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Summary:

Cost Benefit Analysis of Alternative Public Transport Funding in Four Norwegian Cities

The Ministry of Transport and Communications has set up a programme – called POT – for general purpose transport research. Support has been given within this programme to the project ”Alternative urban transport funding – socio-economic evaluations of alternative forms of shared funding for Oslo, Stavanger, Bergen and Trondheim”[1]. The aim of the project is to assess the benefits of setting up different forms of shared funding *(“transport funds”)* in Norwegian cities, based on a combination of national and local contributions, and to determine the extent to which the benefits depend on the constraints imposed on the scheme.

Problem statement

One of the main challenges for public transport in the larger cities is to ensure stable and sufficient revenue flows. An optimal level of service within the public transport system typically presupposes revenue from more sources than the passengers alone. Such funding may take the form of lump sum subsidies, output based subsidies, or designated contributions from toll rings or road pricing schemes. To obtain political acceptance for such funding arrangements one will have to present the different funding arrangements as a whole. The socalled *Package 2 for Oslo* is an example of this type of revenue scheme, where shared funding has been set up which is acceptable to all parties. Similar arrangements, although with varying content, have been set up for *Stavanger, Bergen* and *Trondheim*.

Four reports have been compiled in this project:

1. *Sub report 1* looks at the decision-making processes behind the different transport policy packages in the largest Norwegian cities, assessing the extent to which the approach taken in each package is a result of the way in which it has been organised. The report looks at the development of the packages in several phases and on how environmental measures and ”road pricing” have become more central elements in the debate surrounding these packages (Osland and Bekken 2004).
2. *Sub report 2* studies the politicians’ and decision makers’ preferences for different funding packages for the six largest cities. The report looks at general preferences for shared funding of policy packages, at the contents of

[1] The project has the abbreviation ALTFIN

the packages, and at who should participate in the shared funding (Norheim and Nossum 2004).

3. *Sub report 3* studies funding framework conditions and development trends for public transport in the six largest cities. The main focus in this report is on how public transport adapts to changes in funding framework conditions and on the demand effects of such adaptations (Norheim 2004).
4. *Sub report 4* is this report, which looks at the development of an economically optimal public transport service. The main objective is to assess various "second best" solutions, revealing the social economic benefits of dissolving some of today's funding constraints.

While the first three reports are descriptive accounts of the development in the four biggest cities and of the choices made by policy makers, this fourth report explores the opportunities available if it were possible to relax some of the framework constraints. The project is partly financed through an EU project – REVENUE – where Oslo is one of the case areas.

Economically optimal services

Within traditional ”first best” welfare theory, the possible use of revenue from passenger fares or road pricing does not come into play, nor do the institutional constraints or degrees of freedom affecting policy options, the various transaction costs involved, or the efficiency and political acceptance of potential incentive schemes. The theory assumes that whatever public revenue is generated goes into the general public treasury, that subsidies originate from the same source, and that funds for social welfare purposes will be allocated on the basis of general political priorities or cost benefit evaluations. However, these assumptions are seldom met in practice. There is thus a need to search for ”second best” solutions, i.e. welfare optima subject to certain constraints, such as budget limitations. Some budgets are tighter than other ones, and it is generally not possible to reallocate funds between budget chapters. In addition, political priorities regarding toll rates and public transport fares represent important constraints on policy formation.

The road tolling schemes currently in operation in Norway have been designed so as to raise funds for road improvements, with almost no regard to the operation of public transport. Today, there is a growing debate on the need and opportunity for a more integrated approach to urban transport policy, in which, e. g., revenue from a road pricing scheme may be used to support public transport provision. In this report, we focus specifically on the following second best solutions for urban transport policy:

1. Current subsidy frameworks with varying degrees of freedom for fares and service provision
2. Increased subsidy levels and optimal distribution between the cities
3. Increased costs for car driving in general and for rush hour traffic in particular
4. Changes in institutional constraints and city planning in the form of densification, parking restrictions, enhanced accessibility, or road pricing

All these framework conditions affect the level of subsidies in the short term and the economically optimal subsidy level in the long term. They therefore represent important indirect sources of funding for public transport. Just about how important are they? What is the potential for developing alternative funding models, which combine changes in the institutional constraints with new subsidy schemes, in order to provide an economically optimal service level?

Strategic planning model

To optimise the service level across sectors, there is a need to develop an analytic tool which can take account of:

- Players' preferences
- Different constraints on decision-making
- Different funding models

To this purpose, we have developed the conceptual model FINMOD (Figure S.1). Here, the long term or major ”policy variables” represent framework conditions that are exogenous to the public transport market, affecting ridership and car use, as well as car ownership. Given these exogenous variables and the general institutional constraints, we simulate an optimised public transport provision. While we do not undertake any optimisation of the exogenous conditions like parking conditions, urban density etc, changes in these will affect optimal service provision and funding needs.

Our analysis is based on a UITP[2] Millennium Cities database including data for the five largest cities of Norway. In total, the database comprises 86 cities with comparable data. The entire data set has been exploited in order to estimate the demand effects in FINMOD. The following dependent variables have been analysed: per capita trips by public transport, per capita car trips, and car ownership penetration.

The analyses reveal a clear connection between urban structure, transport services, and travel by car and public transport. High population densities, for example, are associated with lower car use and car ownership rates, but with increased use of public transport. Thus, when we compare the public transport share in Norwegian cities to other European cities with a high population density, the underlying circumstances will be quite different. The analyses also show that:

- Enhanced parking facilities in city centres (spaces per job) will reduce the use of public transport and increase car ownership and use
- Higher fuel prices will increase the use of public transport and diminish car use

[2] International Association of Public Transport

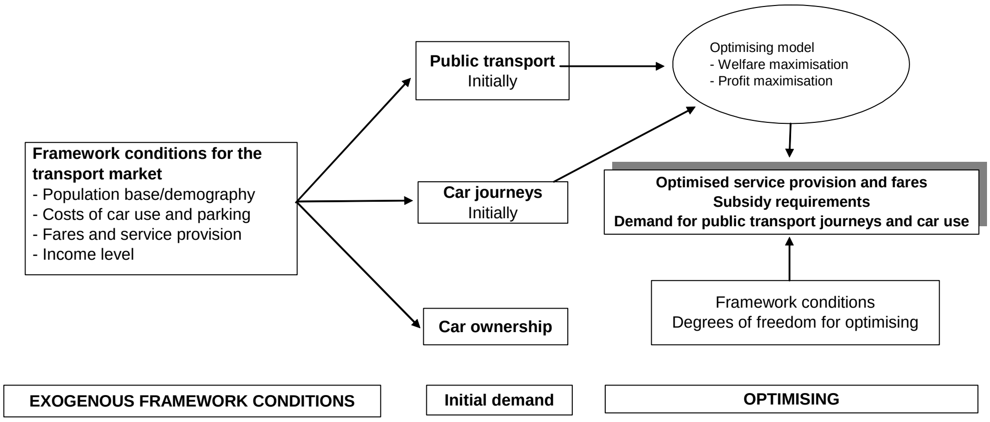

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Figure S.1: Schematic illustration of FINMOD

FINMOD has been developed from the optimisation model of Larsen (1993). It has been used in a number of studies on optimal public transport service in the larger cities, as well as for regional public transport and railways. However, FINMOD remains a basically strategic model, providing the direction of effects rather than an accurate ”answer” on the design of an optimal service. Its strength lies in the fact that it can handle combinations of measures and funding constraints simultaneously. Thus it will be possible to calculate the economic consequences of various funding constraints and compare alternative strategies to each other.

”Optimal” public transport provision

What constitutes an optimal public transport service depends on budget constraints as well as the characteristics of the urban area in question. It may be fruitful to distinguish between *general economic efficiency, market efficiency and profit maximisation (production efficiency)*. In this study, all of these criteria have been used (figure S 2).

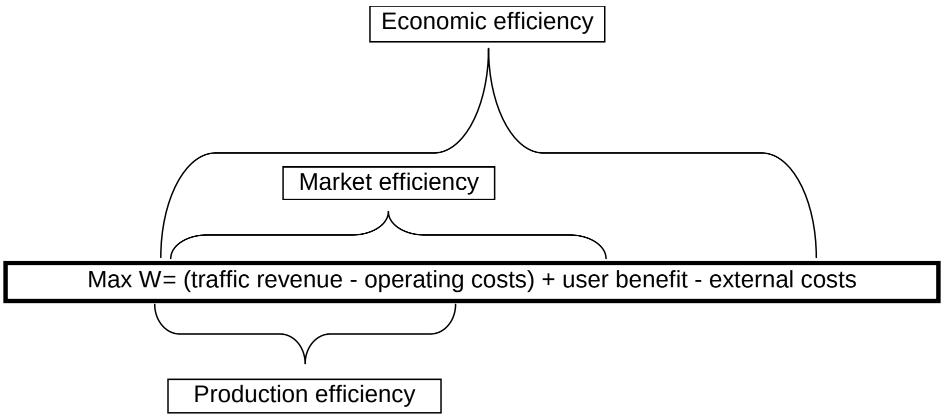

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Figure S.2: Schematic distinction between overall economic efficiency, market efficiency, and production efficiency

Our analyses reveal that an *economically optimal public transport service* for the four cities will require around NOK 1 billion per year in increased subsidies, i. e. more than a doubling from the current level. The increase is largest in Oslo, where there are also more significant congestion problems on the roads. In Stavanger, on the other hand, the optimal subsidy level is roughly equal to today's level.

The increased subsidies would be used to finance a 14 per cent reduction in fares and an approximate 70 per cent increase in frequency, while the fleet size would be reduced by around 30 per cent. These changes are calculated to produce an around 27 per cent increase in public transport ridership and an economic gain of around NOK 1,8 billion (1800 millions) per year. This includes the passenger benefit and reduced congestion, and the external costs of public funding. In the welfare analysis we have used 0.25 as the marginal cost of public fund.

In contrast, the *market efficient solution*, which disregards the external costs of car use, does not give weight to the desirable but costly transfer of rush hour trips from cars to public transport. Thus this type of optimisation would require a smaller increase in subsidy, but still more than NOK 250 million up from the present level. In economic terms, the external costs of car use are less important than the welfare gain accruing to public transport users. This is particularly so in Norwegian cities, where the rates of public transport use are a relatively high, while congestion costs and other external effects of car use are fairly limited.

A market efficient public transport system will to a far greater extent imply a fare-financed service improvement. Rush hour fares increase by almost 90 per cent, while departure frequencies go up by 45 to 77 per cent. This service improvement will result in 17 per cent higher ridership and around NOK 740 million in annual economic benefits.

These analyses also show that it is possible to develop a *public transport service without subsidies*, but with almost 70 per cent higher fares and 14 per cent lower frequency. Generally speaking, this would result in 21 per cent fewer passengers and an economic welfare loss of NOK 2 billion per annum. It is, in other words, possible to imagine a commercially driven public transport service without subsidies, however at the expense of a significant welfare loss.

Figure S.3 shows how the service ought to be developed under differing optimisation criteria. The most pronounced contrast is seen between the market efficient solution, which considers the user benefit of increased frequency, and the production efficient solution, which does not. While in the former case, the frequency increases by more than 50 per cent, it decreases by 16 per cent in the latter. At the same time a production efficient solution would imply cost-based fares, about 70 per cent higher than today.

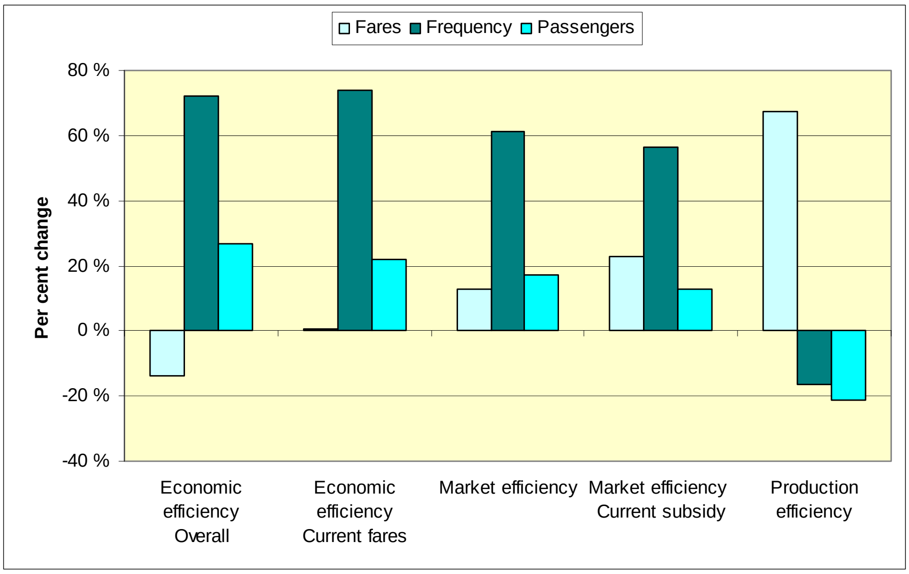

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Figure S.3: Summary of an optimal public transport service in the four largest cities, given different optimisation criteria. Percentage change in fares, frequency and number of passengers. Model calculations based on FINMOD

Effects of changes in exogenous factors

We have assessed the impact of the following hypothetical changes in exogenous factors:

- *20 per cent increased density (population per urbanised area).* This is necessarily a long term development. Interpreted as a cross-sectional comparison, it will also illustrate the significance of differences between densely and sparsely populated areas.
- *20 per cent increased parking opportunities (parking space per work place in city centres).* This is a relatively strong increase. A corresponding reduction will imply that jobs will be created in the city centre without a similar increase in parking spaces.
- *20 per cent increase in fuel prices.* Being determined in part by the international oil market and in part by domestic tax rates, the fuel price directly affects the cost of driving in urban areas and elsewhere.

Table S.1 shows that these changes have a relatively marked effect on the demand for car trips and for public transport. A 20 per cent increase in *population density* will result in 6.8 per cent more journeys by public transport and 6.2 per cent fewer car trips per capita. For our four cities taken together, there will be 3.6 per cent fewer motorised journeys. On the other hand, 20 per cent more parking space in the city centre will weaken the market potential for public transport and result in an approximate 2 per cent increase in motorised traffic. A 20 per cent increase in fuel prices will result in around 5 per cent more public transport passengers and 2 per cent fewer motorised journeys.

Table S.1: Demand effects of changes in exogenous factors. Aggregate results for the four largest Norwegian cities. Model calculations based on FINMOD. Per cent

	Public transport	Car journeys	Car ownership	Motorised journeys
20 % increased population density	6.8	-6.2	-7.1	-3.6
20 % more parking places	-2.8	3.4	4.4	2.1
20 % increased fuel price	4.9	-3.8		-2.0

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Even though the calculated effects are subject to some uncertainty, they do appear reasonable as well as interesting. Improved facilities for cars will generate a certain number of extra car trips, which will replace journeys by public transport. Although we do not include walking and bicycle trips, the picture is relatively clear, indicating an increased scope of travel. This is supported by the UITP database, which shows that the spread-out cities of North America and Australia had more car journeys per inhabitant than the total number of journeys per capita in a Norwegian city.

Obviously, changes in demand will also affect revenues and economic benefits. On the one hand, increased demand for public transport will strengthen the revenue of transport companies and reduce the need for subsidies. In addition, changes in car use will have an effect on congestion and hence on the economic benefit of transferring traffic to public transport. Thus, exogenous changes which increase the demand for public transport and reduce car use may have major effects on the economically optimal level of subsidies.

Multiplicator effects

Changes in the exogenous factors affect public transport demand and finance directly as well as indirectly. The direct effect of increased demand is increased revenue, but also increased costs, not least in the rush hour periods, where there is a need to expand the fleet. The indirect effects are due to changes in demand for car trips and hence changes in congestion costs. In this project we have identified the direct effects as short term effects and the indirect effects as long term effects (figure S.4).

These analyses show that the direct, short term effects of a 20 per cent increase in population density are around NOK 110 million in reduced annual subsidies, growing to NOK 120 million in the long term. Similarly, 20 per cent more parking space in the city centre will result in about NOK 50 million in increased annual subsidy requirements, while and a 20 per cent increase in fuel prices will allow for an around NOK 80 million reduction in annual subsidies.

Even though there is uncertainty in these figures, the main conclusion is clear: the circumstances under which public transport operates in these cities will have an effect on the need for subsidies. Even though major changes in these circumstances are not realistic in the short term, they are highly realistic in the long term. As for the circumstances that are difficult to control, e.g. fuel prices, it may be important to have a ”counterbalancing strategy” ready for use if and when the prices should change significantly. Major drops in fuel prices can lead to a vicious circle for public transport, if the above long term effetcs are not taken into account.

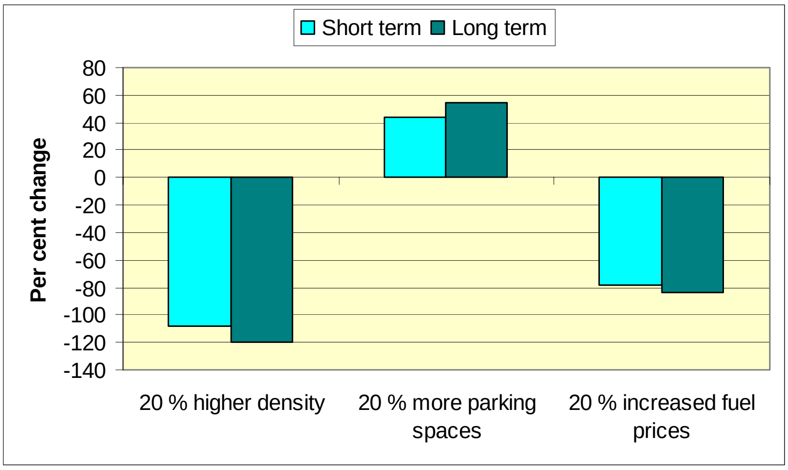

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Figure S.4: Effects of changes in exogenous factors on the level of subsidy in the short and long term. Model calculations based on FINMOD

In our study we have also looked at the long term consequences of changes in exogenous circumstances, given that the cost savings and additional revenue are used to improve the service. In practice this means that we keep the subsidies at the current level and carry out a general economic or a market economic optimisation of the service (figure S.5). In one example we consider a 20 per cent reduction in downtown parking space, which results in increased demand for public transport. Under general economic optimisation, this will result in around 15 per cent more public transport trips. A market economic optimisation will result in around 20 per cent more passengers, because here the emphasis will not be on the most cost-intensive rush hour passengers.

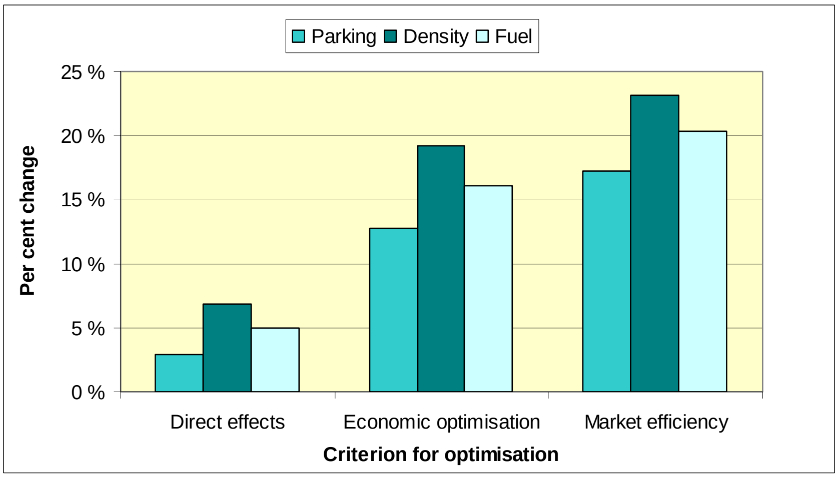

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Figure S.5: Effects of changes in framework conditions on passenger numbers in the short term and long term effect depending on criterion for optimisation Model calculations based on FINMOD

These examples show that this type of adaptation for public transport can be a very effective source of funding, which can result in significant increases in passenger numbers without increased subsidies. However, this assumes a stable, long term policy of priority setting and that public transport is allowed to retain the economic benefits of the improvements.

We have also looked at the consequences of introducing ”road pricing”. In this example we assume a 50 per cent increase in driving costs in the rush hour for all the cities. According to our calculations, this will result in 11 per cent increased public transport ridership in the rush hour and NOK 64 million in increased annual revenue. However, it would also increase the fleet requirements and operating costs by a total of NOK 124 million, so that the total subsidy requirement would increase by around NOK 60 million per annum. This corresponds to an average fare increase of around 7 per cent for all the cities taken together. Thus, road pricing will result in an increased subsidy requirement in the short term, while at the same time providing a significant economic benefit in the form of reduced congestion costs.

If it is possible to use the increased revenue to finance the required subsidy, the benefits of road pricing may be significantly increased. We have looked at one scenario where the increased revenue from road pricing is indeed used to fund the increased public transport subsidy.

These calculations show that an economically optimal level of subsidies will be approximately 1 billion NOK higher than today. If we introduce *”road pricing”*, the optimum subsidy level will be 800 mill NOK higher than today, or almost NOK 200 million per annum lower than the optimal level without road pricing.

Thus, if road pricing is introduced, there is a need to enhance the service level of public transport. Funding this improvement may pose a problem in the short term, depending on budget related barriers. In the longer term, however, the optimal subsidy level will be reduced because the benefits of transferring additional car users to public transport will be rather small and it will no longer be optimal to target large subsidies to such an objective.

Targeted government funding

Finally, we have examined different strategies for targeted government funding, where we start with the state authorities increasing the public transport subsidies for the four cities by 50 per cent, while fares remain the same. The increase in subsidies amounts to NOK 450 million per annum, which is just under half the economically optimal increase calculated above. We have examined various ways of distributing these funds so as to obtain the highest possible welfare gain, while also stimulating public transport companies to develop services in an economically optimal direction:

- An economically optimal allocation of subsidies, i.e. a distribution where the marginal economic benefit per unit of subsidy is the same in all the cities. No redistribution of subsidies between cities may provide higher economic benefit than this.

- A 50 per cent increase in subsidies for all the cities, combined with economic optimisation within each city.
- A 50 per cent increase in subsidies for all the cities, combined with commercial optimisation (production efficiency) within each city.

These analyses show that relatively small benefits can be obtained through redistribution of today’s subsidy amounts among the cities. This is is probably explicable by the county councils' experiencing tight budgets and heavy financial pressure at the outset. Under general economic optimisation, a 50 per cent increase in subsidies will result in around 40 per cent more departures and an increase in public transport ridership of between 13 and 17 per cent (table S.2). The economic benefit is nearly NOK 1200 million per annum.

Table S.2: The effect on an optimal public transport service of a 50 per cent increase in subsidies for the four largest cities, depending on the distribution criteria. Model calculations based on FINMOD

	Welfare maximisation		Profit maximisation
	Redistribution	Fixed distribution	Fixed distribution
Frequency	46 %	36 %	8 %
Capacity per hour	2 %	-1 %	8 %
Peak ridership	13.7 %	13.4 %	10.1 %
Off-peak ridership	16.8 %	16.3 %	8.3 %
Increased passenger benefits	1 083	1 019	563
Increased external costs	216	219	176
Marginal cost of public funding	-112	-112	-112
Overall economic benefits	1187	1126	627
Overall economic benefit per unit of subsidy increase	2.6	2.5	1.4

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If these funds are distributed on the basis of production efficiency, less emphasis will be put on frequent departures. Thus, frequency will rise by just 8 per cent and ridership by 8 to 10 per cent. However, this scenario will also give rise to a nice economic benefit of NOK 627 mill per annum. The most important reason behind these differences is that commercial profit maximisation will put greater emphasis on cost effectiveness, resulting in bigger buses and lower frequency. A general economic optimisation will favour more frequent departures with smaller buses.

Output based funding

Even though an optimal public transport service presupposes increased subsidies, the converse is not necessarily true. More subsidies do not automatically generate an economically optimal service. The public transport companies will operate according to standard business criteria, maximising their own profit rather than the social economic benefit. Even the authorities will not necessarily recognise how the service should be developed in order to achieve an economic welfare optimum. The question is therefore whether it is possible to find an optimal funding mechanism for the public transport companies, which reconciles the incentives of the public transport companies with the socio-economic objectives of the authorities. In some case it will be possible to give the public transport companies full market freedom and exploit the market knowledge which the companies already have, while incentives and framework conditions are set by the authorities.

In this project, we have considered one example of output based funding, where rush hour traffic and rail transport are allowed a somewhat higher subsidy rate:

- NOK 10 per rush hour passenger
- NOK 10 per vehicle km in and outside rush hour for buses
- NOK 18 per train km in rush hour and NOK 22 per train km outside rush hour for tramways and the underground

These incentives are not calculated so as to form an optimal level, but are meant as an example of a relatively simple and homogenous incentive system. This type of funding model will result in 23 per cent more passengers and an economic benefit of around NOK 1,3 billion per annum.

An optimal incentive structure must be fine-tuned to a degree which is beyond the scope of this project. These analyses show nonetheless that output based funding for the four largest cities can produce significant economic benefits and increased ridership, even when we use relatively simple and homogeneous incentives for all the cities.