the shares of the total amount of transport accounted for by transport modes producing different average emission levels per kilometre persons or goods moved
- c) emissions resulting from the production of new infrastructure and its subsequent lighting and maintenance, as well as production of new vehicles that will result from the induced traffic (arrows with alternately long and short dashes)

Among these sources of emissions, a) is usually taken into consideration in cost-benefit analyses, and c) *may* be acknowledged (except for emissions resulting from the production of new vehicles, which are almost never included). If state-of-the-art transport models are used, category b) may be taken into consideration partially, since short-term regional enlargement within existing land use and short-term changes in the shares of different means of transport are accounted for, while long-term effects on the amount of transport (due to changes in land use) and on the modal split (due to reduced quality of public transport) are usually ignored. If the cost-benefit analysis is based on traffic models ignoring induced traffic, all impacts belonging to category b) are usually neglected.

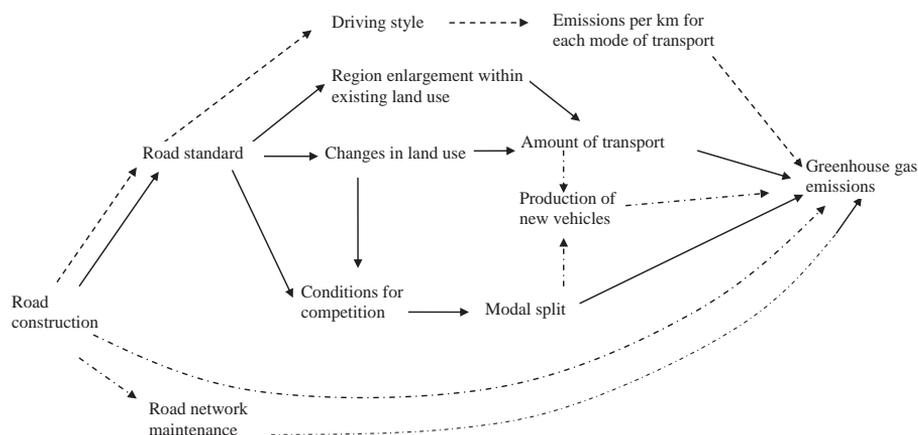


Figure 3. Different ways in which road construction can influence greenhouse gas emissions

Moreover, the price of greenhouse gas emissions is often set at an arbitrary and normally low value. This is discussed further in Chapter 6.

Particulates

Traffic leads to the emission of microplastic particles that are worn and torn off vehicle tires while driving (GESAMP, 2015; Verschoor et al., 2014). Microplastics have become a serious threat to life in the oceans (Sundt et al., 2015). According to the Norwegian Environment Agency (2014, 2015), annual emission estimates of tire rubber dust for Norway, Sweden and Germany range from 1 to 1.4 kg per capita annually, which makes rubber dust the largest land-based source of microplastics pollution in Norway.

Whereas the *local* impacts of pollution caused by particulates are included in the cost-benefit analysis framework used by, for example, the NPRA, the non-local impact from car traffic on maritime environments at a global scale has not been included to date.

Land conversion related impacts

The infrastructure project as a physical entity usually requires the conversion of land that prior to the project has not been used for traffic purposes. Such conversion may imply loss of, for example, farmland, natural areas, parks, and residential neighbourhoods, with resulting negative impacts for biodiversity,

ecosystems, outdoor recreation opportunities, housing, cultural heritage, and neighbourhood amenities generally. Some of these impacts may be included in a cost-benefit analysis (e.g. compensation for demolished dwellings or loss of farmland), but others are most often only partially accounted for through willingness-to-pay investigations or similar methods, or are simply neglected. The validity of the monetized values of land-related impacts included in cost-benefit analyses are contestable; for example, the market price for farmland does not necessarily capture the importance of farmland in a national food security strategy, and any willingness-to-pay investigations concerning impacts from infrastructure construction on natural areas will be unlikely to cover consequences beyond those pertaining to outdoor recreation. Loss of ecosystems and biodiversity is to some extent included as non-monetary impacts. The same applies to impacts on cultural heritage.

Landscape impacts

Infrastructure projects most often lead to changes in the landscapes within which they are inserted. 'Landscape' is here understood in line with the European Landscape Convention, namely as a 'part of the land, as perceived by local people or visitors, which evolves through time as a result of being acted upon by natural forces and human beings' (Council of Europe, 2016). Landscape impacts resulting from new transport infrastructure are often included in environmental impact assessment reports (EIAs) but do not lend themselves easily to quantification and monetizing, and are therefore normally not included in cost-benefit analyses. As noted above, changes in the landscape image are included among the non-monetary impacts in the Norwegian cost-benefit analysis framework, but are viewed in a short-term perspective since they do not include the long-term landscape encroachments resulting from urban sprawl facilitated by infrastructure construction (cf. Chapter 5).

Although some infrastructure projects, such as bridges, may be of such a high design quality that some people perceive them as a positive contribution to the landscape, the landscape impacts of many other transport infrastructure projects are perceived as predominantly negative. This is especially the case during the construction phase, but also after re-establishing vegetation along the newly built infrastructure, the new physical element is often perceived as an encroachment that reduces the quality of the landscape.

4. Underestimation of induced traffic

In this chapter, we discuss a significant weakness in transport models and cost-benefit analysis methodology, namely the handling of induced traffic (see Appendix 3 for a more detailed presentation of existing transport models and their weaknesses). To the extent that the induced traffic is underestimated, this may imply both an underestimation of external costs, and also an overestimation of benefits (most notably, the time savings). The focus of this report is on the former, but the latter will be discussed as well. The immediate travel time savings resulting from a transport project are included in the model, since reduced travel time is often the main motivation for building a piece of infrastructure. However, the gradual erosion of these savings caused by extra traffic growth *induced* by the new or extended road is often not accounted for in road projects or at least substantially underestimated.

In line with Schmidt and Campbell (1956, cited in Cervero, 2001, p. 4), we define induced traffic as ‘the added component of traffic volume which did not previously exist in any form, but which results when new or improved transport facilities are provided’. This includes vehicle traffic resulting from increased distances between origins and destinations, changes in travel routes, changes in travel modes, and changes in trip frequencies (Hills, 1996). Diverting traffic from one route to another (apart from any difference in route length) is not included in the concept of induced traffic as we use it, although such diversions may contribute to increased congestion on a new or expanded road scheme and is included in the notion of generated traffic (Litman, 2014).

4.1. Short-term induced traffic

The best Norwegian transport models are able to estimate short-term induced traffic (i.e. a year or so after opening) fairly accurately. However, they still do not completely account for congestion in all networks and may therefore overestimate the time savings.

In transport corridors with some level of congestion, induced traffic leads to smaller travel time savings than would be the case if no extra traffic were induced. In this sense, the increases in travel time caused by induced traffic represent a negative impact not fully accounted for in cost-benefit analyses based on traffic forecasts ignoring or underestimating induced traffic. Conversely, neglect of the deterrent effect of congestion on future traffic growth can lead to overestimation of travel time savings, since future traffic in the case of no road construction would then be depicted as slower moving than would actually be the case. It should be borne in mind that underestimation of induced traffic, especially in cases where it does not lead to congestion, implies that benefits may be underestimated. Negative environmental impacts will be underestimated in both cases, as we will come back to in section 4.3.

Usually, travel time savings make up most of the expected benefits of new road projects (Banister 2008; Mackie et al., 2001). For example, in the cost-benefit analysis of a recent proposal for a new motorway in Denmark,¹¹ travel time savings amounted to 84% of the total benefits on average for the three alternative layouts. In order to estimate the value of travel time savings, the value of each time unit saved must be assessed, as well as the number of travellers affected and the average number of minutes (or seconds) saved by each traveller. The two latter components are usually estimated using transport model computations.

For a long period, traffic models used for assessing travel demand in Norway and many other countries had ‘fixed matrixes’, which implied that additional traffic induced due to the construction of new infrastructure was neglected (Arge et al., 2000; Button and Hensher, 2001; Marte, 2003; Goodwin and Noland, 2003; MOTOS, 2007; Andersen, 2013; Litman, 2014; Næss et al., 2014). Since the beginning of the present century, better models have been developed and state-of-the-art transport models in Europe are able to assess induced traffic. However, these models seem to underestimate the deterrent effect of congestion on further traffic growth, which may lead to underestimation of the difference in traffic volumes between the ‘build’ and the ‘do-not-build’ alternatives (Nicolaisen & Næss, 2015; Næss, 2011).

¹¹ An additional highway crossing over Limfjord near the city of Aalborg in the northern part of Denmark.

At least in Denmark, common practice has been to assume that traffic growth in the case of no road capacity increase is the same as the national average (Næss, 2011). This is often common practice in Norway too. Since much of the traffic growth for the country as a whole takes place on roads with little or no congestion, this will lead to overestimation of the traffic growth in corridors where congestion is present. This may lead to overestimation of the decline in travel speeds in the 'do-not-build alternatives'. When investigating 35 road projects in Denmark and the UK, Nicolaisen and Næss (2015) found that traffic was on average overestimated by 7% in the 'do-not-build alternatives' ($p < 0.001$). Among the same road projects, traffic in the 'do something' alternatives were underestimated by 5%, suggesting that the models used for these projects were on average not too bad at predicting the additional traffic resulting from road construction. Among a larger sample of 146 road projects, including projects for which no data about the accuracy of do-not-build-alternative predictions were available, Nicolaisen (2012) found an 11% underestimation of traffic on the built road schemes. The implication of overestimating traffic in the 'do-not-build' alternatives is that the baseline for calculating travel time savings from expanding road capacity can be seriously skewed, since an additional 7% traffic growth on an already somewhat congested road can lead to quite sharply increased travel times. The Norwegian transport models are generally better at taking account of congestion than are many other countries' models, but there are still some weaknesses (see Appendix 3).

Among a sample of 120 Scandinavian researchers and consultants dealing with transport modelling in 2010, 59% of the researchers and 68% of the consultants agreed with the statement 'Traffic models are poor at forecasting the effects of induced traffic', whereas only 33% and 23% respectively disagreed with the statement. Similarly, 47% of the researchers and 49% of the consultants agreed with the statement 'Traffic forecasts usually exaggerate the risk of congestion if no new infrastructure is built' compared with 6% and 38% respectively who disagreed (Næss et al., 2014).

In addition to overestimation of time-saving benefits when induced traffic is neglected, such overestimation is also likely to happen in situations where the so-called Braess paradox occurs. The Braess' paradox typically occurs in situations where a new road scheme relieves a bottleneck, but moves traffic in an unfortunate way causing new bottlenecks to emerge. This typically occurs in situations where there are bottlenecks as well as almost-bottlenecks in the road

network – i.e. in networks where the traffic load is relatively high. The explanation of this result is that some drivers choose routes where they save time. However, the time-saving that these drivers experience is smaller than the sum of delays they impose on the remaining drivers in the transport corridor (Nielsen & Landex, 2005).

4.2. Long-term induced traffic

The inaccuracies mentioned above cover only the short-term forecasting inaccuracies (i.e. in the first year after project opening). Longer-term effects due to changes in location patterns, land use, and the service level of public transport are very difficult to model and therefore, to our knowledge, they are not included in any existing transport models in Norway or abroad.

The long-term induced traffic can be substantial, typically around twice as large after 3–5 years or more as in the first year after opening (Noland and Lem, 2002; Litman, 2014). To our knowledge, only one Scandinavian empirical study has investigated long-term induced traffic. Twitchett and Nicolaisen (2013) compared traffic data for all 45 Danish road projects carried out in recent decades for which corridor-level traffic counts before and after project opening were available. For most of the projects, traffic counts after opening existed only for the first year. For these projects, Twitchett and Nicolaisen found that induced traffic one year after opening was on average 10% for motorways, 6% for ordinary highways, close to 0% for rural bypass roads, and almost 60% for motorway bridges. For the four projects shown in Figure 4, traffic data were available for a longer period. For all of these projects, the induced traffic after four years was 2–2.5 times higher than one year after project opening.

The relocation and changed land use components of long-term induced traffic are closely related to the phenomena often referred to as ‘regional enlargement’ and ‘urban sprawl’ (cf. Chapter 5). People tend to expand their radius of action rather than using travel time savings from higher travel speeds for non-travel purposes (i.e. there will not be any travel time savings, or at least they will be much smaller than claimed) (Metz, 2008). In Great Britain, average travelling speed increased by 44% from 1972 or 1973 to 2009, yet the time spent travelling increased by 5% (Banister, 2011).

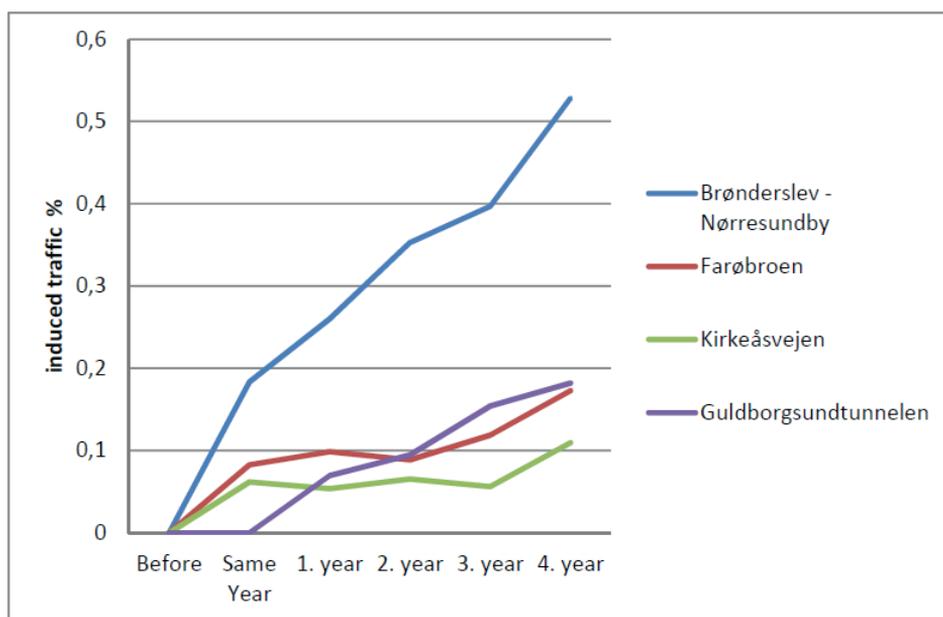


Figure 4. Development in induced traffic in the relevant transport corridors (after subtraction of the general traffic growth) subsequent to the project opening in year 0. Source: Twitchett and Nicolaisen (2013, p. 4)

Neglect of induced traffic and ignoring the deterrent effect of congestion on future traffic growth can render the cost-benefit analysis highly misleading. For example, as a result of using a traffic model that neglected induced traffic, the net present value of a planned new urban highway in Copenhagen (Nordhavnsvej) was calculated to be 2.16 billion DKK, compared with only 0.40 billion DKK if induced traffic had been taken into consideration. In the latter case, the initial congestion relief, and hence travel time savings, would have been substantially reduced as the new road filled up with additional cars.

4.3. Implications for external effects on health, safety and the environment

An obvious implication of underestimating induced traffic is that the estimated time savings will be incorrect: in urban areas they will probably be severely overestimated in many cases, whereas in rural areas the benefits may be underestimated. However, the external effects on health, safety and the environment included in the cost-benefit analysis will be affected too. These

are closely related to the traffic level, and such negative external effects will be systematically *underestimated* when traffic is underestimated, regardless of whether the time savings are overestimated or underestimated. Conversely, any calculated improvements in terms of health, safety or environment will be overestimated if traffic is underestimated. In some cases, a seemingly positive effect in this area may turn out to be negative when taking short-term and long-term induced traffic into consideration. The cumulative effect of traffic underestimations over the project's lifespan may be considerable and should not be ignored.¹²

Accidents

Apart from travel time savings and construction costs, impacts on traffic safety often feature as the most important among the remaining impact categories included in cost-benefit analyses of road construction projects. Usually, the impact of traffic accidents shows as having a positive economic value, reflecting a predicted decrease in traffic accidents due to the new infrastructure. Seen in isolation, such an effect could sometimes be expected (for example, due to the lower number of crossings when driving on a motorway). However, induced road traffic implies that more people will be exposed to the risks of traffic accidents. Moreover, since trips do not start and end on the slip roads of the motorway, but go from origins to destinations all over the city and the region, the increasing traffic caused by a new motorway will expose a larger number of people to the risk of accidents along local roads. These effects may well outweigh the lower safety risk per vehicle kilometre of motorways compared with other roads.

Moreover, new roads such as motorways and urban highways are often dimensioned and signposted for higher speeds than possible or allowed on other parts of the road network. This counteracts any risk reducing effects of avoiding crossings, and any accidents that occur are more likely to be fatal. If the forecast concerning traffic accidents is based on accident statistics for similar types of road schemes as the one proposed, these circumstances may already have been taken into consideration. However, since speed limits on

¹² It is sometimes argued that effect of induced traffic is small. That may be true when it comes to the monetary value of the consumer benefits caused by induced traffic, which are normally a small share of total consumer benefits, due to the decreasing demand curve and the 'rule-of-a-half'. However, the same argument cannot be applied to the external effects of induced traffic. There is no reason to believe that these curves are decreasing.

Norwegian motorways have been increased during recent years, the increased risk effects of higher speed levels on new roads may be underestimated if the forecasting models have not been updated accordingly.

Environment

Neglect of induced traffic implies that environmental impacts such as noise, CO₂ emissions, and local air pollution will be underestimated in cost-benefit analyses based on traffic model forecasts, and some other effects, such as severance, are not included at all. In the same way as for accidents, we often see that environmental effects are incorrectly presented in the cost-benefit analysis with a positive sign, indicating that the infrastructure investment *improves* the environmental conditions. For example, in a report from the Norwegian research and consultancy company SINTEF, the authors concluded that although some of the positive environmental effects of traffic that flowed more freely would be counteracted by induced traffic, they still recommended road capacity increase in congested urban contexts as a measure to reduce emissions (Knudsen and Bang, 2007). Moreover, according to the authors of the SINTEF report, restraining the capacity in the road network is an environmentally unsound measure to promote lower emissions from road traffic. In Denmark, several environmental impact assessments of proposed road building projects have likewise concluded that the impacts of the projects in terms of energy use and CO₂ emissions will be negligible, and the consequences in terms of noise and accidents will be positive (Næss et al., 2012). In some cases, such as the 2006 environmental impact assessment of the proposed Third Limfjord Crossing near Aalborg, the analysis predicted, in line with the above-mentioned SINTEF report, that the construction of a new motorway bypass road would reduce energy consumption and greenhouse gas emissions, alleviate noise, and help to reduce the numbers of traffic injuries and deaths (Næss, 2011). The conclusions from the above-mentioned SINTEF report and environmental impact assessment studies are sharply at odds with state-of-the-art knowledge about impacts of road capacity increases on traffic volumes (SACTRA, 1994; Noland & Lem, 2002; Strand et al., 2009; Litman, 2014).

5. Urban sprawl and implications

5.1. Urban sprawl as a phenomenon

As mentioned in the preceding chapter, the long-term induced traffic resulting from transport infrastructure construction leads to land use changes, particularly in the form of urban sprawl. There is no agreed upon definition of urban sprawl, but the concept is commonly understood as referring to urban spatial expansion characterized by low population density, inefficient use of land and fragmented patterns of development (Christiansen and Loftsgarden, 2011; European Environmental Agency, 2006).

According to a number of authors, metropolitan-level decentralization of workplaces and residences has been a strong and more or less general tendency in Europe (Breheny, 1995, Sieverts, 1999, Bruegmann 2008). According to the European Environmental Agency (2006), urban sprawl is a common phenomenon throughout Europe, although it has been less pronounced in Western Europe in recent decades than in the 1960s and 1970s (CDRC maps, 2016). In the post-communist East European countries, urban sprawl is still proceeding at a high pace (Schwedler, 1999; BBSR, 2016).

However, actual urban developmental trends in Europe are far more nuanced than has been claimed by the most ‘decentralization-deterministic’ debaters. In Sweden and Norway, the long period of spatial urban expansion after the 1950s has been succeeded by a trend of re-urbanization (concentration of new development within the existing urban space) in recent decades (Statistics Sweden, 1992; Næss et al., 2011). The population density within the continuous urban area of Greater Oslo increased by as much as 35% in the period 1985–2015, with a particularly high-density increase in its central parts (Næss et al., 2011; Statistics Norway, 2016). Similar densification processes have taken place in Trondheim, Stavanger, Bergen, and most of the other larger Norwegian cities. There is thus considerable scope for limiting and even reversing sprawl. Importantly, the ‘farewell to sprawl’ policy in Oslo and other Norwegian cities is to a considerable extent a result of effective planning policies aimed at urban containment (Næss et al., 2011). In the case of Oslo,

key land use policy instruments include a strong greenbelt policy (the Marka border) protecting the very popular outdoor recreation forests surrounding the city, a relatively restrictive national policy on farmland conversion, and central government policy guidelines for Coordinated Land Use and Transport Planning (Statlige planretningslinjer for samordnet bolig-, areal- og transportplanlegging) adopted in 1993 and updated in 2014. There has been a strong planning discourse promoting the compact city as a sustainable urban form. Case-specific natural, historical, cultural, and political conditions have also been important. A strong tradition of skiing and walking in surrounding forests has secured popular support for urban containment. The increased popularity of ‘cafe culture’ and urban living has contributed to a shift in housing preferences away from suburban single-family houses. Planning policies have promoted this cultural trend through densification, traffic calming, and aesthetic upgrading.

However, new highway construction in urban regions counteracts the policies aiming at more compact urban development. The land use impacts of road construction appear in a longer time-perspective than the initial induced traffic and they involve chains of mechanisms whereby road capacity expansions affect land use developments that in turn contribute to increased traffic volumes (Litman, 2014; Noland and Lem, 2002; Kasraian et al., 2016). Higher travel speeds by car allow for longer journeys to be undertaken within the same time budget as earlier. Improvements in the accessibility of outskirt locations enable households and businesses to move to locations that are more car-based locations and longer distances from the city centre. This increases the market demand for dwellings and commercial buildings at such locations and thus makes construction of housing, workplaces, and retail and other activities in peripheral, car-dependent and traffic-generating areas more attractive. Based on a commuting model simulation, Engebretsen and Gjerdåker (2012) estimated how a hypothetical upgraded and new road network, respectively, would increase the ‘attraction index’ of workplaces located in different parts of Norway. As illustrated in Figure 5, road construction leading to higher travel speeds is likely to increase considerably the geographical areas within which businesses recruit their staff. Logically, this implies longer average commuting distances. Whereas peripheral residents may thus increase their opportunities for finding jobs far away from home, their possibilities for securing local jobs will diminish, since local residents will increasingly have to compete for the local jobs with non-local applicants.

Policies to enable people to make longer commutes thus tend to lock more people into increasingly long commuting distances.

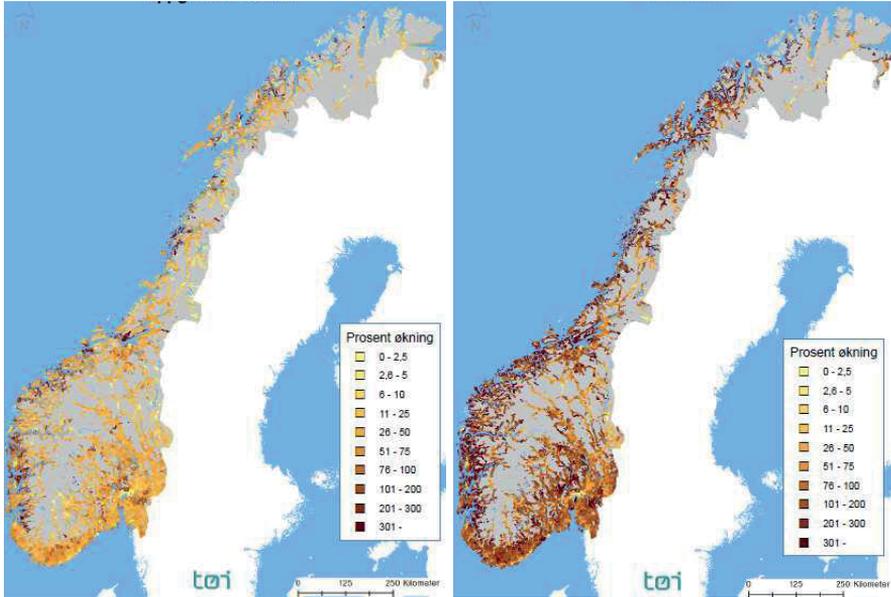


Figure 5. Percentage increase in attraction index for workplaces within a driving distance of 45 minutes by an upgraded road network (left) and new road network (right) road network. Source: Engebretsen and Gjerdåker (2012), pp. 25–26

In addition, the new roads themselves, together with, for example, the demand for more parking or additional lanes on other roads resulting from the extra traffic induced by the road project, take up space and push urban development outwards.

Although urban sprawl accounts for a considerable part of the long-term induced traffic, it is not the only part. Road construction, particularly in urban regions with some level of congestion, is also likely to make people accept longer travelling distances within the existing built environment, and they are thus likely to choose their place of residence, workplace, service facilities, and leisure opportunities more independently from each other. Some of these changes in location patterns within the existing built environment may take place within a short time after a new road has been opened (e.g. driving to a more distant shopping mall instead of using shopping opportunities closer to home), but other changes may be more long-term (such as changing to a job

located farther away from home, or moving to a dwelling farther away from the existing workplace).

In a longer term, additional traffic increase may occur due to reductions in the quality of public transport resulting from the initial loss of passengers triggered by road development (Mogridge, 1997). This reduced quality will in turn make car travel even more competitive compared with public transport.

5.2. Negative impacts of infrastructure-induced urban sprawl

The extent to which urban sprawl takes place depends on a number of different factors of influence, and it is possible to counteract, at least partly, the driving forces pushing towards urban sprawl if there is a strong spatial planning regime and political willingness to promote more compact and concentrated urban development. Nevertheless, highway development in urban regions tends to facilitate and encourage urban sprawl, and it will be a tougher task for planning authorities to counteract sprawl if much highway development takes place than if there were no road capacity increase (Litman, 2016). It should be noted that infrastructure-induced urban sprawl is an effect not only of road construction, but also of public transport investments (notably high-speed rail), making it faster and more convenient to travel from the outskirts of a metropolitan area to the city centre.

Since building densities are normally lower on the outskirts of an urban region than in its inner parts, and inner-city construction of dwellings and commercial buildings often takes place in areas that are already dominated by technical encroachments, such sprawls will entail a higher consumption of natural areas and/or farmland than would otherwise be the case. Apart from the land taken for constructing the road project, decentralized and low-density urban development will require the construction of more access roads and usually more parking space than if urban development were to take place as densification within existing urban areas. Such development entails direct economic as well as ecological costs.

Table 1, based on Litman (2016), shows some of the negative environmental impacts that road construction in urban area can generate by facilitating and encouraging urban sprawl.

Table 1. Indirect environmental impacts of road construction that facilitates urban sprawl. Source: Litman (2016, p. 2).

Increased Pavement Area	More Dispersed Development
<ul style="list-style-type: none"> • Reduced open space (gardens, parks, farmlands, and wildlife habitat) • Increased flooding and storm-water management costs • Reduced groundwater recharge • Aesthetic degradation 	<ul style="list-style-type: none"> • Reduced open space (farmlands and wildlife habitats) • Longer travel distances, increased amounts of total vehicle travel • Reduced accessibility for non-drivers, which is inequitable (unfair to disadvantaged people) • Increased vehicle traffic and resulting external costs (congestion, accident risk, energy consumption, pollution emissions)

Moreover, the building types typical for outer-metropolitan housing developments usually require more energy for space heating and cooling (both in total and per square metre of floor area) than new urban dwellings. Besides their increased energy use, low-density residential developments involve higher consumption of construction materials than apartment buildings (up to a certain number of stories), due to the larger amount of ‘building envelopes’ (roofs and exterior walls) per square metre of floor area for single-family houses than for apartment buildings and terraced houses. These construction materials often represent considerable embedded energy consumption, and they have sometimes been produced through processes involving serious encroachments on nature, biodiversity, and landscapes in the countries or regions from which they have been imported.

Although the sprawl generating effects of road construction are theoretically highly plausible, it has often been difficult to show these effects empirically, let alone to estimate their size. According to Litman (2016), it can be difficult to determine the exact land use impacts of a particular transport planning decision, especially its indirect, long-term consequences. Impacts depend on, for example, the relative demand for different types of development (greenfield versus densification), the degree to which a particular transport project will improve accessibility and reduce costs, land use policies and the

strength of the land use planning regime, and how a transport policy or project integrates with other factors. In a Norwegian context, Falleth (1999) found that there had been considerable urban development adjacent to a new main road in Sarpsborg, but the areas that had been built upon had already been set aside for urban development in the municipal land use plans. It was therefore hard to judge the direction of causality. Were the areas developed because the new road made it more profitable to build there, or was the road layout adapted to the municipal intentions about where to establish new areas for commercial development? A similar problem of identifying causality appertains to a Danish study (Hovgesen and Nielsen, 2005), which showed that a considerable amount of commercial and residential construction had taken place along the new E 45 motorway through Jutland in Denmark after its completion, but the authors were not able to demonstrate a causal influence.

The authors of a recent study of the Ålesund region encountered similar difficulties in disentangling the land use effect of highway construction (Tønnesen et al., 2016). Considerable urban development has taken place around a suburban second-order centre adjacent to the new road (in the Moa area), and previous industrial buildings in this area have been changed into offices or stores. However, this took place also in the decades prior to the opening of the new road. The geographical setting of this case made it difficult for Tønnesen et al. to compare it with other suburban areas farther away from the new road where urban development could have taken place instead. Due to the specific geographical setting of the Ålesund region, with the main city centre located at the end of a narrow peninsula, the suburban second-order centre is located closer to the centroid of all buildings in the region than the historical city centre. The new development in the Moa area therefore did not result in any increase in trip distances. The unsuccessful attempt to identify the sprawl effects of the road construction in the Ålesund case must, at least partly, be attributed to the choice of a very atypical geographical study area, as well as lack of data for the period before road construction.

However, occasional newspaper interviews with property developers have revealed examples of some of the mechanisms by which faster road connections contribute to urban sprawl (Figure 6). In an interview reported on 2 May 2014 in the newspaper *Tromsø*, a property developer in Tromsø stated that he was ready to build 750 new dwellings in a remote greenfield area on Kvaløya once the construction of a new bridge over the sound separating Kvaløya from the main urban area of Tromsø has been finally decided.

Similarly, a newspaper article in *Bergens Tidende* in 2015 reported that plots for a single-family housing development in the suburban municipality of Os had recently been sold for more than NOK 3 million in expectation of a planned, new four-lane motorway connection. According to the journalist, the anticipated new road development made it a more attractive prospect to settle in ‘exurban’ areas in the regions of Bergen, Trondheim, and Stavanger. Similar effects were anticipated by estate agents interviewed by Danish newspaper journalists in the wake of motorway construction bringing exurban villages closer to the city of Aalborg.

 <p>OS UTENFOR BERGEN — Her planer for 750 boliger</p> <p>CHERSKTSBILDE: Den røde ovalen viser området Nord-Gruppen vil bygge. Høyrytua er en i bildet og Kvaløya til høyre.</p> <h3>Har planer for 750 boliger</h3> <p>Med ny forbindelse mellom Tromsøya og Kvaløya vedtatt står Nord-Gruppen klar til å bygge inntil 750 boliger på Kvaløya.</p>	<h2>Firefelts motorvei gir prisstigning</h2> <p>Ny firefelts motorvei til Os kan løfte boligprisene ytterligere i den populære pendlerkommunen utenfor Bergen. Bedre veiforbindelse gjør det mer attraktivt å bosette seg utenfor storbyene både i Bergen, Trondheim og Stavanger.</p>
 <p>STORT OMRÅDE: Styreleder Ole Christian Salomonsen i Nord-Gruppen med kart om boligområdet som ligger bak ham, oppover i terrenget. Foto: Kjetil Vik Foto: Kjetil Vik</p>	<p>Anita Hoemsnes, Bjørn-Egil Mikalsen og Ingrid Bjørklund Publisert: 16.04.2015 – 21:52 Oppdatert: 17.04.2015 – 17:36</p> <p>f t in B ✉</p> <p>I Os utenfor Bergen solgte DNB Eiendom nylig en tomt til over tre millioner kroner. DNB-megler Anders Fosbæk Vangen tror han skal få solgt de to gjenværende til priser godt over 2,5 millioner.</p>

Figure 6. Newspaper clippings from *Tromsø* (left) and *Bergens Tidende* (right)

Whereas little research-based empirical evidence exists from a Norwegian context of the sprawl inducing effect of highway construction, some studies conducted in other countries have demonstrated such effects. Based on a

systematic review of recent empirical evidence from the USA, Europe, and East Asia, Kasraian et al. (2016) concluded that proximity to the road network was frequently associated with increases in employment densities as well as the conversion of land to a variety of urban uses, including commercial and industrial development. From a study conducted in the USA, the researchers calculated that the aggregate population of cities that were geographically central in 1950 would have grown by 8% between 1950 and 1990 if the interstate highway system had not been built, rather than declined by the observed 17% (Baum-Snow 2007). In Switzerland, Killer and Axhausen (2009) investigated how the size of the commuting regions changed during the period 1970–2005. A pronounced enlargement of the regions took place in that period, and both the number of employees commuting across municipal borders and the commuting distances increased sharply. According to Killer and Axhausen, the enlargement of the commuting regions was due to a number of sociodemographic and spatial factors, among which changed accessibility due to changes in transport infrastructure and land use was one of the most important factors. Land use changes have created longer distances between dwellings and workplace concentrations, whereas transport infrastructure development has made it easier to overcome these distances and has facilitated further dispersal of residential development and workplaces.

The sprawling urban development facilitated by infrastructure development reducing the ‘friction of distance’ within an urban region does not just induce more traffic in the corridor connecting the new peripheral housing or commercial areas with the central city. Due to the generally poorer public transport provision in the outer areas and the easier conditions for local car driving (e.g. in terms of uncongested local roads and ample parking possibilities), sprawl also contributes to increased car traffic to local destinations such as stores for daily necessities purchases, pre-schools, and schools to which children are escorted (Dovre and TØI, 2012). Such local car trips make up an additional contribution to the increased energy use and greenhouse gas emissions resulting from major transport infrastructure development in metropolitan areas.

5.3. Additional local infrastructure investments

Besides land consumption to accommodate new, peripherally located buildings, urban sprawl also requires the construction of local infrastructure such as water pipes, sewers, electricity lines, and access roads to connect the

new, peripheral developmental areas with existing settlements. Such constructions impose an extra cost on the local community (and ultimately the residents) due to a reduced opportunity to exploit economies of scale.

Only a few Norwegian studies have investigated the infrastructure costs resulting from different urban developmental patterns (e.g. Moen and Sigholt, 1970; Mønnesland, 1991; Jones, 1997). The conclusions are largely the same: both investment and operational costs in connection with roads, water pipes, sewers, electric cables, and other technical infrastructure are higher for dispersed urban developmental alternatives than for concentrated ones, simply because the length of each type of installation is greater in sprawling urban structures. This applies both to the major transport arteries and pipeline systems connecting different parts of the city and to the corresponding local installations in each separate developmental area. The findings of the Norwegian studies are in line with the conclusions of more comprehensive and more well-known international studies such as the 'Costs of Sprawl' studies carried out in the USA in the 1970s and 1990s (Burchell and Listokin, 1982; Burchell et al., 1998).

Often, outward urban expansion will also require the establishment of new pre-schools and primary schools, as well as other local public services. If the capacity of such social infrastructure within the existing urban areas is already fully utilized, the need to construct new pre-schools and primary schools will not represent any additional cost. However, if there is vacant capacity in the existing schools, the construction of new such buildings in sprawl areas will represent additional costs. Alternatively, new school bus routes will need to be established to connect the new peripheral residential areas to existing schools.

5.4. Reduced quality of public transport

An additional long-term negative impact of induced traffic caused by highway development in urban areas is the reduced quality of public transport due to reduced economies of scale (Downs, 1962; Thomson, 1977; Mogridge, 1997). Transport investments that make car driving easier will induce people to shift from using public transport to using cars, as discussed above in Chapter 4. This will erode the income base for public transport providers. Unless compensated through increased public funding, this will lead to reduced public transport services (e.g. in terms of less frequent departures, closure of some lines, and increased fares) (Mogridge, 1997). The companies may also cut back on maintenance and comfort, which is likely to increase the frequency of

technical problems and thus reduce the regularity and punctuality of the services. Reduced accessibility for non-drivers is a likely result of these mechanisms.

The point of departure for this argument is that the consequences of increased urban traffic in terms of travel speeds are the opposite for car traffic and public transport.¹³ Whereas increased car traffic will, as already mentioned, cause congestion and lower speeds on urban roads, higher patronage of public transport may facilitate more frequent departures (thus reducing waiting times) and/or establish a more fine-meshed network of public transport routes¹⁴ (reducing walking distances to stops and interchange times). Higher patronage could also create an economic surplus, enabling the transport company to invest in faster vehicles (with reduced driving times) and more comfortable vehicles. Public transport operators would thus gain economies of scale, contrary to the ‘diseconomies’ of scale that characterize an increased flow of cars on the road network.

If road capacity is increased, there will be less congestion for a given amount of traffic. Compared with public transport, car travel has thus become more attractive, and some travellers have changed from using public transport to driving. However, as this implies a decreased quality level of public transport, car drivers will tolerate higher levels of congestion before they shift to using public transport, because the alternative (public transport) is perceived as even worse. When the situation has stabilized, the modal split at which car and public transport is on average perceived as equally attractive is reached at a lower quality level for both car traffic and public transport than before the road extension. This counter-intuitive and paradoxical conclusion is often referred to as the Downs–Thomson paradox (Mogridge, 1997).

Moreover, urban sprawl, which is probably a long-term effect of highway development in urban regions, tends to reduce population densities within existing built-up areas and thus erodes the passenger base along existing public transport routes. Urban sprawl may also lead to the establishment of new bus routes offering basic public transport accessibility in remote residential areas where the number of passengers will be too low to generate high ticket

¹³ The argument mainly refers to public transport running on separate rights of way.

¹⁴ This may involve substantial investment if the track is fixed rail.

revenues. This will place additional strain on the economy of public transport provision and may lead to reduced services in other parts of the network.

5.5. Negative impacts on lifestyle and public health

Health effects are now being included in cost-benefit analyses, but only when they are positive. For example, if infrastructure for walking and/or cycling is built as part of a new road scheme, the better conditions for a physically active lifestyle resulting from the footpath or cycle path are taken into consideration as a positive health effect. However, road development first and foremost creates better conditions for car driving, tempting people to drive instead of using non-motorized modes. The negative health effect of mode switch from walking and cycling to car use is *not* normally included in cost-benefit analyses. These effects are difficult to measure and to price correctly, but we do not see any good reason why only the switch from car to walking or cycling should be included and not the mode switch that goes in the opposite direction.

One of the ramifications of the induced traffic resulting from road construction projects is that some people who previously cycled or walked to their daily destinations may find it significantly time-saving and convenient to drive after the opening of the new road scheme to the extent that they shift from non-motorized modes of transport to transport by car. This is probably even more likely to happen for commuting trips, since the deterrent effect of congestion is usually strongest in the peak periods. However, traffic that flows more freely can also make it more attractive to replace non-work trips on foot or by bike (e.g. for shopping) with car trips to more distant destinations. Furthermore, among those shifting from using public transport to transport by car, there will be a reduction in the distance walked to and from public transport stops.

Improved public transport in cities is also likely to attract new passengers among previous cyclists and pedestrians. For example, an impact analysis of a planned light rail scheme in Aarhus, Denmark, estimated that ca. 50% of the new public transport passengers generated by the new light rail service would be previous cyclists and walkers, 25% would be new travellers, and only 25% would be previous car drivers (COWI, 2010). By contrast, the new public transport passengers attracted among previous car drivers would be likely to increase their walking time due to the distances they would have to cover between home and public transport connection, between transport routes, and between their final transport stop and their destination. However, the net

result of improvements in urban public transport services is likely to be a somewhat reduced number of trips by non-motorized modes.

Transport infrastructure projects can affect public health negatively due to encroachments on landscapes and green outdoor recreation areas. This effect extends beyond what might be reflected in any assessment of ‘willingness to pay’ or ‘compensation demand’ in standard cost-benefit analyses. Such public health effects include impacts through changed levels of physical activity in outdoor recreation as well as impacts on mental health from loss of visually attractive amenities. Some Norwegian empirical evidence of such effects exists (Ihlebak et al., 2012; Skalleberg et al., 2015).

5.6. Sociocultural negative impacts

Transport infrastructure projects can affect the importance attached by people to their neighbourhoods and local communities, as well as the meaning and significance that residents and users attach to places. The projects can thereby also affect individuals’ conceptualizations of self (Hague and Jenkins, 2005).

Transport infrastructure projects can create barrier effects in themselves, splitting previously continuous local neighbourhoods. The barriers may be absolute (e.g. a railway or motorway without pedestrian bridges or underpasses or other types of roads crossing) or relative (e.g. a heavily trafficked road that is dangerous or difficult to pass outside a few traffic-light controlled crossings, and/or where the traffic lights are regulated to give priority to the traffic on the main road, resulting in long waiting times for those wanting to cross the road). Apart from making crossing more time-consuming and inconvenient, infrastructure that splits neighbourhoods in two tends to reduce the amount of contact between residents living on either side of the piece of infrastructure (NZ Transport Agency, 1997). Such severance can in turn develop into the perception of the road as a mental barrier dividing the former common neighbourhood into ‘us’ and ‘those on the other side’, as illustrated by Danish poet Dan Turell (1975) in his autobiography. As shown by Appleyard (1981), increased traffic on roads passing through a neighbourhood tends to reduce considerably the number of acquaintances and friends that people have in their local area. In an urban context, highway development can reduce social interaction along the road itself and along connected roads where induced traffic occurs.

In a broader and long-term perspective, transport infrastructure development (roads as well as public railways, airports, and others) that increases the general mobility level of society will tend to reduce people's ties to their local neighbourhoods. This is probably a particularly relevant effect of fixed links. Local meeting places disappear when the local store and post office closes down, and residents are forced to drive to the shopping centre kilometres away; after a while the residents will no longer know their neighbours and change their behaviour, such as starting to lock their doors. Increased mobility contributes to larger job markets and housing markets ('travel to work areas'). Increased mobility, together with a more specialized job market and diversified leisure interests, contribute to make people's patterns of acquaintances and friends interest based rather than proximity-based, thus weakening the local neighbourhood as a base for social contact (Pløger, 1995). Moreover, road development contributing to a higher share of trips being made by car means that trips where people who live in a neighbourhood can potentially make contact with each other (e.g. while waiting for the bus or metro, or on public transport vehicles) are replaced with trips where the drivers sit encapsulated in their cars. According to Putnam (2000), urban sprawl and road building have contributed to a reduction in the social ties between people. Putnam's analysis refers to the USA context during the last four decades of the 20th century, but the mechanisms described are probably also relevant to the Norwegian context.

Large spending on urban road capacity increases sends the signal that car driving is supposed to be an important and growing form of urban transport, also in the future, and that there is no urgency to change towards a 'sustainable mobility' paradigm (Banister, 2008). Also, by undermining the population base for public transport – and hence the level of, and perceived attractiveness of, public transport services (Mogridge, 1997) – urban road capacity increases can contribute to the development of a cultural norm according to which the car is increasingly seen as the 'normal' means of transport (Næss and Strand, 2012). The 'transport cultures' evolving in this way will probably exert a certain conformity pressure towards a travel behaviour in accordance with what is 'normal' (albeit probably not very strong, since 'dissidents' rarely risk any sanctions).

5.7. Lock-in effects, from freedom to necessity

Transport investments designed to increase mobility tend to increase the spatial separation between activities and create built environments and location patterns that require increased mobility. The physical entities of sprawling built environments and high-capacity road infrastructure represent large ‘sunk costs’ that might have to be written off within a sustainable mobility paradigm. Such spatial structures also contribute to shaping lifestyles, contracts, and mobility cultures that are incompatible with sustainable mobility. This makes it politically more difficult to implement policies aiming to promote a transition toward a sustainable mobility paradigm. Such potential lock-in effects also apply to schemes such as road pricing as well as to policies to concentrate population growth in an urban region around public transport nodes (Isaksson and Richardson, 2009).

Moreover, mobility as freedom tends, after some time, to turn into mobility as a necessity. In the short term, transport investment allowing faster travel may give accessibility benefits (but also negative environmental and safety impacts due to increased traffic volumes). However, in a longer term, the increased access to distant jobs that local residents may experience is counterweighed by higher competition for locally available jobs from non-local residents. Thus, increased travel speeds tend to not only make it possible but also necessary for people to travel over longer distances to carry out their daily and weekly activities. According to German sociologist Hartmut Rosa, the ‘social acceleration’ has several negative social and psychological effects and may alienate us from living the lives that we want to live rather than increase our freedom and opportunities (Rosa, 2015).

Again, we see an asymmetry, whereby the arguments for the wider benefits of road development leading to regional enlargement assume that people’s shopping opportunities and job options will generally increase since they can access such facilities within a wider geographical area. These arguments implicitly assume that shopping at the local store or working in the local labour market will still be possible. However, when a more or less self-sufficient community turns into a suburb of the nearest city, driving several kilometres each day may no longer be voluntary.

6. Underpriced environmental assets – greenhouse gas emissions

In a cost-benefit analysis of a transport infrastructure project, where impacts are, to the extent feasible, expressed in monetary terms, each impact can in principle be regarded as the product of a physical effect and a unit price (given that they are included in the model at all, cf. Chapter 3). Then, even if the physical environmental effects were complete and realistic (which is not the case, cf. Chapters 4 and 5), the impact might still be underestimated if the price per unit is too low. This is the topic of this chapter.

As noted in chapter 1, there are different valuation techniques available to measure external costs, which can be seen as equivalent to society's willingness to pay to avoid these impacts. In principle, we are searching for a 'true' price (or rather, a true price path throughout the lifespan of the project), and in an ideal world different valuation methods will converge and reveal this price. In practice, however, the result depends on the technique chosen, for example revealed preference techniques versus stated preferences techniques (it can be argued that only the latter is able to cover the total economic value including non-use values). In many cases, the only available solution is to use expert panels or the shadow price on political decisions, i.e. techniques not based on consumers' own preferences and therefore considered to be second-best solutions in a cost-benefit analysis.

A number of environmental effects, including greenhouse gas emissions, are included in the Norwegian analysis framework, many of them based on stated preference studies, and the prices are fairly updated (see Samstad et al., 2010). In the case of environmental goods, which often have high income elasticity *and* increasing scarcity on the supply side, we would expect the price paths to be high and sharply increasing over time. However, the prices used for environmental effects in transport project cost-benefit analyses are generally low in Norway, and far from reflecting our politicians' concern for the environment and the ambitious goals adopted, particularly for the reductions

in greenhouse gas emissions (GHGs). As noted by Welde et al. (2013), it is unclear why the environmental prices in Norway are also substantially lower than those used in cost-benefit analyses in our neighbouring country, Sweden.¹⁵ We are reluctant to claim that the Norwegian prices are ‘wrong’. Perhaps the Swedish calculation prices are influenced more by political objectives and therefore should not be interpreted as the Swedish population’s stated willingness to pay?

The term ‘underpricing’ in the section heading has been used to illustrate that the low value per unit explains why the cost-benefit analysis fails to take account of environmental impacts. However, as indicated above, it is not obvious that the problem should be solved by ‘manipulating’ the prices so that they become ‘politically acceptable’. Another solution might be, for example, to instead use a multi-criteria analysis including environmental and intergenerational equity as separate criteria, or to insert overall constraints on the total use of scarce natural resources. Possible solutions are discussed in Chapter 8.

6.1. Road projects and the climate

Underpricing may be a problem related to several impacts in a cost-benefit analysis. However, greenhouse gas emissions are a special case of underestimated costs of transport projects. A stable climate differs from most other environmental goods, principally in its global nature and in the serious and possibly irreversible effects of major changes. Furthermore, transport is a major source of greenhouse gas emissions, contributing to 26% of Norway’s total emissions covered by the Kyoto Protocol (2012). Road traffic accounted for the major part (19%) (Thune-Larsen, 2016). In addition to the direct emissions from the traffic, there are indirect emissions associated with the generation of electric power and production of fuel, vehicles, and infrastructure. With a traditionally strong relationship between GDP and transport volume, the basic scenario for the period 2010–2050 is a continued growth in transport volume of 50%. However, due to energy efficiency and the

¹⁵ The level of income is generally higher in Norway than in Sweden. Other calculation prices, such as the value of time, are therefore at the same level or *higher* in Norway than in Sweden. It may also be noted that the Swedish cost-benefit analysis includes volatile organic compounds in the monetary part of the analysis, whereas this effect is not priced in the Norwegian cost-benefit analysis (Welde et al., 2013).

trend towards a larger share of electric cars¹⁶, total emissions have not increased as much as the transport volume in recent years, but they will do so in the future unless more effective measures are implemented (Thune-Larsen, 2016).

Norway's ambition for 2030 is a 40% reduction compared with the 1990 level, followed by full carbon neutrality within 2050. According to the current national transport plan (National Government, 2013), by as early as in 2020, the transport sector should have reduced carbon emissions by 2.5–4 million tons CO₂ equivalents per year, relative to expected emissions. In particular, the growing transport demand following population growth in and around the largest cities is to be met by public transport, walking, and cycling, and *no growth in car traffic*. There seems to be a broad understanding among experts and policymakers that action must be taken to encourage modal shift and a general reduction in per capita transport volumes, in addition to investing in low-emission technologies. However, this is not reflected in the calculated price of greenhouse gas emissions. In Norway, the unit price used in road sector cost-benefit analyses is 250 NOK (2015) per ton, and will increase to 370 NOK by 2020 and to 930 NOK by 2050 (NPRA, 2014). This price level is based on an estimate from 2005 of the marginal abatement cost of fulfilling the Kyoto Protocol.¹⁷ The price in 2020 and 2050 is based on a prognosis for the future allowance price in the European Emission Trading System (EU ETS) for enterprises. EU ETS was launched in 2005 and is currently the largest carbon trading market in the world. Major parts of Norwegian emissions from power plants, manufacturing industry, offshore petroleum production, and aviation all fall within the scope of this system. However, emissions from the road sector are not covered. Unfortunately, the system has had major credibility problems. Partly due to the economic crisis in Europe, a large excess of quotas has been building up, leading to very low allowance prices (Kverndokk, 2016). A

¹⁶ It is important to be aware that electric cars are not zero-emission vehicles, although they do not pollute in the local environment where they are driving. For one thing, the production of the components that the car consists of requires energy use with its related emissions. Moreover, in the integrated Nordic (and to an increasing extent European) electricity market, a considerable proportion of the electricity used to load the batteries of Norwegian electric cars has been produced in power plants in other European countries fired by coal, oil or nuclear power.

¹⁷ It should be noted that the price given in the former NPRA guidelines from 2005 was 210 NOK, and thus the increase to 250 NOK in 2015 was very small and did not even cover the increase in the consumer price index in the period.

revision of the system, with fewer quotas, is planned after 2020, and the higher calculation price for 2050 reflects the assumption that European climate policy will become somewhat more ambitious over time and be reflected in the allowance prices. However, the effect of discounting will ‘eat up’ a large share of the expected growth, and no real price adjustment is assumed after 2050.

The consequence of using carbon prices at this low level is that greenhouse gas emissions rarely influence the results of cost-benefit analyses (Volden, 2013). Time savings will easily offset even large increases in greenhouse gas emissions, and traffic reducing measures will appear as profitable only to the extent that they generate other benefits (for example, investing in a public transport scheme may generate time savings for travellers), while the effect of avoiding emissions has a very limited economic value.

6.2. When there is no ‘correct’ price

In the absence of a global price of carbon reflecting the damage caused by emissions, it is not readily apparent which price one should have used in a cost-benefit analysis. If one follows the fundamental principle of a cost-benefit analysis (‘the Norwegian population’s willingness to pay’), greenhouse gas emissions caused by Norwegians are relevant only to the extent that they directly affect the welfare of Norwegian citizens. Since Norway is a very small country, this would imply a price very close to zero, and illustrates why Nicholas Stern, in *The Stern Review on the Economics of Climate Change*, described climate change as ‘the greatest market failure the world has seen’ (Stern, 2006, p. 8).

If we accept that a global perspective should be taken on this particular impact, we should seek to estimate the *global* marginal social cost of carbon. While this may be correct in theory, it would be extremely difficult to quantify in practice, and there are also serious ethical objections to such an approach – an attempt to estimate the global willingness to pay for emission reductions would certainly give low values, since those who are hardest hit by climate changes, at least in the short term, are people in poor countries.

Another complicating factor is that if there is a binding target or an agreement that determines total emissions, and given that it is adhered to, it can be argued that the emissions from a given project will not cause an increase in total emissions but will rather be matched by a reduction elsewhere in the economy.

The Norwegian White Paper NOU 2012:16 discusses relevant principles for valuation of greenhouse gas emissions in cost-benefit analyses. The committee recommended the use of implicit valuation, implying that the marginal abatement cost necessary to reach a given emission limitation target is estimated. It should be noted that the carbon price in this situation cannot be interpreted as the social cost of carbon, only as the abatement cost of fulfilling a given target. It will naturally depend heavily on the level of ambition that is inherent in the target.

The current CO₂ tax and quota structure for the private sector could in theory be seen as indicators of the government's climate ambitions. For example, a natural starting point for valuing emissions from car traffic could be the CO₂ tax on petrol (currently 410 NOK per ton). However, as noted in NOU 2012:16, the tax and quota structure is highly differentiated, and in many sectors reflects other considerations than the climate. In a cost-benefit analysis, a joint carbon price path should be applied to all emissions, to ensure cost-effectiveness.

Norway supports a target of limiting the increase in the global mean temperature to two degrees Celsius relative to pre-industrial levels. An international agreement to support this target was signed at the UN Climate Change Conference in Paris December 2015. This target seeks to account for future generations, and, according to Bye (2016), it is probably the closest we can get to a 'global marginal social cost of carbon'. Different international studies have used model computations and simulated the necessary carbon price path to obtain the two degree target. The results vary considerably, depending on assumptions in the models about, for example, the technological development or the discount rate used. On average, they start around 400 NOK per ton today and rise to more than 2100 NOK in 2050,¹⁸ which is significantly higher than the current path used by the NPRA. It should be noted that the traditional approach in these simulations has been to assume that the carbon price covers all emissions worldwide, and/or emissions can be traded worldwide (the cost-efficient approach). This is hardly realistic, and in a case where, for example, rich countries such as Norway must contribute more, the price will naturally have to be *much higher*.

¹⁸ 43 EUR in 2020, 68 EUR in 2030, and 235 EUR in 2050 (2009 prices), assuming an exchange rate of EUR 1 = NOK 9 (NOU 2012:16).

As noted in NOU 2012:16, if Norway is also subject to *domestic emission reduction targets* that are more ambitious than the international agreement, and if considered binding, the calculation price should be derived from the constraints resulting from such targets. Calculations from the central government working group Climate Cure 2020 have shown that a target to reduce domestic emissions by 12 million tons would be achieved with a joint price in the area of 1500 NOK (2004) per ton towards 2020. If companies that take part in the EU ETS market are kept outside, the price on remaining emissions (including emissions from the transport sector) increases to 3400 NOK.

We are not aware of any studies that have estimated the shadow price on sector-specific targets, such as the no-growth-in-car-traffic ambition. In principle, the shadow price can be calculated, and will obviously give an even higher price on carbon emissions.

In summary, there is no ‘correct’ price on carbon emissions, but most valuation principles discussed in the literature give a higher price than the one currently used. NOU 2012:16 recommends implicit valuation, whereby the carbon price is derived from international agreements or domestic political targets – the stricter the target, the higher the abatement cost. Similar recommendations were later given by the Green Tax Committee (NOU 2015:15). However, the committee responsible for the latter White Paper suggested that emissions covered by EU ETS should pay the allowance price (under the assumption that it will increase in the near future), and *all* other emissions (including emissions from road traffic) should pay a price determined by the domestic target.

6.3. The additional problem caused by discounting

In addition to the low monetary value set for greenhouse gas emissions and other environmental impacts, the importance of long-term environmental consequences is significantly downplayed due to the discounting rules of cost-benefit analyses. As noted by Barfod and Leleur (2012), this is an important philosophical and moral problem in the evaluation of long-term impacts. While there is a logic behind the assumption that a person prefers to receive money now rather than the same amount in the future (people are impatient, they face a risk of dying, and money obtained now can be invested to earn interest), the same logic cannot be applied to explain why the current

generation's consumption of a public good (such as a stable climate) is worth more than future generation's consumption of the same good.

Although lower discount rates for long-term impacts have recently been introduced in Norwegian cost-benefit analysis guidelines and in the UK (Ministry of Finance, Norway, 2014), the Norwegian discounting rules still imply that an impact occurring in 100 years from now will have a present value of only 4–5% of its non-discounted value. In most countries, much higher discount rates than those in Norway are used. Small (1998) noted that the effect of a climate disaster in 150 years, causing damage to a country of more than its gross domestic product, would – with conventional discounting – be equivalent to a very small cost today. Still, the discounting of future impacts of global warming places alternatives that generate high greenhouse gas emissions in a much more favourable light than would otherwise be the case, and may lead to the preference for such solutions rather than lower-emission alternatives. In principle, similar bias will also occur in relation to other long-term environmental consequences, such as loss of biodiversity and biological productivity due to local pollution, and the fragmentation of natural areas represented by transport infrastructure construction.

The problem could in principle be solved by using a price path for greenhouse gas emissions which is steep enough to outweigh the effect of discounting. As noted by the White paper NOU 1997:27, environmental goods typically have high income elasticity, combined with increasing scarcity, which may indicate a sharp increase in these values over time. An interesting observation is that early works on optimal pricing of exhaustible resources showed that it could imply an exponential price path over time (Hotelling, 1931). Further work on defining optimal price paths over time would be very useful for the development of theory as well as for practice. And clearly, such a price path should be faced by polluters in the economy, and not only be established for use in the cost-benefit analysis.

7. The distribution of the neglected and underestimated negative impacts

In this Chapter we discuss the ways in which many of the neglected and underestimated negative impacts identified in the previous chapters may have differential impacts, both spatially and socially. Such distributional effects are not defined as neglected and underestimated *real* impacts (cf. Figure 1), but they should be identified, described, and communicated to decision-makers as part of a project evaluation.

Below, we discuss some common distributional effects of increased traffic due to new transport infrastructure. However, it should be noted that the final distributional effects are very difficult to determine, not least because people will have, to a greater or lesser extent, the possibility to avoid a negative impact, although probably at a cost (e.g. people can buy a car or can move to another location).

Suburbanites versus inner city residents

One of the consequences of new urban major roads making it easier to drive from suburbs to the inner city is that more cars will drive through the inner-city streets. There will also be higher levels of noise and air pollution in the urban districts adjacent to the new or expanded roads (except those in tunnels). Since much of the traffic originates in suburban and exurban parts of the metropolitan area, the question of who benefits and who has to carry the burdens arises. At least in the short term, the travel speeds and convenience of the suburbanites will improve, while those living ‘downstream’, and in particular in the inner city, will become more exposed to noise, air pollution, and the risk of traffic accidents. In particular, if new roads pass through or feed into urban districts where the population is already exposed to poor local environmental quality, the road projects may contribute to increased social polarization and aggravate spatial segregation between privileged and marginalized population groups.

Car drivers versus public transport users

As discussed earlier, transport investments that make car driving easier will induce people to shift from using public transport to using cars. This will erode the income base for public transport providers and will lead to reduced public transport services.

Moreover, given budget constraints on the total spending on transport infrastructure projects, the money spent on road building can delay planned improvements in the public transport system or even prevent them from being implemented. The situation in the Oslo metropolitan area is one such example, as the more than 40 billion NOK proposed to be spent on an extension of the E18 motorway westward from the central parts of Oslo through the suburban municipalities of Bærum and Asker may lead to the postponement of the planned construction of a railway and a metro tunnel under the inner part of Oslo. Without these tunnels, the increase in the frequency of departures on the metro lines and commuter trains necessary to accommodate the politically desired rise in travel by public transport cannot be realized. Besides resulting in a higher share of car traffic than envisaged in the policy goal formulations, the spending of money on road building instead of public transport infrastructure is likely to lead to more crowded public transport vehicles and hence a lower level of comfort for the public transport passengers.

Creation of shadow areas

However, some *public* transport investments may also create undesired distributional effects. Since high-speed rail tends to replace rather than complement existing connections, the relative distance in terms of travel time from locations between the stops to the focal points may increase as the distances between the stops increase. Shadow areas will be created as certain local destinations become less accessible and in this sense more distant. The local effect of acceleration is then the social exclusion of those living in these shadow areas between stops, and may cause their resistance against being disconnected.

Selectivity of public transport provision

Internationally (especially in the USA), criticism has been raised against certain high-class, new, urban rail schemes because, under given budgetary constraints, they draw funding away from improvement to existing bus routes serving larger populations, including ethnic minorities and other low-income groups

living in less privileged urban districts (Garcia and Rubin, 2004), and contribute to socio-spatial polarization (Richardson and Jensen, 2008).

Local social and political impacts linked to decision-making processes

In addition to the impacts pertaining to the construction process per se, local populations may feel alienation and disempowerment due to lack of influence on disruptive changes in people's local environments. Some of the most important aspects of social impacts involve not the physical changes in a community or any relocation of human populations, but the meanings, perceptions, or social significance of these changes. From the time of the earliest announcement of a project or rumours about a project, hopes as well as hostilities can begin to mount. Speculators can lock up potentially important properties, politicians can manoeuvre for position, and interest groups can form or redirect their energies (Interorganizational Committee on Guidelines and Principles for Social Impact Assessment, 1994). According to a UN convention on strategic environmental assessments (SEAs), the public participation and consultations are an important element of an appropriately conducted SEA (United Nations, 2003). Especially, if such consultations have not been performed to a sufficient extent, the decision-making process and the construction phase may lead to alienation and disempowerment among local residents.

Future generations

The justification for discounting future consequences is based on expectations of continuous economic growth: if we will be ten times richer in the future, paying a cost of 1000 USD then will affect our welfare much less than if we pay the same amount of money today. This justification thus depends upon the highly contested assumption that growth can go on continually without running into environmental limits. Moreover, from a moral perspective, discounting rates can only logically apply when the people benefiting from a development are the same as the people suffering the costs. A motorway built today may give short-term benefits to contemporary car travellers, while the negative impacts of its contribution to global warming will mainly affect future generations, no matter how rich they might become.

House prices

The cost of renting or buying a house normally amounts to a large share of a family's budget. People's wealth will determine the house they can afford in

terms of type, size, and geographical area. Any consequences of a transport project on housing prices may therefore be highly relevant to planners and decision-makers. Urban sprawl is sometimes claimed to have a positive distributional effect in that it contributes to reduced pressure on housing prices in the city centre, as it will be possible for more people to buy a house at a lower price in the suburbs. In comparison, a policy to develop dense cities based on public transport ('sustainable cities') could lead to very high housing prices if the authorities do not adequately provide or facilitate the necessary growth in housing supply. It is important to consider such effects in land use and transport planning, to ensure affordable houses for the population.

As mentioned in Section 5.3, several studies have shown that urban sprawl is usually more costly for society as a whole than urban densification. When people looking for somewhere to live are faced with housing prices that have increased much more in inner-city areas than in suburban areas, this may justify redistributive measures such as heavy taxation on profits from sales of urban land and the use of such taxes to subsidize affordable inner-city housing.

8. How can the neglected and underestimated negative impacts be handled?

We have discussed various types of negative impacts of transport projects which are currently not being properly handled in cost-benefit analyses. The impacts discussed are of very different kinds. A distinction should be made between impacts which are ignored, or accidentally omitted, due to practical measurement problems or poor data, on the one hand, and impacts missing due to more fundamental weaknesses of the model on the other hand. The former type of impacts could, in principle, be included by investing in more or better data, or (minor) developments in transport models or valuation methods. The latter might call for more fundamental changes or completely different approaches.

For example, most of (but not all) disadvantages pertaining to the construction period could probably be included in the cost-benefit analysis with limited effort. The same is true for short-term underestimation of induced traffic. On the other hand, the disregard of political objectives, favoritism toward the present generation, and disregard of major risks (disasters and irreversible effects), are by nature more difficult to handle. Although the CBA is not designed for handling these aspects, the model could potentially be constrained or corrected in various ways. Alternatively, one may focus on other decision-support tools and analyses instead. Similarly, the ignorance of impacts in secondary markets, such as the long-term effects of urban sprawl, follow from inherent assumptions about perfect markets which do not hold in the real world. These impacts may potentially be quantified and included as add-ons to the effects obtained from the partial-equilibrium model, in the same way as is often suggested for the wider benefits. Alternatively, one may reject the partial equilibrium model altogether.

There are principally different views on what it means to ‘improve’ the basis for decisions. Some are of the opinion that all advantages and disadvantages of

a project should ideally be quantified and given a price-tag, so that alternatives can be ranked unambiguously. Others are less ambitious when it comes to pricing, and think that impacts can be described on different measurement scales or in qualitative terms, as long as they are recognized. A discussion of the pros and cons of monetizing, and the pros and cons of the CBA as such, is beyond the objective of this study. In this short chapter we will just outline (without concluding) some possible ways to reduce or mitigate the problems discussed earlier.

Further development in the transport model system¹⁹

Norway practices the use of a transport model system that includes national and regional passenger transport models and a freight transport model, to assess both the current level of traffic and the future level with and without intervention. As discussed in Chapter 4, these models have some serious weaknesses, particularly when it comes to estimating long-term induced traffic that follows from land use changes. Land use and transport are closely intertwined, such that transport models and land use models need to be integrated to capture all effects adequately, including the wider benefits and costs. There are also weaknesses when it comes to handling congestion in the network in a short-term perspective, but the NPRA is currently working on this part and the results are promising.

A recent development that should be mentioned is the land use and transport integration (LUTI) models, which assess the land use impact of transport schemes and provide a rigorous analysis of the demographic, economic, and transport impacts of land use proposals. LUTI models may be viewed as a means of improving traditional transport models by adding the element of location choices by households and businesses to the conventional transport model choices of destination, mode, and route. However, the extension comes at a price in terms of the complexity that makes their validation much more difficult (Wenban-Smith and Van Vuren 2009). Furthermore, it is not straightforward to use LUTI models as input to a cost-benefit analysis. The risk of double-counting has been discussed in relation to the wider benefits. When it comes to environmental costs, they will normally have to be computed 'on the side' anyway, and a LUTI model may provide more realistic

¹⁹ A more detailed presentation and discussion of the existing transport models used in Norway and the potential for developing LUTI models is given in Appendix 3.

input to such an assessment than an ordinary transport model.²⁰ Another obstacle, however, is that land use depends on politics, which vary from time to time and on the political regime in power. Furthermore, in Norway land use is heavily regulated, which makes it quite difficult to model it using LUTI models. However, assuming that land use is unaffected by major transport investment schemes is, in most cases, not realistic either.

Another type of model that is frequently discussed in relation to the wider benefits, is general equilibrium models, which ensure that supply meets demand in *all markets* simultaneously. Such models may also be given a geographical dimension, by modelling the transport market in the same way as markets for goods and services. Serious efforts have been made to develop spatial computable general equilibrium (SCGE) models to cover the wider benefits, particularly by allowing monopolistic competition instead of perfect competition, and by allowing for agglomeration effects. In principle, general equilibrium models should also include, for example, markets for land and ‘markets’ for environmental goods, so that all direct and indirect effects, positive as well as negative, are covered in the same model. However, our impression is that so far little has been done to develop the models in the ‘negative impacts’ direction.

It should never be forgotten that transport models are only models. It is de facto impossible to predict what will happen in a 40 year perspective, as this is highly dependent on political decisions (for example the choice to develop a ‘sustainable city’ would imply a very different path than following the ‘predict and provide’ paradigm). Næss and Strand (2012; 2015) have addressed this issue while arguing that transport models used to forecast future traffic should differ between the different levels of planning stages: operational, tactical, and strategic. They proposed that at the ‘strategic’ level of planning, scenario analyses may be more suitable than transport models.

Improved valuation – in real life and in cost-benefit analyses

Given that it is desirable to quantify as many impacts as possible and give them a monetary value so that alternatives can be ranked unambiguously, correct valuation is crucial. In Chapter 6, we have shown that the current carbon price

²⁰ However, as noted before, some environmental effects may be taken into account by the individuals (for example, when long-term effects in terms of noise and air pollution decrease people’s willingness to locate to certain areas), which might give rise to some double-counting on the cost side as well.

path is very low, whether seen in relation to the two degree target or to domestic emission reduction targets. It is beyond the objective of this study to propose more appropriate calculation prices for use in the cost-benefit analysis, and we therefore only point out that some of the problems discussed in this report would be mitigated with more correct prices (in this case probably a lot higher) on certain environmental impacts.

Correct pricing in the cost-benefit analysis is important, but correcting the prices *actually paid in the market* would be the first-best solution, which might remove the market failure altogether. More specifically, the prices people face should reflect the social marginal cost. If polluting and causing congestion is free of charge (or very cheap), this will naturally lead to inefficiently high levels of transport demand, and thus it may be difficult to explain to people that they do not ‘need’ a road capacity increase.

The Green Tax Commission recommended that taxes on emissions should be high enough to reach domestic emission reduction targets, and subsidy schemes with negative climate effects must be abolished (such as tax reductions for commuters, the tax-exempt rate on the use of privately owned cars for business travel, and the right to duty-free imports of alcohol and tobacco) (NOU 2015:15). This recommendation applies to all externalities. The Commission recommended that the price of road usage should reflect the social cost of accidents, congestion, and all kinds of environmental impacts, and it proposed new environmental taxes in areas in which environmentally harmful activities are not priced today, such as a new ecosystem service tax on land use changes to limit biodiversity loss.

Constraining the cost-benefit analysis

As noted in NOU 1997:27 and later public reports, there are, in principle, two ways of taking environmental impacts into account in a CBA – the first is to measure them in monetary terms, and the second is to constrain the analysis, for example by establishing ‘safe minimum standards’ that must be adhered to. These constraints can be set so as to ensure that, for example, intergenerational equity is taken into account.

Pearce et al. (2006) discussed the difference between sustainability assessment and cost-benefit analysis, and presented different ways to restrict the cost-benefit analysis to take future generations into account. One perspective starts from the assertion that certain natural assets, such as a stable climate are critical to the extent that they must be protected at some target level. This has

resulted in the idea of a ‘compensating project’, meaning that projects that cause environmental damage are ‘balanced out’ by projects that result in environmental improvements. The overall consequence is that projects *in the portfolio* maintain the environmental status quo.

Minken (2016) discussed how to introduce overall constraints on CO₂ emissions into the optimization problem formally, in the same way as there is a limited financial budget available. The constraints should apply to the portfolio level, more specifically the national transport plan. The problem to be solved is thus to maximize the net benefits of an investment plan by selecting projects within a given budget constraint *and* a given GHG emissions constraint. Although Minken (2016) formulated such a problem, he did not solve it.

Another solution may be to define a broader objective function in which profitability and/or economic efficiency is only one criterion, and another solution may be intergenerational equity. This was suggested in a methodological guidebook from an international research project on how to develop sustainable land use and transport strategies (Minken et al., 2003). More specifically, the authors suggested using a linear combination of two terms: economic efficiency, and an undiscounted term representing the annual benefits in a year far into the future. Environmental targets (as well as other crucial requirements) may also be included as separate criteria in the objective function or kept apart while making sure that only strategies that meet them are considered in the analysis.

Yet another (but related) approach is the attempt to develop composite decision-support systems by combining cost-benefit and multi-criteria decision analysis, including a process of a decision conference involving a high number of different stakeholders and decision-makers. The approach consists of a cost-benefit analysis part and a multi-criteria assessment decision analysis part, in which the result of the assessment is expressed as a total value based on both parts (Barfod and Leleur, 2012).

More careful treatment of non-monetary impacts

Some impacts are, by nature, not appropriate for economic evaluation because they are subjective, or well beyond reasonable expectations of methodological capture. In the current cost-benefit analysis framework used by the national public road authorities, there is also a set of non-monetary impacts, and some of the new impacts discussed in this report should probably be added to this

set. It is crucial that these non-monetary impacts are taken seriously by analysts as well as decision-makers, and that they are assessed in a sufficiently long-term perspective.

If one looks beyond the cost-benefit analysis, there is a broader field of different frameworks and approaches that have been developed to address the impacts of policies, plans, programmes, and projects in multiple sectors. We consider it useful to learn from these other methodologies, not least environmental assessments, when presenting and assessing impacts that remain as non-monetary impacts in the cost-benefit analysis framework.

The field of environmental assessment is itself a field of constant innovation, evolving as the conception of environmental impact is broadened to integrate social, sustainability, biodiversity, climate, and health considerations (Morgan, 2012; Pope et al., 2013; Kågström and Richardson, 2015). The common forms of impact assessments in the field are environmental impact assessment, strategic environmental assessment, social impact assessment, policy assessment, health impact assessment, and sustainability assessment (Pope et al., 2013).

In the field of environmental assessment, public participation is a crucial element. Participation is a legal requirement in environmental assessment, enforced in Europe by European Union Directives since 1985 (Commission of the European Community 1985; 2014). There are several reasons for this participatory approach. The first reason is that involving those directly affected by proposed developments allows for new knowledge to be accessed, which can lead to more informed decision-making. For example, understanding how transport developments impact on local communities can be partly measured and modelled (e.g. air pollution effects on public health), but some types of impacts will benefit from participatory inputs (e.g. assessing how a community might be affected by severance, or the significance of landscape impacts). The second reason is that involving the public in assessment processes plays a part in legitimizing that decision-making. This is partly due to the inherently value-laden nature of knowledge construction using tools such as environmental assessment (Richardson, 2005), which has led to calls for greater transparency through participation in all stages of the assessment process, and not only in information gathering. Thus, participatory environmental assessment is both about sensitizing it to alternative kinds of knowledge, but also about exposing assumptions and judgements, values, and choices to public scrutiny and debate. Much attention has been given to how assessment processes can be

made participatory. Issues at stake include whether participatory norms are actually followed in practice (Blicharska et al., 2011, Isaksson et al., 2009), and the extent to which knowledge generation within EAs is objective or value-driven (Richardson, 2005, Cashmore et al., 2010). Partly in response to such challenges, the environmental assessment field is continuously engaged with questions about how alternative and potentially incommensurate forms of knowledge – quantitative, qualitative, expert generated, informal, and indigenous – can be integrated into assessment processes. A critical issue for the field has been the tension between adopting approaches and methodologies that are open to multiple forms of knowledge, and those that are more closely aligned to the requirements of formal planning processes (Jay et al. 2007). In response, many different methods and analytical frameworks have been used, and the field can be recognized by its diversity in practices (Pope et al. 2013; Vanclay and Esteves, 2011 for social impact assessment; Harris-Roxas et al. 2012 for health impact assessment).

9. Conclusions

The point of departure for this study was the strong emphasis among stakeholders, planners, consultants, and academics on the *positive* impacts that might be neglected or underestimated in the current cost-benefit analysis framework. Our ambition was to draw attention to the fact that neglected or underestimated impacts may also be negative. There is much to suggest that those who commission cost-benefit analyses (and sometimes also those who perform them) may have an incentive to deliberately overestimate the positive impacts and underestimate the negative ones, in order to make the project appear as profitable (Samset et al., 2014; Kvalheim, 2015).

In this report, we have discussed the following four main categories of neglected and underestimated negative impacts:

- Disadvantages pertaining to the construction period
- Neglected environmental costs
- Induced traffic, urban sprawl, and negative implications
- Underpricing of environmental assets

The first category is expected to have a large impact on the economic profitability of the project. Most projects take years to implement, with adverse effects on accessibility and other disruptions to neighbourhoods and the local environment. It is difficult to understand why such effects are disregarded in the current framework, and not even mentioned among the non-monetary set of impacts. The other three categories are to a large extent about environmental costs. The second category (neglected environmental costs) includes certain impacts that are fully or partly disregarded in the monetary as well as the non-monetary part of the cost-benefit analysis. The third category is multifaceted and includes a number of different impacts that are related to induced traffic, including the negative impacts of ‘regional enlargement’, which are often referred to as ‘urban sprawl’. The fourth category includes underestimation caused by very low prices on certain impacts, of which we have particularly discussed greenhouse gas emissions. It is easy to see that the

combined effect of environmental effects being neglected, severely underestimated due to traffic being underestimated, *and* underpriced, may be substantial.

We have rather briefly outlined some possible ways to reduce or mitigate the problems and improve the basis for decisions. The solutions range from further improvements to the transport models and improved valuation, to constraining the analysis and focusing more on the description and assessment of those impacts that remain as non-monetary impacts in the framework. Ideally, of course, all shortcomings of the cost-benefit analysis (including those not discussed in this report) should be seen together when improvements in the model are discussed. Generally, when one weakness is corrected, there is often a risk of another weakness worsening.

Furthermore, the choice of solutions clearly depends on the *scope* of the various neglected and underestimated impacts. It is important to note that we have *not* made an empirical investigation of the various impacts, either relative to each other or relative to any positive impacts that might be neglected or underestimated. This should be the subject of future empirical studies.

References

- Algers, S. and Beser, M. (2002). 'SAMPERS—the new Swedish national demand forecasting tool'. In: Lundquist, S., Mattsson, L.-G. (Eds.), *National Transport Models: Recent Developments and Prospects*. Springer.
- Andersen, J. A. (2013). *The shaping of transport model based knowledge production: An embedded case study of Danish transport modelling practice in a contemporary and historical perspective*. Ph.D. thesis. Aalborg: Aalborg University.
- Andersen, S.N., Nilsen, Ø.L., Gutiérrez, M.D. and Tørset, T. (2016). *Impacts on land use characteristics from fixed link projects: four case studies from Norway*, European Transport Conference 2015, Transportation Research Procedia 13 (2016) pp. 145 – 154
- Arge, N., Homleid, T. and Stølan, A. (2000). *Modeller på randen: Bruk av transportmodeller i norske byområder—En evaluering* [Models on the Edge: Use of Traffic Models in Norwegian Urban Areas— An Evaluation] (Oslo: LOKTRA-prosjekt).
- Appleyard, D. (1981). *Livable Streets*. Berkeley: University of California Press.
- Banister, D. (2008). 'The sustainable mobility paradigm'. *Transport Policy*, 15 (3), pp. 73-80.
- Banister, D. (2011). 'The trilogy of distance, speed and time'. *Journal of Transport Geography*, 19 (4), pp. 950-959.
- Barfod, M. B. and Leleur, S. (2012). *Optimising Transport Decision Making using Customised Decision Models and Decision Conferences*. Lyngby: Technical University of Denmark.
- Baum-Snow, N. (2007). 'Did Highways Cause Suburbanization?' *Quarterly Journal of Economics*, 122 (2), pp. 775-805.

- BBSR (Federal Institute for Research on Building, Urban Affairs and Spatial Development) (2016). *Where the population in Europe is growing or shrinking*. Accessed April 27, 2016 at http://www.bbsr.bund.de/BBSR/EN/SpatialDevelopment/SpatialDevelopmentEurope/AnalysesSpatialDevelopment/Projects/PopulationDevelopment/PopulationDevelopment_node.html
- Blicharska, M., Isaksson, K., Richardson, T. and Wu, C.-J. (2011). 'Context dependency and stakeholder involvement in EIA: the decisive role of practitioners', *Journal of Environmental Planning and Management*, 54 (3), 337- 354.
- Boardman, A., Greenberg, D., Vining, A. and Weimer, D (2011). *Cost-Benefit Analysis*, 4th edition, Pearson
- Breheeny, M. (1995). *The compact city and transport energy consumption*, Transactions of the Institute of British Geographers, 20(1), pp. 81–101.
- Bremnes, H., Kristoffersen, S. and Sandsmark, M. (2011). *Evaluering av IKT-investeringer. Et forprosjekt*. Working paper M 1103 Høgskolen i Molde
- Bruegmann, R. (2008). 'Point: Sprawl and accessibility', *Journal of Transport and Land Use*, 1(1), pp. 5–11.
- Bruvold, A., Hernæs, Ø., Ibenholt, K., Vennemo, H. and Parmer, P. (2016). *Netto ringvirkninger i fire infrastrukturprosjekt*, Vista Analyse report 2016/01.
- Bull-Berg, H., Volden, G.H. and Grindvoll, I. (2014). *Ikke-prissatte virkninger i samfunnsøkonomisk analyse. Praksis og erfaringer i statlige investeringsprosjekter*, Concept report no. 38.
- Burchell, R. W. and Listokin, D. (eds) (1982). *Energy and Land Use*. New Brunswick, New Jersey: Rutgers University Press.
- Burchell, R. W. et al. (1998). *The costs of sprawl – revisited*. Washington D. C.: Transportation research board. Available at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_39-a.pdf
- Button, K. and Henscher, D. A. (2001). *Handbook of Transport Systems and Traffic Control*. Amsterdam/San Diego/Oxford/London: Pergamon/Elsevier.

- Bye, B. (2016). 'Samfunnsøkonomiske kostnader fra utslipp av klimagasser', chapter in Hagen, K.P. and Volden, G.H. (eds), (2016), *Investeringsprosjekter og miljøkonsekvenser. En antologi med bidrag fra 16 forskere*, Concept report no. 48.
- Cairns, C., Atkins, S. and Goodwin, P. (2002). 'Disappearing Traffic? The Story So Far'. *Proceedings of the Institution of Civil Engineers; Municipal Engineer*, 151(1), pp. 13-22.
- California Department of Transportation (not dated). *Temporary Effects During Construction Activities. Sacramento: California Department of Transportation*. Accessed December 2016 at <http://www.dot.ca.gov/dist4/sfobbdeis/deis4b.htm>
- Cashmore, M., Richardson, T., Hilding-Ryedvik, T. and Emmelin, L. (2010). 'Evaluating the effectiveness of impact assessment instruments: theorising the nature and implications of their political constitution', *Environmental Impact Assessment Review*, 30, pp. 371–379.
- CDRC maps (2016). *Dwellings: Modal Age*. Accessed April 27, 2016 at <http://maps.cdrc.ac.uk/#/metrics/dwellingage/default/BTTTTT/7/-2.1973/52.3555/>
- Cervero, R. (2001). *Induced Demand: An Urban and Metropolitan Perspective*. University of California, Department of City and Regional Planning, Berkeley. Accessed December 1, 2013 at <http://www.uctc.net/papers/648.pdf>
- Christiansen, P. and Loftsgarden, T. (2011). *Drivkrefter bak urban sprawl i Europa* (Driving forces of urban sprawl in Europe). TØI report 1134/2011. Oslo: Institute of transport economics.
- Commission of the European Community (1985). *Directive 85/337/EEC of the council of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment*.
- Commission of the European Community (2014). *Directive 2014/52/EU of the European Parliament and of the council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment*.
- Council of Europe (2016). *The European Landscape Convention*. Accessed February 22, 2016 at <http://www.coe.int/en/web/landscape/the-european-landscape-convention>.

COWI (2010). *Århus Kommune. VVM-redegørelse og miljørapport for Letbane i Århus-området - etape 1*. [Municipality of Aarhus. EIA report and environmental report for Light Rail in the Aarhus area – stage 1]. Kongens Lyngby: COWI.

Department for Transport (2014). *TAG UNIT A2.1. Wider Impacts. Transport Analysis Guidance (TAG)*, January 2014.

Department for Transport (2011). *Road Transport Forecasts 2011*.
<http://assets.dft.gov.uk/publications/road-transport-forecasts-2011/road-transportforecasts-2011-results.pdf>

Dovre and TØI (2012). *Kvalitetssikring av konseptvalg (KS2): Intercitystrekningene*.
https://www.regjeringen.no/nb/dokumenter/kvalitetssikring-ks1-av-konseptvalgutr-2/id712738/?regi_oss=90

Downs, A. (1962). 'The law of peak-hour expressway congestion'. *Traffic Quarterly*, 16 (3), pp. 393-409.

Duranton, G. and Puga, D. (2004). 'Micro-foundations of urban agglomeration economics'. In Henderson, J.V. and Thisse, J.E. (eds.) *Handbook of regional and urban economics*, pp. 2063-2118. Amsterdam.

Engebretsen, Ø. and Gjerdåker, A. (2012). *Potensial for regionforstørring* (Potential for region enlargement). TØI report 1208/2012. Oslo: Institute of Transport Economics.

European Environmental Agency (2006). *Urban sprawl in Europe: The ignored challenge*. Copenhagen: EEA.

Ewing, R. and R. Cervero (2010). 'Travel and the built environment'. *Journal of the American Planning Association*, 76, pp. 1–30.

Falleth, E. I. (1999). 'Suburban growth and land actors along by-pass roads in Norway'. *European Planning Studies*, 7 (3), pp. 357-371.

Feldman, O., Nicoll, J., Simmonds, D., Sinclair, C., and Skinner, A. (2008). 'Use of integrated transportation land use models in the wider economic benefits calculations of transport schemes'. *Journal of the Transportation Research Board*, 2076.

- Garcia, R. and Rubin, T. A. (2004). 'Crossroad blues: the MTA Consent Decree and just transportation', in Lucas, K. (ed.) *Running on empty: Transport, social exclusion and environmental justice*, pp. 222-256. Bristol: Policy Press.
- GESAMP (2014). *Sources, fate and effects of microplastics in the marine environment: part 2 of a global assessment*. London: International Maritime Organization, Joint Group of Experts on the Scientific Aspects on Marine Environmental Protection.
- Goodwin, P. and Noland, R. B. (2003). 'Building new roads really does create extra traffic: a response to Prakash et al.' *Applied Economics*, 35 (13), pp. 1451-1457.
- Graham, D. J. (2007). 'Agglomeration, productivity and transport investment', *Journal of Transport Economics and Policy* 41, 317-343.
- Graham, D., S. Gibbons and R. Martin (2009). *Transport investment and the distance decay factor of agglomeration benefits*. Working paper. Imperial College of London.
- Hagen, K. P., Pedersen, K. R. and Tveter, E. (2014). *Ringvirkninger fra Samferdselsinvesteringer. En utredning finansiert av Samferdselsdepartementets program for overordnet transportforskning*, SNF prosjekt nr. 2498.
- Hague, C. and Jenkins, P. (eds.) (2005). *Place identity, planning and participation*. London/New York: Routledge.
- Hansen, W. (2015). *Makroøkonomiske effekter av ferjefri E39 – en SCGE-modellanalyse*, TØI report 1411/2015.
- Hansen, W. and Johansen, B.G. (2016). *Beregning av netto ringvirkninger på utvalgte prosjekter. NTP 2018-2029*. TØI rapport 1471/2016
- Harris-Roxas, B., Viliani, F., Bond, A., Cave, B., Divall, M., Furu, P., Harris, P., Soeberg, M., Wernham, A. and Winkler, M. (2012). 'Health impact assessment: the state of the art', *Impact Assessment and Project Appraisal*, 30:1, 43-52.
- Heinzerling, L. and Ackerman, F. (2002). *Pricing the priceless – Cost Benefit Analysis of Environmental Protection*. Georgetown Environmental Law and Policy Institute, Georgetown University Law Centre, Washington, D.C.

- Heum, P., Norman, E.B., Norman, V.D. and Orvedal, L. (2012). *Tørrskodd på jobb. Arbeidsmarkeds-virkninger av ferjefritt samband Bergen-Stavanger*. SNF arbeidsnotat nr. 33-12
- Hills, P.J. (1996). 'What is induced traffic?'. *Transportation*, 23 (1), pp. 5-16.
- Hotelling, H. (1931). 'The economics of exhaustible resources', *Journal of political economy*, 39(2), 137-175
- Hovgesen, H. H. and Nielsen, T. S. (2005). 'Effekter af motorveje' (Effects of motorways). In Egebjerg, U. and Simonsen, P. (eds.), *Byen, vejen og landskabet: motorveje til fremtiden*, pp. 15-42. Aalborg and Copenhagen: Aalborg University ; KVL Center for Forest, Landscape and Planning; the Danish Road Directorate.
- Ihlebak, C., Aamodt, G., Aradi, R., Claussen, B. and Thoren, A-K. H. (2012). 'The association between urban green space and health in Oslo'. *Norsk Epidemiologi*, 22. Suppl. 1, p. 40.
- Isaksson, K. and Richardson, T. (2009). 'Building legitimacy for risky policies: The cost of avoiding conflict in Stockholm'. *Transportation Research Part A: Policy and Practice*, 43 (3), pp. 251-257.
- Isaksson, K., Richardson, T. and Olsson, K. (2009). 'From consultation to deliberation? Tracing deliberative norms in EIA frameworks in Swedish roads planning', *Environmental Impact Assessment Review*, 29: pp. 295–304.
- Jara-Diaz, S. (1986). 'On the Relation between User Benefits and the Economic Effects of Transportation Activities'. *Journal of Regional Science*, 26 (2), pp. 379-391.
- Jay S., Jones C., Slinn P., Wood C. (2007). 'Environmental impact assessment: retrospect and prospect'. *Environmental Impact Assessment Review*, 27: 287–300.
- Jones, K. (1997). *Drift og vedlikehold av teknisk infrastruktur. Variasjon i ressursbruk med bebyggelsestype i boligområder*. (Operation and maintenance of technical infrastructure. Variation in resource use across different types of housing areas.) Project report 1997:15. Oslo: Norwegian Institute for Urban and Regional research.

Kasraian, D., Maat, K., Stead, D. and van Wee, B. (2016). 'Long-term impacts of transport infrastructure networks on land-use change: an international review of empirical studies'. *Transport Reviews*, 36 (6), pp. 772-792.

Kenworthy, J. R. and Laube, F. B. (1999). 'Patterns of automobile dependence in cities: an international overview of key physical and economic dimensions with some implications for urban policy'. *Transportation Research Part A*, 33, pp. 691-723.

Killer, V., and Axhausen, K. (2009). *Änderungen in der Schweizischen Pendlerregionen*. Presentation to workshop Räumliche Erreichbarkeiten und die Dynamik der Pendlerverflechtungen in Deutschland und der Schweiz 1970-2005, March.09, Dortmund.

Knudsen, T. and Bang, B. (2007). *Miljømessige konsekvenser av bedre veier* [Environmental impacts from better roads]. SINTEF rapport STF50 A07034. Trondheim: SINTEF.

Kvalheim, E.V. (2015). *Kan man stole på samfunnsøkonomiske analyser? En gjennomgang av elleve analyser av prosjektet Stad skipstunnel*. Concept working paper.

Kverndokk, S. (2016). 'Økonomiske virkemidler i miljøpolitikken', chapter in *Investeringsprosjekter og miljøkonsekvenser*, Hagen, K.P. and Volden, G.H. (eds), (2016), *Investeringsprosjekter og miljøkonsekvenser. En antologi med bidrag fra 16 forskere*, Concept report no 48.

Kågström, M. and Richardson, T. (2015). 'Space for action: How practitioners influence environmental assessment', *Environmental Impact Assessment Review*, 54, pp. 110–118.

Laird, J.J. and Mackie, P.J. (2014). 'Wider economic benefits of transport schemes in remote rural areas'. *Research in Transportation Economics*, 47, 92 - 102 (11)

Litman, T. (2014). *Generated Traffic and Induced Travel. Implications for Transport Planning*. Victoria: Victoria Transport Policy Institute, <http://www.vtpi.org/gentraf.pdf>

Litman, T. (2016). *Evaluating Transportation Land Use Impacts. Considering the Impacts, Benefits and Costs of Different Land Use Development Patterns*. Victoria: Victoria Transport Policy Institute, <http://www.vtpi.org/landuse.pdf>

- Maat, K.; Van Wee, B. and Stead, D. (2005). 'Land use and travel behaviour: expected effects from the perspective of utility theory and activity-based theories'. *Environment and Planning B: Planning and Design*, 32, pp. 33-46.
- Mackie, P. and Preston, J. (1998). 'Twenty-one sources of error and bias in transport project appraisal'. *Transport Policy*, 5, pp. 1-7.
- Mackie, P., Jara-Diaz, S. and Fowkes, A.S. (2001). 'The value of travel time savings in evaluation'. *Transportation Research Part E*, 37 (2-3), pp. 91-106.
- Mackie, P., Worsley, T. and Eliasson, J. (2014). 'Transport appraisal revisited'. *Research in Transport Economics*, 47, pp. 3-18.
- Marte, G. (2003). 'Slow Vehicle Traffic is a more Attractive Alternative to Fast Vehicle Traffic than Public Transport'. *World Transport Policy and Practice*, 9 (2), pp. 18-23.
- Mehammer, B.S. (2016). 'Netto ringvirkninger av NTP-prosjekter: Hvor er effektene størst', presentation at NPRA seminar March 2016
- Melo, P. C., D. J. Graham and R. B. Noland (2009). 'A meta-analysis of estimates of urban agglomeration economies'. *Regional Science and Urban Economics*. Vol. 39, pp. 332-342.
- Metz, D. (2008). 'The Myth of Travel Time Saving'. *Transport Reviews*, 28 (3), pp. 321-336.
- Ministry of Finance (2014). *Prinsipper og krav ved utarbeidelse av samfunnsøkonomiske analyser mv.* [Principles and requirements pertaining to the preparation of social cost-benefit analyses etc.] Oslo: Ministry of Finance.
- Ministry of the Environment (2009). *Nature Diversity Act*. Act of 19 June 2009 No. 100 Relating to the Management of Biological, Geological and Landscape Diversity
- Minken, H. (2012). *Til debatten om samfunnsøkonomisk analyse i transportsektoren*, TØI-rapport 1198/2012.
- Minken, H. (2015). *Samfunnsøkonomisk ineffektivitet i transportsektoren*, TØI report no 1444/2015

- Minken, H. (2016). 'Project selection with sets of mutually exclusive alternatives', *Economics of Transportation* 6 (2016) pp 11-17.
- Minken, H. and Samstad, H. (2005). *Nyttekostnadsanalyser i transportsektoren. Rammeverk for beregningene*. TØI Report no 798/2005.
- Minken, H., Jonsson, D., Shepherd, S., Järvi, T., May, T., Page, M., Pearman, A., Pfaffenbichler, P., Timms, P. and Volde, A. (2003). *Developing sustainable land use and transport strategies. A methodological guidebook*, Deliverable from PROSPECTS (Procedures for Recommending Optimal Sustainable Planning of European City Transport Systems), TØI Report no 619-2003.
- Moen, K. O. and Sigholt, T. M. (1970). *Byplankostnader*. (Costs in urban planning.) NIBR-report 17. Oslo: Norwegian Institute for Urban and Regional research.
- Mogridge, M. H. J. (1997). 'The self-defeating nature of urban road capacity policy: A review of theories, disputes and available evidence'. *Transport Policy*, 4(1), 5–23.
- Morgan, R. (2012). 'Environmental impact assessment: the state of the art'. *Impact Assessment and Project Appraisal*, 30, 5-14.
- MOTOS (2007). *Transport Modelling: Towards Operational Standards in Europe*. MOTOS project EU. Handbook.
http://www.motosproject.eu/?po_id=handbook (Accessed December 18, 2009).
- Mønnesland, J. (1991). *Natur- og miljøvennlig tettstedsutvikling - en vurdering av økonomiske hindringer*. (Environmentally sound urban development – an assessment of economic obstacles.) NIBR Working Paper 1991:114. Oslo: Norwegian Institute for Urban and Regional research.
- Navrud, S. (2016). 'Miljøverdsetting. Verdsettingsmetoder og verdioverføring', in Hagen, K.P. and Volden, G.H. (2016). *Investeringsprosjekter og miljøkonsekvenser. En antologi med bidrag fra 16 forskere*. Concept report no. 48.
- Nicolaisen, M. S. (2012). *Forecasts: Fact or Fiction. Uncertainty and Inaccuracy in Transport Project Evaluation*. Ph.D. thesis. Aalborg: Aalborg University.

- Nicolaisen, M. S. and Næss, P. (2015). 'Roads to nowhere: The accuracy of travel demand forecasts for do-nothing alternatives'. *Transport Policy*, 37, pp. 57-63.
- Nielsen, O. A. & Landex, A. (2005). *Vejforbindelse mellem Lyngbyvej og Gittervej – et eksempel på Braess paradox*. Trafikdage på Aalborg Universitet, 2005.
- Nielsen, K. L. (2000). *Appraisal of large-scale transport infrastructure projects*. Unpublished Ph.D. thesis. Aalborg: Aalborg University.
- Noland, R. B. and Lem, L. L. (2002). 'A review of the evidence for induced travel and changes in transportation and environmental policy in the US and the UK'. *Transportation Research Part D: Transport and Environment*, 7 (1), pp. 1-26.
- Norwegian Environment Agency (2015). *Microplastics*. Downloaded February 25, 2016 from <http://www.environment.no/topics/waste/microplastics/>
- Norwegian Environment Agency (2014). *Sources of microplastics to the marine environment*, Norwegian Environment Agency (Miljødirektoratet).
- Norwegian Government (2013). *Nasjonal transportplan 2014-2023* [National transport plan 2014-2023]. Adopted by the Norwegian Parliament on June 18, 2013. Oslo: Norwegian Government.
- NOU 2012:16, *Cost-Benefit Analysis*, Official Norwegian Reports.
- NOU 2015:15, *Environmental Pricing – Report from the Green Tax Commission*, Official Norwegian Reports.
- NPRA/Statens vegvesen (2014). *Konsekvensanalyser, håndbok V712, veiledning*.
- NPRA/Statens vegvesen (2015). *Dokumentasjon av beregningsmoduler i EFFEKT 6.6*. Statens vegvesen rapporter, nr. 358.
- NRA/Jernbaneverket (2012). *Høyhastighetsutredningen 2010-2012 Konklusjoner og oppsummering av arbeidet i Fase 3. Del 1*. [The high speed rail report 2010-2012. Conclusions and summary from the work during Stage 3. Part 1.].
- NRA/Jernbaneverket (2011). *Metodehåndbok JD 205. Samfunnsøkonomiske analyser for jernbanen*. Versjon 3.0. Juli 2011.

- NZ Transport Agency (1997). *Social severance*. Research Report 080. Accessed February 22, 2016 at <https://www.nzta.govt.nz/resources/research/reports/80/>
- Nyborg, K. (2012). *The Ethics and Politics of Environmental Cost-Benefit Analysis*, Routledge.
- Næss, P. (2011). 'The Third Limfjord Crossing– a case of pessimism bias and knowledge filtering'. *Transport Reviews*, 31 (2), pp. 231-249.
- Næss, P. (2012). 'Urban form and travel behavior: experience from a Nordic context'. *Journal of Transport and Land Use*, 5 (2), pp. 21-45.
- Næss, P. (2013). 'Residential location, transport rationales and daily-life travel behavior: The case of Hangzhou Metropolitan Area, China'. *Progress in Planning*, 79 (1), pp. 1-50.
- Næss, P. and Strand, A. (2012). 'What kinds of traffic forecasts are possible? ', *Journal of Critical Realism*, 11 (3), pp. 277-295.
- Næss, P. and Strand, A. (2015). 'Traffic forecasting at 'strategic', 'tactical' and 'operational' level: A differentiated methodology is necessary'. *disP*, 51 (2), pp. 41-48.
- Næss, P., Næss, T. and Strand, A. (2011). 'Oslo's Farewell to Urban Sprawl', *European Planning Studies*, 19: 1, 113 — 139.
- Næss, P., Nicolaisen, M. S. and Strand, A. (2012). 'Traffic forecasts ignoring induced demand: a shaky fundament for cost-benefit analyses'. *European Journal of Transport and Infrastructure Research*, 12 (3), pp. 291-309.
- Næss, P., Andersen, J., Nicolaisen, M. S. and Strand, A. (2014). 'Transport Modelling in the Context of the 'Predict and Provide' Paradigm'. *European Journal of Transport and Infrastructure Research*, 14 (2), pp. 102-121.
- Pearce, D., G. Atkinson, P. Mourato (2006). *Cost-Benefit Analysis and the Environment. Recent Developments*. OECD 2006.
- Pløger, J. (1995). *Byliv og modernitet – mellom nærmiljø og urbanitet?* [Urban life and modernity – between local environment and urbanity?]. Doctoral thesis. Oslo: University of Oslo.

Pope, J., A. Bond, A. Morrison-Saunders and F. Retief (2013). 'Advancing the theory and practice of impact assessment: setting the research agenda'. *Environmental Impact Assessment Review*, 41: 1-9.

Porter, M. (1998). *Clusters and Competition*, Boston: Harvard Business School Press, 1998.

Putnam, R. D. (2000). *Bowling alone. The collapse and revival of American community*. New York: Simon and Schuster.

Rekdal, J., Larsen, O.I., Løkketangen, A. and Hamre, T.N. (2014). *TraMod_By Del 1: Etablering av nytt modellsystem*, Revidert utgave av rapport 1203. Rapport 1313. Møreforskning.

Richardson, T. (2005). 'Environmental assessment and planning theory: four short stories about power, multiple rationalities and the need for situated ethical judgement'. *Environmental Impact Assessment Review*. 25 (4) pp. 341-365.

Richardson, T. and Jensen, O.B. (2008). 'How Mobility Systems Produce Inequality: Making Mobile Subject Types on the Bangkok Sky Train', *Built Environment*, 34 (2), pp. 218-231.

Rosa, H. (2015). *Social acceleration: a new theory of modernity*. New York: Columbia University Press.

SACTRA (1994). *Trunk Roads and the Generation of Traffic*. Standing Advisory Committee on Trunk Road Assessment, UK Department of Transport. London: HMSO

SACTRA (1999). *Transport and the Economy*. London: Standing Advisory Committee on Trunk Road Assessment.

Sager, T. (2013). 'The Comprehensiveness Dilemma of Cost-Benefit Analysis', *European Journal of Transport and Infrastructure Research*, 13(3), 2013.

Samset, K. and Volden, G.H. (2013). *Investing for impact. Lessons with the Norwegian State Project Model and the first investment projects that have been subjected to external quality assurance*, Concept report no. 36.

Samset, K., Volden, G.H., Welde, M. and Bull-Berg, H. (2014). *Mot sin hensikt. Perverse incentiver – om offentlige investeringsprosjekter som ikke forplikter*, Concept report no 40.

- Samstad, H., Ramjerdi, F., Veisten, K., Navrud, S., Magnussen, K., Flügel, S., Kili, M., Halse, A.H. and Elvik, R. (2010). *Den norske verdsettingsstudien – Sammendragsrapport*. TØI report 1053/2010.
- Sasson, A., Nordkvede, M. and Reve, T. (2014). *Fergefri E39 – næringsøkonomiske gevinster ved fjordkryssing*, BI-rapport 3/2014.
- Schmidt, R. E. and Campbell, E. M. (1956). *Highway Traffic Estimation*. Eno Foundation for Highway Traffic Control, Saugatuck, CT.
- Schwedler, H. U. (1999). *Greenfield Development Versus Inward Urban Development—Challenges in Sustainable Development in Central and Eastern Europe* (Berlin: European Academy of the Urban Environment).
- Sieverts, T. (1999). *Zwischenstadt—zwischen Ort und Welt, Raum und Zeit, Stadt und Land*. (The between city—between place and world, space and time, city and countryside), *Bauwelt Fundamente*, 118, 3rd edition. Wiesbaden: Vieweg.
- Skalleberg, K., Raanaas, R. K., Thoren, A.-K. H., Tveite, H. and Aamodt, G. (2015). 'Access to Green Space in School Neighbourhoods and Self-Reported Health Among Norwegian Adolescents', in Egoz, S. (ed.). *Hva betyr landskapsdemokrati? - Defining Landscape Democracy*, pp. 70-71. (Conference Reader). Ås: Centre for Landscape Democracy, NMBU.
- Small, K. (1998). 'Project Evaluation', Working paper, Oct. 22, 1998, Dep. Of Economics, University of California, Chapter 5 in Gómez-Ibanez, J.-A., Tye, W. and Winson, C. (eds.), *Transportation Policy and Economics; A Handbook in Honor of John R. Meyer*, UCTC No. 379 (The University of California Transportation Center).
- Statistics Norway (2016). *Areal og befolkning i tettsteder (I)*, Tabell: 04859, Statistics Norway, Oslo, accessed March 26th, 2016 at <https://www.ssb.no/statistikkbanken/selectvarval/saveelections.asp>
- Statistics Sweden (1992). *Tätorter 1990. Befolkning och areal i tätorter och glesbygd. Reviderade uppgifter. Statistiska meddelanden Na 38 SM 9201*. Örebro: Statistics Sweden.
- Stern, N. (2006). *Stern Review on The Economics of Climate Change. Executive Summary*. HM Treasury, London.

Strand, A., Næss, P., Tennøy, A. and Steinsland, C. (2009). *Gir bedre veger mindre klimagassutslipp?* TØI report 1027/2009. Oslo: Institute of Transport Economics.

Sundt, P., Schulze, P.-E. and Syversen, F. (2015). *Sources of microplastic-pollution to the marine environment*. Report M-321. Oslo: Norwegian Environment Agency.

Tennøy, A., Wangsness, P. B., Aarhaug, J. and Gregersen, F. A. (2016). 'Experiences with Capacity Reductions on Urban Main Roads – Rethinking Allocation of Urban Road Capacity?' *Transportation Research Procedia*, 19, pp. 4-17.

The Interorganizational Committee on Guidelines and Principles for Social Impact Assessment (1994). *Guidelines and Principles For Social Impact Assessment*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Downloaded February 21, 2016 from http://www.nmfs.noaa.gov/sfa/social_impact_guide.htm

Thomson, J.M. (1977). *Great cities and their traffic*. London: Gollancz.

Thune-Larsen, H. (2016). 'Klimaproblemer og bærekraftig transport', in Hagen, K.P. and Volden, G.H. (2016), *Investeringsprosjekter og miljøkonsekvenser. En antologi med bidrag fra 16 forskere*. Concept report no. 48

Turell, D. (1975). *Vangede Billeder* [Vangede pictures]. Copenhagen: Gyldendal.

Tveter, E. (2015). *The link between the functional employment density and productivity in Norway*, Oct. 2015 Research gate.

Tveter, E. (2016). *Forsøk på estimering av agglomerasjonseffekter fra samferdselsinvesteringer*, presentation at NPRA seminar, March 2016

Twitchett, C. and Nicolaisen, M. S. (2013). 'Trafikspring [Induced traffic].' *Trafik og Veje*, (8), 7-9.

Tønnesen, A., Tennøy, A. and Gundersen, F. (2016). *The effects of urban road capacity expansions*. Paper for the European Transport Conference 2016, 5-7 October 2016 in Barcelona.

Ulstein, H., Skogstrøm, J.F.B., Aalen, P. and Grünfeld, L.A. (2015). *Produktivitetseffekter av Ferjefri E39*, Menon report, 2015.

United Nations (2003). *Protocol on Strategic Environmental Assessment to the Convention on Environmental Impact Assessment in a Transboundary Context*. Ukraine: Kiev.

Vanclay, F., Esteves, A.M. (2011). *New Directions in Social Impact Assessment: Conceptual and Methodological Advances*. Cheltenham: Edward Elgar.

Venables, A. J. (2007). 'Evaluating Urban Transport Improvements - Cost-Benefit Analysis in the Presence of Agglomeration and Income Taxation'. *Journal of Transport Economics and Policy*, 41 (2), 173-188.

Verschoor, A., L. de Poorter, E. Roex, E. and B. Bellert (2014). *Quick scan and Prioritization of Microplastic Sources and Emissions*. RIVM Letter report 2014-0156.

Volden, G. H. (2013). *Use of Carbon Prices in Cost-Benefit Analysis Practices in Project Appraisals of Major Public Investment Projects under the Norwegian State Project Model*. Concept report no. 37. Trondheim: Norwegian University of Science and Technology.

Welde, M., Eliasson, J., Odeck, J. and Börjesson, M. (2013). *Planprosesser, beregningsverktøy og bruk av nytte-kostnadsanalyser i vegsektor. En sammenligning av praksis i Norge og Sverige*, Concept report no. 33.

Wenban-Smith, A. and Van Vuren, T. (2009). *Using transport models in spatial planning. Issues from a review of the London land-use/ transport interaction (LUTI) model*. Paper presented at Association for European Transport and contributors 2009. <http://webcache.googleusercontent.com/search?q=cache:RobQZeQb9NwJ:astracts.aetransport.org/paper/download/id/3305+&cd=4&hl=no&ct=clnk&gl=no>

Appendix 1: Common critique against the cost-benefit analysis

The cost-benefit analysis as basis for public sector decisions is criticized from several perspectives. Some of the most commonly mentioned weaknesses are summarized below. Here, we focus on general issues, not issues related to transport sector models and practices only.

Controversial value judgements

As noted by Nyborg (2012) and Heinzerling and Ackerman (2002), cost-benefit analysis is not 'value-free'. The cost-benefit analysis normally postulates (explicitly or implicitly) a utilitarian social welfare function, defined as the sum of all individual utilities, where utility is measured in terms of willingness to pay. However, Nyborg showed that although each individual's willingness to pay is proportional to their (unobservable) utility change, it is not generally true that the *sum* of individuals' net willingness to pay will rank alternative projects in the same way as the aggregate utility change. There is simply no generally accepted method to measure cardinal and interpersonally comparable utility. However, it is reasonable to believe that the marginal utility of income is declining in income. This should imply that more weight is given to poor people's willingness to pay. The cost-benefit analysis does the opposite, namely gives more weight to rich than poor people's utility changes.²¹

²¹ The problem can be handled by adjusting the various effects identified in the cost-benefit analysis directly via distribution weights, whereby, for example, effects on low-income families, certain geographic regions, or specific age brackets are attached more weight in line with society's preferences. However, the use of distribution weight is difficult in practice, it requires highly detailed data, and can at best be used for the first-order effects (direct effects), despite the fact that the final distribution should be examined. NOU 2012:16 recommends that distribution weights should not be used.

Distributional issues and conflicts of interest

It can be argued that efficiency and distribution should be separated, and that the cost-benefit analysis only measures efficiency. However, cost-benefit analysis is based on the Kaldor-Hicks efficiency criterion, which states that a scheme is an improvement to society if, *hypothetically*, those who are made better off could have compensated those who are made worse off and still be better off themselves after having done so. It is assumed that redistribution is taken care of through the tax system and not through the projects. However, this is not very realistic in real democratic decision-making processes. As noted by Nyborg (2012), actual and hypothetical Pareto improvements are fundamentally different, and conflicts of interest should not be disregarded in actual projects. Most guidelines for cost-benefit analysis therefore suggest that the analysis should be supplemented by a presentation of how costs and benefits are distributed, in addition to the net present value.

The discount rate and future generations

A further ethical problem that we face when performing a cost-benefit analysis and use it as a tool for decision-making is the serious *intergenerational* equity problem that it creates. Discounting future net benefit flows has a strong foundation in individual behaviour: individuals prefer to consume now rather than later, and financial markets set a price on obtaining money now rather than later. However, in the case of infrastructure investments, it is problematic to allow members of the current generation, who make the decisions, to downgrade the welfare of future generations systematically. More generally, there is no guarantee that a 'profitable' project is acceptable from a sustainability perspective. On the contrary, the discounting may make long-term environmental problems 'disappear', despite the fact that they can be both severe and irreversible.

Some economists have proposed to solve this problem by using a low and/or falling discount rate over time, yet this may lead to adverse effects on saving. Others have suggested supplementary requirements to ensure that environmental assets are upheld over time, but as noted by Pearce et al. (2006), it is not clear how to apply such criteria to single projects. An interesting contribution, therefore, has been made by Minken (2016), who suggests that the key is to use constraints not on single projects, but on the project portfolio, such as the national transport plan. Other researchers have argued that sustainability can be ensured by defining a broader objective function in which economic efficiency derived from cost-benefit analysis is only one

indicator, and impacts for future generations can be another (Minken et al., 2003). To our knowledge, this approach has not been much used in practice.

Disregard of market inefficiencies

The assumption of perfect competition and constant returns to scale may give rise to fundamental problems. The cost-benefit analysis is a partial equilibrium model as opposed to a general equilibrium model. This means that it computes the benefits and costs in the markets directly affected by the project. Direct effects will eventually be transferred to other markets, where price changes in secondary markets may be experienced as ‘pecuniary externalities’. Assuming an economy without market failure, all such indirect effects are just transformations of the direct effects and thus already captured by a well-specified cost-benefit analysis (see Small, 1998 or Jara-Diaz, 1986, for a detailed discussion).

However, if markets are *not* efficient, the allocation in the economy is not efficient in the first place. If an investment project reduces the adverse effect of a market failure, there may be an added value that is not captured in the cost-benefit analysis. Similarly, the effects could be negative if the project creates or increases a market failure. The potential for such effects has mainly been noted for transport investments, in the case of external economies of agglomeration, reduced monopoly power, and increased labour supply in an economy with tax wedges. However, in principle, such wider impacts could also be relevant in other sectors (see Bremnes et al., 2011 for a discussion of the possible wider benefits of ICT projects).

Biased estimates

In textbooks, cost-benefit analysis is often implicitly referred to as an appraisal performed by a ‘value-free’ analyst or researcher, while in real life the analysis is often commissioned and sometimes performed by stakeholders in the project or scheme to be assessed. Mackie and Preston (1998) listed 21 sources of error and bias in transport investment analyses, and concluded that appraisal optimism was the greatest risk.

This critique does not only apply to the cost-benefit analysis, but rather to all types of project appraisal tools. However, it is commonly believed that the CBA as a quantitative tool is more ‘objective’ than qualitative assessments. This is, of course, not true, as the results are based on a wide range of assessments and assumptions that are highly subjective. The mere complexity

of the method and the lack of transparency make it difficult to reveal such bias.

Measurement difficulties

Stated preference valuation techniques have been critiqued for allowing ethical and political values to influence the results, which makes it difficult to interpret them as self-centred consumer benefits (Nyborg, 2012, Sager, 2013). This raises the question of double-counting and creates doubt about how cost-benefit analysis results are to be interpreted. Furthermore, such valuation studies are verytime and resource consuming, which leads to pressure to use outdated or inappropriate values from other studies (Heinzerling and Ackerman, 2002). However, in recent years, progress has been made regarding the valuation methods themselves and the value transfer techniques, and some authors paint a fairly positive picture of the potential for using monetized environmental impacts in cost-benefit analyses (Navrud, 2016).

Unpriced is ignored?

As noted by Heinzerling and Ackerman (2002), not all impacts *can* be fully priced, even with the best valuation techniques. Cost-benefit analysis takes an anthropocentric view of social welfare, which means that nature and animals do not have intrinsic value, and effects on them are only relevant to the extent that humans have a willingness to pay to protect them. Even then, only the stated preference methods are able to capture the total economic value of environmental goods, including for example option values, existence, and conservation values, whereas other methods measure only the direct user values.

In principle, impacts that cannot be priced should be included and assessed as non-monetary impacts in the cost-benefit analysis. However, in practice, it is difficult to avoid the tendency that such impacts are neglected. Furthermore, as shown by Bull-Berg et al. (2014), the non-monetary part of the appraisal often has serious methodological weaknesses.

The comprehensiveness dilemma

As an increasing number of impacts have been priced and included in the cost-benefit analysis over time, due to new methods for eliciting preferences, the analysis has become more complete (which may be a positive development in light of the previous argument). However, the interpretation of the results has become more problematic, with different prices used in the analysis based on

different valuation methods, some of which can be interpreted as pure consumer values and others as influenced by the respondents' ethical and political values. According to Sager (2013), there is a 'comprehensiveness dilemma', meaning that planners must choose between a narrow cost-benefit analysis making good economic sense, but being incomplete, and a comprehensive cost-benefit analysis that lacks a clear interpretation.

Appendix 2: A critical view on the wider benefits

What are the wider benefits²²

The cost-benefit analysis is a partial equilibrium model that computes effects for economic agents in the primary markets, in this case the transport markets. However, the transport markets are closely linked to other markets, and improvements in the transport infrastructure will normally lead to changes in production and sometimes prices in these markets. For example, better transport infrastructure in a certain district may lead to higher rents and/or property values in the same district, and subsequently to higher prices on retail goods. Another example is when employees choose to work longer hours due to time savings. Then, their income will increase and they will spend it in markets for goods and services, where in turn production will increase (assuming that people are free to choose their working hours and that wages and other prices are set in a free market). These changes in local prices are termed pecuniary externalities. However, in complete markets, they do not involve *real* externalities, but are rather transformations and redistributions of the direct impacts. Adding them to the direct impacts would therefore be double-counting; what one party gains, someone else loses.

Only in a situation in which there is market failure in the secondary markets, *and* in which the transport investment reduces its adverse effects on the economy, may there be a value that is additional to transport user benefits. Examples of market failure are externalities (positive or negative), imperfect competition, taxation, transaction costs, and asymmetric information.

The literature has identified four main types of wider economic benefits that may occur in relation to transport projects:

(1) *Productivity and economies of scale (agglomeration)*

²² This section is mainly based on NOU 2012:16

Economic geography has provided insights into the mechanisms that can explain geographical concentrations of economic activity. Alfred Marshall wrote about the economies of scale in cities (agglomeration effects) more than 100 years ago, and noted that some benefits in cities are external to each firm and each individual, but internal to the city. A number of different drivers contribute to such agglomeration effects: cost sharing (sharing a local infrastructure and intermediate inputs), better functioning labour markets (matching and pooling), specialization and variability, knowledge in networks, technological spill-overs, entrepreneurship, and innovation. Typically, a distinction can be made between the following:

- a. agglomeration effects within a particular value chain (cluster effects)
- b. agglomeration effects that arise from urban scale or city size in general.

An investment in transport infrastructure that increases the effective or functional city size may in theory generate such positive external effects, which are not taken into account by firms and individuals.

(2) The wider benefits of increased labour supply

In the case of distorting income taxes, the market agents may not take into account the full benefits of an increase in their labour supply. Therefore, if travel time savings result in increased working hours, the increase in production will exceed the additional income received by the individual. The difference, which equals the income tax, is a wider benefit.

(3) Production changes in markets with imperfect competition

Markets may be characterized by imperfect competition, implying that producers charge a price in excess of marginal cost. In such cases, the total production will be inefficiently low. If improved transport triggers competition and increases production in such markets, it will be a benefit to society, which the firms themselves do not take into account. However, this effect is only relevant in sheltered sectors with an elastic demand and a high mark-up ex ante, and in which the transport cost constitutes a considerable share of producers' total cost.

(4) Interaction between transport services and land use

A transport project may result in price changes in the property market. If the scheme facilitates urban development as areas previously used for transport are

released (for example, when a new tunnel releases land that the road previously occupied on the surface), the value of the developed area (net of the development costs) will in principle be a wider benefit and not merely a distributional effect. It could also be argued that, in opening up for increased densification and hence less need for urban spatial expansion, such a development would reduce some of the ‘costs of sprawl’ that we discuss in this report. However, NOU 2012:16 notes that *if* this effect is triggered by enhanced productivity, it is already included in the wider benefit (see (1) above), and should not be counted twice.

Attempts to measure the wider benefits

Empirical studies focus primarily on the potential for regional enlargement understood as an increased number of households with an acceptable travel distance to the city centre (i.e. (1a) above). Some researchers have tried to find a correlation between infrastructure and a long-term increase in the labour supply (see (2) above), but such an effect has proven difficult to document. In the case of (3) and (4), there is even greater uncertainty and lack of empirical documentation.

Although the correlation between city size and productivity is well documented, it has proven difficult to measure any causal relationship between them, and even more difficult to separate the effects of the various drivers.²³ The results of different studies depend critically on what is measured (the definitions of productivity and agglomeration vary and are not consistent across different studies) and on model specifications and assumptions. Most studies seem to focus on the ‘general’ type of agglomeration effects and not the cluster effects taking place in specific value chains. Examples of influential contributions to measure the former type are the publications by Venables (2007) and Graham (2007), while Porter (1998) made an influential contribution to the understanding cluster effects.

Different models seek to explain how proximity between agents, most often expressed by a measure of ‘functional city size’, may influence productivity in the city, measured by, for example, average wage level. When generalized transport costs decrease, firms and individuals will travel more and longer

²³ See Duranton and Puga (2004) for an overview of these mechanisms.

distances, within the city centre as well as to and from other areas, and thus the functional city size increases.

An important parameter when determining the effective city size is the ‘distance decay factor’, which accounts for how interactions with the city centre decline with increasing distance from it. There is much to suggest a rapid decline; for example, Graham et al. (2009) found that the effects of employment in one area on productivity in another area declined by more than the inverse of the distance between the two areas.

There is also much focus in the literature on the elasticity of productivity with respect to the measure of functional city size (e.g. see Melo et al. 2009 for a review of available research in this area). Melo et al. (2009) report an average elasticity of 0.058, which suggests that if the functional city size (measured by the number of residents) increases by 1%, productivity in that city will increase by 0.058%. Estimates seem to vary widely between countries, between sectors, and in how functional city size is measured. According to NOU 2012:16, it appears that the correlation between city size and productivity is stronger in the UK than in other countries, for unknown reasons. For example, findings from Sweden show a weaker correlation than in the UK.

In the UK, the Department for Transport (DfT) has been a driver in developing the methodology for measuring the wider benefits, and the majority of studies are carried out on UK data. The DfT has also developed guidelines on how to estimate the wider benefits, including types (1)–(3) mentioned above. The latest version of the guidelines was published in 2014 (Department for Transport, 2014). However, the DfT points out that there is great uncertainty about these effects, and they should only be considered if a scheme is likely to increase accessibility in an area in close proximity to an economic centre or large employment centre. Analyses of wider benefits have been made for a few very large transport projects, such as Crossrail and HS2 high-speed rail, and in these cases they have been shown as considerable.

In principle, a general equilibrium model that comprises various forms of market failure would be the ideal solution to deal with any wider impacts of transport investments. Work has been conducted nationally and internationally to expand general equilibrium models to fit this purpose. There is still some way to go before a detailed transport network is integrated into a spatial computable general equilibrium (SCGE) model allowing for all relevant forms of market failure. Most studies therefore instead attempt to ‘add’ one or more

wider benefits to the ordinary consumer benefits. Hansen (2015) has described one of the most recent SCGE models developed by TØI, which can be said to represent best practice.

Norwegian studies

In 2010, the Norwegian Public Roads Administration (NPRA) was mandated to develop a methodology to include the wider benefits of transport schemes in relation to a major initiative to make the entire western coast of Norway ferry-free ('Ferry-free E39'). This is not really one project, but rather a number of individual fjord crossings, each of which has primarily local importance in a limited geographical region. It is a prestige project for the NPRA, with many enthusiastic stakeholders in the coastal communities. The wider benefits are much referred to, and seem to be crucial to legitimize the project. In the period 2010–2016, the 'Ferry-free E39' project organizers commissioned numerous studies that discuss the wider benefits and how they can be measured in different case projects along the western coast of Norway. Table 2 summarizes the most important results that were presented at a NPRA seminar in March 2016.

Table 2. 'Ferry-free E39' studies presented at NPRA seminar, March 2016

Study	Research institution	Type of wider benefit	Distance decay	Productivity elasticity	Double-count if added to consumer surplus? (according to authors)	Case project	
						Name	Wider impacts in monetary terms
Heum et al. (2012)	SNF	(1) agglomeration	Fully integrated labour market up to 45 minutes	10 %	No	Bergen-Stavanger	10 bill. NOK per year
						Rogfast	8.5 bill. NOK per year
Sasson et al. (2014)	Handels- høyskolen BI	(1) cluster effect	Fully integrated labour market up to 60 minutes		Yes	Sognefjorden	0.3 bill. NOK per year
						Hafast	2.0 bill. NOK per year
Tveter, E. (2016)	Møreforskning Molde	(1) agglomeration	'Effective density' decreases with distance	0.2%	No	Møreaksen	1-15 mill. NOK (25 years), 0.02-0.3 % of consumer benefits
						Oslofjord crossing	538 mill. NOK (40 years), 0.7 % of consumer benefits
Hansen and Johansen (2016)	TØI	(1) agglomeration, and (3)	'Effective density' decreases with distance		No	Different NTP projects	2.5-24 %
						E39 Kr.sand-Tr.heim	21 bill. NOK, 14 % of consumer benefits
Fossen and Reiel-Heggedal (2016)	Oslo Economics/BI	(1) agglomeration, and (2)	'Effective density' decreases with distance	4 %	No	Ringeriksbanen	401 mill. NOK (40 years)
						E16 Skaret-Høn	1892 mill. NOK (40 years)
						Combined	1892 mill. NOK (40 years)
Ulstein et al. (2015)	Menon	(1) agglomeration	'Effective density' decreases with distance	4 % - 9 %	Yes	Ferry-free E39	122-373 bill. NOK (45 years)
Bruvoll et al. (2016)	Vista Analyse	(1) agglomeration, and (2)	'Effective density' decreases with distance	0-8 % depending on industry	Probably not	Ålesund-Molde	5.4 bill. NOK (40 years)
						E16 Voss-Arma	2.6 bill. NOK (40 years)
Mehammer et al. (2016)	COWI	(1) agglomeration, (2) and (3) [by adding 10 %]	'Effective density' decreases with distance		Probably not	E6 Åsen-Steinkjer	206 mill. NOK (40 years)
						E39 Stord-Os	409 mill. NOK (40 years)
						Lierdiagonalen	1.49 bill. NOK (40 years)

Inspired by Venables (2007), Heum et al. (2012) used a highly simplistic approach, whereby the wage differences between labour markets of different sizes were used to deduce a 0.10 productivity elasticity, and this in turn was used to compute the hypothetical productivity increase if labour markets increased efficiently. However, instead of assuming a monocentric city expansion, Hume et al. assumed that the E39 project would yield a ‘chained labour market’ all the way from Bergen to Stavanger (more than 200 km) with no distance decay factor. With this approach, all benefits are realized immediately, and a reference alternative is chosen, for which no urbanization takes place at all. Not surprisingly, the wider impacts are enormous.

Sasson et al. (2014) took a different approach. While other studies have focused on general agglomeration, they used a cluster complementarity based evaluation, focusing on whether there was a match between the business structures in the regions that were integrated. In common with Heum et al., they did not use a distance decay factor. They also assumed that equalization of productivity between regions always takes the form of the least efficient region being lifted up to the most efficient region’s level. This approach gave large benefits, but these could not be interpreted as wider benefits, as the model would probably also capture direct consumer benefits.

Tveter (2016) used a model based on the work published by Graham (2007) but with a density function that distinguished between internal density (in the city) and ‘effective density’ (connection with other regions), including a distance decay factor. Tveter found that on average there were 7% add-ons to the direct consumer benefits.

Others studies have used variants of Tveter’s model, and yielded similar results. All of the researchers noted that the choice of productivity elasticity is crucial. However, the elasticities were not studied, but were taken from the international literature. Some of these studies have computed an additional effect of increased labour supply or improved competition, but in a highly simplistic way (for example, a mere 10% add-on, by assumption).

Hansen and Johansen (2016) used a general equilibrium model including production changes in markets with imperfect competition. They studied 18 transport projects and found add-ons in the range of 2.5–24% of consumer benefits, and higher in projects that connected areas with large wage differences, projects that were real game-changers (opened up new possibilities), and in which a large share of the journeys were related to business, not leisure.

These studies proved some new insights, but have in common that they all *simulate a hypothetical effect* based on assumptions and parameter values taken from other, international studies. Thus, they cannot be said to provide empirical evidence of any causal relationship, either between transport infrastructure and effective city size, or between city size and productivity in Norway.

One of very few Norwegian ex post studies, conducted by Hagen et al. (2014), looked at five fixed-links projects from the 1990s and studied their long-term economic impacts. They did not come to any clear conclusions about the existence of wider benefits. On the contrary, for two of the projects they found no sign of such effects at all. Rather, the Askøy bridge project, close to Bergen, tempted families from Bergen to move out of the city and onto the island of Askøy, and commute to the same jobs as they had before the start of the project. Another study worth mentioning was conducted by Andersen et al. (2016), who followed four fixed-link projects in rural areas that were five years into their operational phases, in order to examine the effects on commuting, population, housing prices, and number of companies. Their findings showed small impacts on most variables. For two of the projects, the values went in the positive direction, whereas for the other two, the values fluctuated around zero or negative. The authors suggested that more studies of the same type should be performed, to help distinguish when positive changes might appear.

As noted in NOU 2012:16, several studies of Norwegian data have examined directly the correlation between road investment and productivity, without specifically addressing functional city size. These studies revealed no general correlations between road investment and productivity.

Our comments

A transport scheme may well have positive impacts on the local economy and on employment. Such impacts are, as a general rule, pecuniary externalities that are offset by corresponding, but reverse, impacts elsewhere in the country. They are already included in the direct consumer benefits of a well-specified cost-benefit analysis. Furthermore, it should be noted that any wider benefits will normally be correlated with the direct consumer benefits. Thus, if the computed consumer benefits are low, it is not likely that there will be wider benefits that will change the picture.

Most economists would probably agree that there is a theoretical foundation for the wider benefits of improved transport infrastructure. However, many have also noted the strict assumptions that must be met for wider benefits to be of relevance. For example, the projects should: be game-changer projects; open up for completely new possibilities; integrate areas that were previously separated, but not located far from each other; they should be in areas with a large economic mass, and with large differences in productivity. Following the public discussion about the wider benefits, we have the impression that these limitations are often not understood. We also have the impression that some of the studies funded as part of the 'Ferry-free E39' project were intended to illustrate a *potential* effect rather than describe an expected effect. For example, to our knowledge, any agglomeration mechanisms taking place in 'chained labour markets' stretching over 200 km have not been documented in previous projects, and remain to be examined empirically. Even the more realistic and moderate studies have in common that they disregarded issues such as user fees or tolls, congestion, and any negative productivity change in other regions that 'lost' their workers. The latter argument is presented by Minken (2015), who points out that there may well be economies of scale outside the cities too. All such limitations have been mentioned in the literature, but seem to be neglected in the public debate and in practical calculations.

A further observation is that the Norwegian studies all seem to *assume* that regional enlargement must take place in regions where the land use, population density, and population size of the existing cities remain constant (*i.e. people cannot move to areas with larger labour markets*). As noted by Harald Minken in his presentation at the NPRA seminar on the wider benefits of the 'Ferry-free E39' project, held in March 2016, a considerable share of the estimated wider benefits can probably be explained by the mere assumption that people cannot move. We do not know whether this assumption is due to an unspoken restriction on the NPRA's opportunities in road planning, or whether it is perhaps an adaptation of the fact that transport models cannot handle changes in land use. In Venables' model, it was assumed that all the space within the city was already occupied and the only way to increase effective urbanization was therefore through commuting. This is not a realistic assumption, even for large European cities, and certainly not for most regions in Norway. If agglomeration was the main goal, it would probably be far more efficient and more effective to facilitate for people to move *into* the cities.

As also noted by Harald Minken during the above mentioned seminar, by building highways we may actually do the opposite of what we want to do, namely facilitate for city residents *to move out of the city* and to become long-distance commuters, as documented in the Askøy case. Although Metz (2008) did not study the effect of particular road investments, he described the general development in people's average travel time and travel distances over time, and found that travel time remained constant at approximately 1 hour per day for decades, whereas the distances travelled increased steadily over time. It is very likely that relocation is part of the explanation for his finding – people exchange the potential travel time savings offered to them, for cheaper, bigger, nicer houses outside the urban areas. The models and analyses simply *assume* that this is not happening, by assuming that land use is not affected by transport investments. However, one may argue that if people are allowed to move, the basis for wider benefits will weaken considerably. Agglomeration effects rest on the importance of physical proximity. When a city resident moves out of the city, he or she will usually drive home earlier, spend more time in the 'home-office', etc. Thus, even though they still work in the city centre, their contribution to agglomeration effects will, at best, remain constant.

Furthermore, the wider benefits of increased labour supply rest on the assumption that workers enjoy time savings, and that a share of these time savings will be used to work more hours. This does not hold if, as shown by Metz (2008), no travel time savings are actually realized. In the long term, the commuter may experience that life is more exhausting than living in the city centre, and it is not unlikely that he would choose to exit the labour market *earlier* than he would as a city resident.

The expert committee that reviewed the Norwegian guidelines for cost-benefit analysis in 2012 concluded that agglomeration effects *might* be of relevance in large projects in urban areas, and in such cases should be *discussed separately* (NOU 2012:16). Conversely, the wider benefits of increased labour supply are highly uncertain, and no major error will be made if such effects are excluded. Increased competition is another highly uncertain effect and probably a very limited source of wider benefits that may normally be disregarded. Finally, any positive land use effects in the form of property values might be double-counted (and, the expert committee could have noted that negative land use effects are not discussed in this literature at all). In our view, these conclusions are still valid.

However, it is important to note that the distributional effects of transport infrastructure projects may be large and highly relevant to decision-makers, not least in a Norwegian context, where regional policy is strong and there is broad political consensus that we should have settlement and economic activity across the whole country. To quote the respected urban and transport economist Kenneth Small, ‘A simple partial equilibrium analysis is often sufficient for estimating total benefits and costs – but is entirely inadequate for estimating their distribution across the population’ (Small, 1998, p. 11). This, however, is another problem and has nothing to do with wider benefits.

Appendix 3: Improvements in the model systems – status Norway

Existing models

Norway practices the use of a National Transport Model System (NTMS) to assess both the current level of traffic and the future level with and without intervention. The NTMS consists of the National Passenger Transport Model (NTM), Regional Passenger Transport Models (RTMs) (one for each of the five regions in Norway), and a Freight Transport Model (FTM). The main difference between the NTM and RTMs is that the former is used to model long-distance passenger transport (i.e. trips longer than 70 km). RTMs are used for trips shorter than 70 km, and are the most often used models when conducting cost-benefit analyses in Norway.

The RTMs are used for forecasting road traffic, and are built along the same lines as similar transport models used in a number of other European countries, such as the NTM in the UK (Department for Transport, 2011) and SAMPERS in Sweden (see Algers and Beser, 2002).

The Norwegian RTM uses a bottom-up approach to estimate the number of trips people make. First, it estimates the total number of trips; second, it allocates those trips to actual journeys made between specific origins and destinations; third, it allocates those journeys to specific modes of transport; and fourth and finally, it allocates the journeys made via a particular mode to specific routes across the transport network. Most importantly, the RTM is used to forecast the number of future trips subject to changes in inputs that are entered into the model. For example, if a new road is to be built, the resulting changes will affect the model outcomes (e.g. in terms of travel cost, which may, in turn, have an effect on how people travel).

The basic structure of the RTM is illustrated in Figure 7. An RTM starts by producing the level of service (LOS) matrices observed in the network, as shown at the lower left-hand part of the diagram. These matrices contain information on travel times, distances, and other travel costs between zones for each region and for all modes of transport. The LOS matrices are inputs to the transport demand model that estimates the mode and destination choice,

as shown in the middle of Figure 7. Other important inputs and determinants of the demand model are data from travel surveys that track the way people travel without regard to travel costs or demographic data relating to zones for the generation of trips. The function of the demand model (mode and destination choice) is to use inputs from the LOS matrices and data from travel surveys to determine how the final trips would be distributed among specific origins, destinations, and modes by which they are made. Next, data on car ownership²⁴ and population are combined with information generated by the mode-choice model to produce a schedule of trip generations by age groups. Once the schedule of trip generations has been established, trip matrices by errands are calculated. The trips produced in this way are then distributed to the network through the network model according to travel purposes, as shown on the lowermost right-hand side of Figure 7.

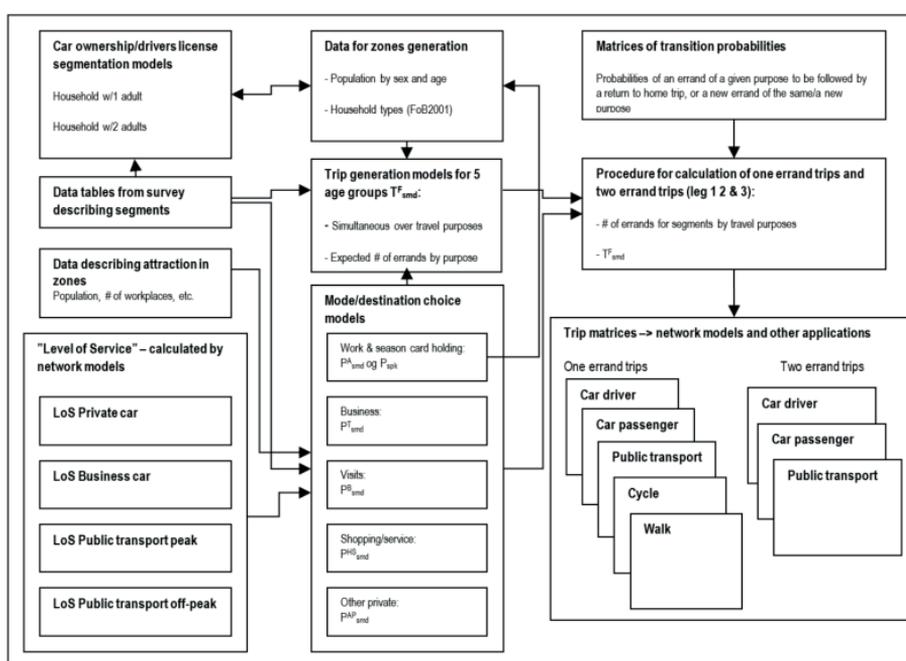


Figure 7. The framework of the Norwegian Regional Transport Model (RTM)

²⁴ Car ownership is an important driver for car use and traffic in the medium and long term. Prognoses for car ownership are computed in a separate model, based on variables such as income, demographics, composition of households, and average travel costs between zones. However, car ownership is an independent variable in an RTM and is thus not affected by the project to be evaluated. If there is reason to believe that there will be such an effect, there is a possibility to change car ownership manually in the RTM model.

The RTM can be used to forecast future traffic growth rates at the local levels as well as at the regional levels. Furthermore, the RTM can be used to assess what the traffic level at specific road segments would be if a specific project was undertaken, such as an expansion of the road network. Such an expansion might be expected, for example, to lead to a change in the level of service (e.g. in travel time, mode and destination choice, trip generation, and errands) and finally lead to changes in the number of trips made for various travel purposes. For forecasting purposes, the model readily accounts for certain developments (such as the expected population growth, changes in car ownership patterns, and expected investments that have an impact on the level of service) and it then produces a forecast of the expected traffic in the network, which can be aggregated at the local, regional, and national levels. The RTM (like all other models of this type) is sensitive to the quality of the input data that are used (e.g. its accuracy depends on whether the data on travel costs are correct, or whether the travel zones are specific enough to reproduce the actual travel pattern).

Another issue that needs to be considered because it is relevant for the issue being addressed in this report, relates to the way the RTM is updated. The system underlying the model and the validation process are consistently subjected to peer review to ensure that the model follows best-practice procedures and that it provides robust results. The last major update of the model was in 2014 (see Rekdal et al., 2014).

From the above description of the RTM, it can be concluded that: (1) its main purpose is the assessment of the short-distance passenger transport implications of any policy intervention, (2) it provides a detailed picture of traffic flows at the regional levels for the base case or 'do nothing' scenario and, (3) it does not account for land use changes.

From these three points, it is obvious that the RTMs as practised in many countries, almost by definition do not forecast what is expected to happen. At best, they envisage what could happen if one stopped planning any new major changes today (i.e. they assume that travellers' behaviour, economic and population trends, and land use trends will continue the same way next year and in the future as they do today).

There are other shortcomings of the RTM that may need improvement for it to be a proper tool for decision-making. The first is that the RTM does not appropriately account for congestion in the road networks; its congestion model is per link and it is not accounted for the fact that congestion in one link can cause more congestion downstream. In some Norwegian cities, including Oslo and Bergen, congestion during some periods of the day

represents a problem in terms of increased travel time costs and increased levels of pollutants. For the RTM to be encompassing as decision-making tool, accounting for congestion is necessary. The Norwegian Public Roads Administration (NPRA) is charged with developing and maintaining the RTM, and is currently working on how to accommodate congestion in the model.

Another problem with the RTM as a decision-making tool, and one that is often raised by non-experts, is that the RTM is too much of a 'black box' and that it should be made simpler and transparent for the non-expert to comprehend. This is a critical issue since the results of RTMs are used by the decision-makers who are non-experts and who should be able to comprehend the results. Therefore, as a minimum, a short and concise explanation of what the RTM is, what it takes and does not take into account, and the uncertainties involved in its predictions and results should be developed.

Yet another problem with RTM and related to the above-mentioned problem, which is typical for Norway, is that the RTM is used at all levels of planning, including the strategic, tactical, and operational levels. In its present form, the RTM seems more suitable for 'tactical' and 'operational' planning (i.e. short-term and medium-term planning). Tactical planning covers a time span of 3–20 years, and the details covering the aim of assessing a given project are readily available. During operational planning, traffic flows and travel mode choices are forecasted within a limited geographical region or area when there are expected changes in infrastructure supply. Næss and Strand (2012; 2015) have addressed this issue, while arguing that the model used to forecast future traffic should be context dependent (i.e. it should differentiate between the different levels of the planning stages discussed above. Of interest for our case, Næss and Strand proposed that at the 'strategic' level of planning, where the RTM evidently is not the most appropriate method for forecasts, scenario analyses should be used.

One of the most serious shortcomings of the RTM is that it does not take into account land use changes and thus not the longer term effects discussed in Chapters 4 and 5 of this report. Common sense and a good deal of research have attested that the supply of transport infrastructure influences patterns of development and location choices for housing and firms. Furthermore, land use patterns too influence the number of trips, destination, and mode choice (e.g. Kenworthy and Laube 1999; Maat et al., 2005; Ewing and Cervero 2010; Næss 2012; 2013). In summary, land use and transport are closely intertwined such that transport models and land use models need to be integrated to capture all effects adequately; including wider benefits and costs. Such integration has become known as LUTI (Land Use Transport Interaction)

models. LUTI models are used a great deal in other countries, especially in the UK and Germany, but have yet to become established in Norway.

Land Use Transport Interaction (LUTI) models²⁵

A general definition of a LUTI model is that it assesses the land use impact of transport schemes and provides a rigorous analysis of the demographic, economic, and transport impacts of land use proposals. The term ‘land use’ refers mainly to activities that use space, such as spaces in which people live and work. In the strict sense, land use (i.e. hectares used for housing or other purposes) is usually incidental or only accounted for implicitly in floor-space forecasts. The interaction between land use and transport models as represented by a LUTI model developed for London (Feldman et al. 2008) is shown in Figure 8.

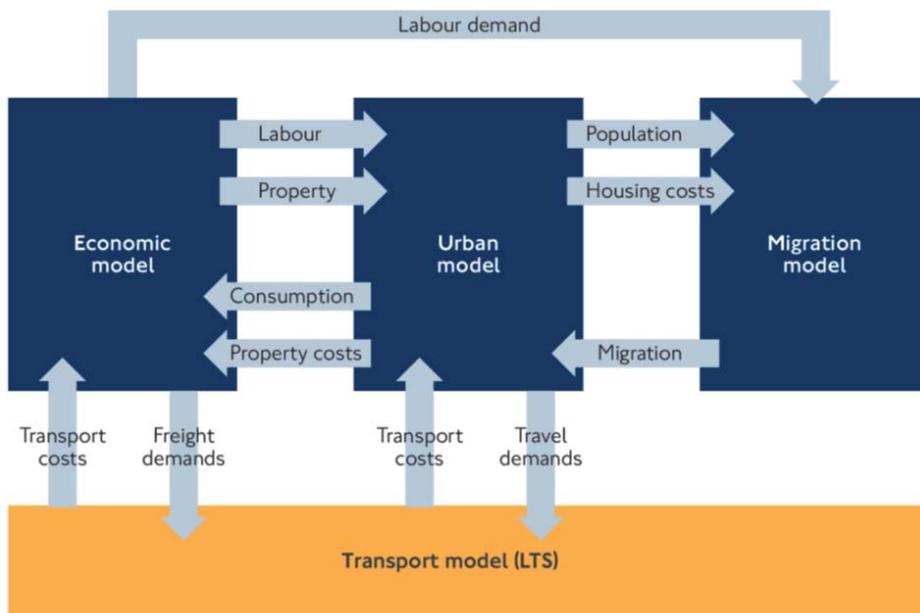


Figure 8, A LUTI model – interaction between land use and transport models

Figure 8 demonstrates that a LUTI modelling system is one in which almost everything affects everything else to a greater or lesser extent, either immediately or gradually. The pattern of land use largely determines travel

²⁵ It should be noted that, to date, improved descriptions of the negative impacts of transport investments have not been the main focus when LUTI models have been being developed. However, since there is a potential to apply them for that purpose, we have included a section on LUTI models.

patterns, and the patterns of accessibility or congestion (calculated in the transport model) influence how the land is then used.

LUTI models could be viewed simply as a means for improving traditional transport models for such a purpose, by adding the element of location choices by households and businesses to the conventional transport model choices of destination, mode, and route. However, the extension that LUTI models offer to our understanding of the economic and social motivations for trip-making and location choices comes at a price in terms of complexity, which makes their validation much more difficult (Wenban-Smith and Van Vuren 2009).

LUTI models have been quite extensively used to calculate wider *benefits* in UK practice, for two reasons: (1) for practical reasons, as almost all the data required for the WebTAG wider benefits calculations are data already used in LUTI modelling, and (2) because ‘moves to more productive jobs’ (and, optionally, agglomeration calculations) make use of changes in job location, which are forecast by LUTI models but not by pure transport models.

Currently, LUTI modelling is moving rapidly to incorporate elements of economic modelling (and some economic models are incorporating elements of LUTI modelling). Regarding the question of whether LUTI captures *negative* wider impacts, it does happen and there are examples that have shown this. Feldman et al. (2008) showed negative agglomeration effects arising from road pricing schemes.

There are some specific problems that may deter the standardized use of LUTI models, at least in the case of Norway. The first and the most crucial problem is that land use depends on politics, which vary from time to time and on the political regime in power. This makes it quite difficult to model land use with LUTI models. Second, land use in Norway is heavily regulated in the sense that the usage of parcels of land is pre-determined and empirically the parcels are used for those purposes. However, these two problems can be overcome, while still developing LUTI models for Norway. One way is that LUTI models should not estimate land use per se, but to estimate the floor space required for other activities as a result of infrastructure development. To exemplify, given that a parcel of land has been politically or historically assigned to, for example, a school, a LUTI model should estimate the square metres or square kilometres that will be required as a result of a transport investment in the immediate area. Such an estimation will be value added to policy-making. However, it should be noted that a standard LUTI model cannot be developed to suit all projects. What needs to be developed is a framework that can be adjusted for individual projects.

Concept report series

Paper version ISSN 0803-9763

Web version ISSN 0804-5585

Norwegian www.ntnu.no/concept/publikasjoner/rapportserie

English summary www.ntnu.edu/concept/publications/report-series

Report	Title	Author
No. 1	Styring av prosjektporteføljer i staten. Usikkerhetsavsetning på porteføljenivå <i>Project Portfolio Management. Estimating Provisions for Uncertainty at Portfolio Level.</i>	Stein Berntsen og Thorleif Sunde
No. 2	Statlig styring av prosjektledelse. Empiri og økonomiske prinsipper. <i>Economic Incentives in Public Project Management</i>	Dag Morten Dalen, Ola Lædre og Christian Riis
No. 3	Beslutningsunderlag og beslutninger i store statlige investeringsprosjekt <i>Decisions and the Basis for Decisions in Major Public Investment Projects</i>	Stein V. Larsen, Eilif Holte og Sverre Haanæs
No. 4	Konseptutvikling og evaluering i store statlige investeringsprosjekt <i>Concept Development and Evaluation in Major Public Investment Projects</i>	Hege Gry Solheim, Erik Dammen, Håvard O. Skaldebø, Eystein Myking, Elisabeth K. Svendsen og Paul Torgersen
No. 5	Bedre behovsanalyser. Erfaringer og anbefalinger om behovsanalyser i store offentlige investeringsprosjekt <i>Needs Analysis in Major Public Investment Projects. Lessons and Recommendations</i>	Petter Næss
No. 6	Målformulering i store statlige investeringsprosjekt <i>Alignment of Objectives in Major Public Investment Projects</i>	Ole Jonny Klakegg
No. 7	Hvordan tror vi at det blir? Effektvurderinger av store offentlige prosjekt <i>Up-front Conjecture of Anticipated Effects of Major Public Investment Projects</i>	Nils Olsson
No. 8	Realopsjoner og fleksibilitet i store offentlige investeringsprosjekt <i>Real Options and Flexibility in Major Public Investment Projects</i>	Kjell Arne Brekke
No. 9	Bedre utforming av store offentlige investeringsprosjekter. Vurdering av behov, mål og effekt i tidligfasen <i>Improved Design of Public Investment Projects. Up-front Appraisal of Needs, Objectives and Effects</i>	Petter Næss med bidrag fra Kjell Arne Brekke, Nils Olsson og Ole Jonny Klakegg

Report	Title	Author
No. 10	Usikkerhetsanalyse – Kontekst og grunnlag <i>Uncertainty Analysis – Context and Foundations</i>	Kjell Austeng, Olav Torp, Jon Terje Midtbø, Ingemund Jordanger, og Ole M Magnussen
No. 11	Usikkerhetsanalyse – Modellering, estimering og beregning <i>Uncertainty Analysis – Modeling, Estimation and Calculation</i>	Frode Drevland, Kjell Austeng og Olav Torp
No. 12	Metoder for usikkerhetsanalyse <i>Uncertainty Analysis – Methodology</i>	Kjell Austeng, Jon Terje Midtbø, Vidar Helland, Olav Torp og Ingemund Jordanger
No. 13	Usikkerhetsanalyse – Feilkilder i metode og beregning <i>Uncertainty Analysis – Methodological Errors in Data and Analysis</i>	Kjell Austeng, Vibeke Binz og Frode Drevland
No. 14	Positiv usikkerhet og økt verdiskaping <i>Positive Uncertainty and Increasing Return on Investments</i>	Ingemund Jordanger
No. 15	Kostnadsusikkerhet i store statlige investeringsprosjekter; Empiriske studier basert på KS2 <i>Cost Uncertainty in Large Public Investment Projects. Empirical Studies</i>	Olav Torp (red.), Ole M Magnussen, Nils Olsson og Ole Jonny Klakegg
No. 16	Kontrahering i prosjektets tidligfase. Forsvarets anskaffelser. <i>Procurement in a Project's Early Phases. Defense Aquisitions</i>	Erik N. Warberg
No. 17	Beslutninger på svakt informasjonsgrunnlag. Tilnærminger og utfordringer i prosjekters tidlige fase <i>Decisions Based on Scant Information. Challenges and Tools During the Front-end Phases of Projects</i>	Kjell Sunnevåg (red.)
No. 18	Flermålsanalyser i store statlige investeringsprosjekt <i>Multi-Criteria Decision Analysis In Major Public Investment Projects</i>	Ingemund Jordanger, Stein Malerud, Harald Minken, Arvid Strand
No. 19	Effektvurdering av store statlige investeringsprosjekter <i>Impact Assessment of Major Public Investment Projects</i>	Bjørn Andersen, Svein Bråthen, Tom Fagerhaug, Ola Nafstad, Petter Næss og Nils Olsson
No. 20	Investorers vurdering av prosjekters godhet <i>Investors' Appraisal of Project Feasibility</i>	Nils Olsson, Stein Frydenberg, Erik W. Jakobsen, Svein Arne Jessen, Roger Sørheim og Lillian Waagø
No. 21	Logisk minimalisme, rasjonalitet - og de avgjørende valg <i>Major Projects: Logical Minimalism, Rationality and Grand Choices</i>	Knut Samset, Arvid Strand og Vincent F. Hendricks
No. 22	Miljøøkonomi og samfunnsøkonomisk lønnsomhet <i>Environmental Economics and Economic Viability</i>	Kåre P. Hagen

Report	Title	Author
No. 23	The Norwegian Front-End Governance Regime of Major Public Projects – A Theoretically Based Analysis and Evaluation	Tom Christensen
No. 24	Markedsorienterte styringsmetoder i miljøpolitikken <i>Market oriented approaches to environmental policy</i>	Kåre P. Hagen
No. 25	Regime for planlegging og beslutning i sykehusprosjekter <i>Planning and Decision Making in Hospital Projects. Lessons with the Norwegian Governance Scheme.</i>	Asmund Myrbostad, Tarald Rohde, Pål Martinussen and Marte Lauvsnes
No. 26	Politisk styring, lokal rasjonalitet og komplekse koalisjoner. Tidligfaseprosessen i store offentlige investeringsprosjekter <i>Political Control, Local Rationality and Complex Coalitions. Focus on the Front-End of Large Public Investment Projects</i>	Erik Whist, Tom Christensen
No. 27	Verdsetting av fremtiden. Tidshorisont og diskonteringsrenter <i>Valuing the future. Time Horizon and Discount Rates</i>	Kåre P. Hagen
No. 28	Fjorden, byen og operaen. En evaluering av Bjørvikautbyggingen i et beslutningsteoretisk perspektiv <i>The Fjord, the City and the Opera. An Evaluation of Bjørvika Urban Development</i>	Erik Whist, Tom Christensen
No. 29	Levedyktighet og investeringstiltak. Erfaringer fra kvalitetssikring av statlige investeringsprosjekter <i>Sustainability and Public Investments. Lessons from Major Public Investment Projects</i>	Ola Lædre, Gro Holst Volden, Tore Haavaldsen
No. 30	Etterevaluering av statlige investeringsprosjekter. Konklusjoner, erfaringer og råd basert på pilotevaluering av fire prosjekter <i>Evaluating Public Investment Projects. Lessons and Advice from a Meta-Evaluation of Four Projects</i>	Gro Holst Volden and Knut Samset
No. 31	Store statlige investeringers betydning for konkurranse- og markedsutviklingen. Håndtering av konkurransemessige problemstillinger i utredningsfasen <i>Major Public Investments' Impact on Competition. How to Deal with Competition Issues as Part of the Project Appraisal</i>	Asbjørn Englund, Harald Bergh, Aleksander Møll and Ove Skaug Halsos
No. 32	Analyse av systematisk usikkerhet i norsk økonomi. <i>Analysis of Systematic Uncertainty in the Norwegian Economy.</i>	Haakon Vennemo, Michael Hoel and Henning Wahlquist
No. 33	Planprosesser, beregningsverktøy og bruk av nytte-kostnadsanalyser i vegsektoren. En sammenlikning av praksis i Norge og Sverige.	Morten Welde, Jonas Eliasson, James Odeck, Maria Börjesson

Report	Title	Author
	<i>Planning, Analytic Tools and the Use of Cost-Benefit Analysis in the Transport Sector in Norway and Sweden.</i>	
No. 34	Mulighetsrommet. En studie om konseptutredninger og konseptvalg <i>The Opportunity Space. A Study of Conceptual Appraisals and the Choice of Conceptual Solutions.</i>	Knut Samset, Bjørn Andersen and Kjell Austeng
No. 35	Statens prosjektmodell. Bedre kostnadsstyring. Erfaringer med de første investeringstiltakene som har vært gjennom ekstern kvalitetssikring	Knut Samset and Gro Holst Volden
No. 36	Investing for Impact. Lessons with the Norwegian State Project Model and the First Investment Projects that Have Been Subjected to External Quality Assurance	Knut Samset and Gro Holst Volden
No. 37	Bruk av karbonpriser i praktiske samfunnsøkonomiske analyser. En oversikt over praksis fra analyser av statlige investeringsprosjekter under KVVU-/KS1-ordningen. <i>Use of Carbon Prices in Cost-Benefit Analysis. Practices in Project Appraisals of Major Public Investment Projects under the Norwegian State Project Model</i>	Gro Holst Volden
No. 38	Ikke-prissatte virkninger i samfunnsøkonomisk analyse. Praksis og erfaringer i statlige investeringsprosjekter <i>Non-Monetized Impacts in Economic Analysis. Practice and Lessons from Public Investment Projects</i>	Heidi Bull-Berg, Gro Holst Volden and Inger Lise Tyholt Grindvoll
No. 39	Lav prising – store valg. En studie av underestimering av kostnader i prosjekters tidligfase <i>Low estimates – high stakes. A study of underestimation of costs in projects' earliest phase</i>	Morten Welde, Knut Samset, Bjørn Andersen, Kjell Austeng
No. 40	Mot sin hensikt. Perverse insentiver – om offentlige investeringsprosjekter som ikke forplikter <i>Perverse incentives and counterproductive investments. Public funding without liabilities for the recipients</i>	Knut Samset, Gro Holst Volden, Morten Welde and Heidi Bull-Berg
No. 41	Transportmodeller på randen. En utforskning av NTM5-modellens anvendelsesområde <i>Transport models and extreme scenarios. A test of the NTM5 model</i>	Christian Steinsland and Lasse Fridstrøm
No. 42	Brukeravgifter i veisektoren <i>User fees in the road sector</i>	Kåre Petter Hagen and Karl Rolf Pedersen
No. 43	Norsk vegplanlegging: Hvilke hensyn styrer anbefalingene	Arvid Strand, Silvia Olsen, Merethe Dotterud Leiren and Askill Harkjerr Halse

Report	Title	Author
	<i>Road Planning in Norway: What governs the selection of projects?</i>	
No. 44	Ressursbruk i transportsektoren – noen mulige forbedringer <i>Resource allocation in the transport sector – some potential improvements</i>	James Odeck (red.) and Morten Welde (red.)
No. 45	Kommunale investeringsprosjekter. Prosjektmodeller og krav til beslutningsunderlag. <i>Municipal investment practices in Norway</i>	Morten Welde, Jostein Aksdal and Inger Lise Tyholt Grindvoll
No. 46	Styringsregimer for store offentlige prosjekter. En sammenliknende studie av prinsipper og praksis i seks land.	Knut Samset, Gro Holst Volden, Nils Olsson and Eirik Vårdal Kvalheim
No. 47	Governance schemes for major public investment projects: A comparative study of principles and practices in six countries	Knut Samset, Gro Holst Volden, Nils Olsson and Eirik Vårdal Kvalheim
No. 48	Investeringsprosjekter og miljøkonsekvenser. En antologi med bidrag fra 16 forskere <i>Environmental impact of large investment projects. An anthology by 16 Norwegian experts</i>	Kåre P. Hagen (red.) and Gro Holst Volden (red.)
No. 49	Finansiering av vegprosjekter med bompenger. Behandling av og konsekvenser av bompenger i samfunnsøkonomiske analyser. <i>Financing road projects with tolls. The treatment of and consequences of tolls in cost benefit analyses.</i>	Morten Welde, Svein Bråthen, Jens Rekdahl and Wei Zhang
No. 50	Prosjektmodeller og prosjekteierstyring i statlige virksomheter <i>Project governance and the use of project models in public agencies and line ministries in Norway</i>	Bjørn Andersen, Eirik Vårdal Kvalheim and Gro Holst Volden
No. 51	Kostnadskontroll i store statlige investeringer underlagt ordningen med ekstern kvalitetssikring <i>Cost control in major public investment projects in Norway</i>	Morten Welde
No. 52	Statlige investeringstiltak under lupen. Erfaring med evalueringer av de 20 første KS-prosjektene <i>A Close-up on Public Investment Cases. Lessons from Ex-post Evaluations of 20 Major Norwegian Projects</i>	Gro Holst Volden and Knut Samset
No. 53	Fremsynsmetoder <i>Foresight methods</i>	Tore Sager
No. 54	Neglected and underestimated negative impacts of transport investments	Petter Næss, Gro Holst Volden, James Odeck and Tim Richardson

Forskningsprogrammet Concept skal utvikle kunnskap som sikrer bedre ressursutnyttning og effekt av store, statlige investeringer. Programmet driver følgeforskning knyttet til de største statlige investeringsprosjektene over en rekke år. En skal trekke erfaringer fra disse som kan bedre utformingen og kvalitetssikringen av nye investeringsprosjekter før de settes i gang.

Concept er lokalisert ved Norges teknisk- naturvitenskapelige universitet i Trondheim (NTNU), ved Fakultet for ingeniørvitenskap og teknologi. Programmet samarbeider med ledende norske og internasjonale fagmiljøer og universiteter, og er finansiert av Finansdepartementet.

The Concept research program aims to develop know-how to help make more efficient use of resources and improve the effect of major public investments. The Program is designed to follow up on the largest public projects over a period of several years, and help improve design and quality assurance of future public projects before they are formally approved.

The program is based at The Norwegian University of Science and Technology (NTNU), Faculty of Engineering Science and Technology. It cooperates with key Norwegian and international professional institutions and universities, and is financed by the Norwegian Ministry of Finance.

Address:

The Concept Research Program
Høgskoleringen 7A
N-7491 NTNU
Trondheim
NORWAY

ISSN: 0803-9763 (print version)
ISSN: 0804-5585 (web version)
ISBN: 978-82-93253-65-5 (print version)
ISBN: 978-82-93253-66-2 (web version)

