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# Designing ridership incentives

**Kristine Wika Haraldsen and Bård Norheim**

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# Preface

This study is the second part of the larger project *Incentives and Evaluation for Improved Public Transport*. The study has been conducted in cooperation with VTI with funding from K2, Sweden's national centre for research and education on public transport.

Analyses are conducted by Kristine Wika Haraldsen and Bård Norheim. Andreas Vigren has provided data and contract descriptions and, together with Roger Pyddoke, Karin Brundell-Freij and Harald Høyem, contributed useful comments.

Oslo, September 2018

*Bård Norheim*

Urbanet Analyse

# Abstract

The objective of this study is to analyse the impact of different level of ridership incentives contained in public transport contracts in Sweden. There is evidence to suggest that, thus far, the inclusion of such ridership incentives in various types of contracts has had little or no effect. This raises the question of why incentives have proved ineffective and whether it is possible to estimate welfare-optimal incentive schemes. The study is based on a non-linear optimisation model with various constraints on the level of freedom within the contract. Five contracts in the Stockholm and Skåne regions are analysed.

These analyses show that output-based funding in the form of subsidies per passenger can produce significant economic benefits and increased patronage with the same level of public funding.

Public transport supply without subsidies can be profitable; however, if the operators are free to design the service, it will inevitably lead to higher fares, reduced service levels and larger buses. Therefore, a failure to subsidise public transport will result in a loss of welfare.

In order to achieve increased patronage through ridership incentives, the operator must have the necessary level of freedom to change the service level. If the operator cannot change fares or reallocate the supply, there will be no change in the allocation of resources or the number of passengers unless external shocks affect patronage.

A central result from this study is that ridership incentives must be significantly increased from current levels if they are to have an impact on patronage and take account of the welfare benefit to existing passengers. Without a basic subsidy, and given that the public authority retains ticket revenue, ridership incentives must be 220-300 percent of current ticket revenue in order to induce the operator to deliver a welfare-optimal level of service.

# 1. Introduction

The Swedish Parliament has set the specific political goal of doubling patronage (cf. the Swedish Doubling Project). A subsidy related to patronage is an intuitive and desirable policy instrument for achieving this goal, as such a subsidy provides an incentive for public transport operators to attract more passengers.

In order to ensure the efficient use of public funds, public authorities must consider how the level of subsidy influences an operator's supply of public transport services. Although subsidies in the form of incentives per passenger, referred to as *ridership incentives*, are common in Swedish public transport contracts, there is little research on what might be the optimal level of subsidy or incentive. The aim of this paper is to contribute to current knowledge regarding the optimisation of ridership incentives in order to ensure the efficient use of subsidies for public transport.

In this context, subsidies are defined as all financial transfers from public authorities to public transport operators. Total subsidies consist of ticket revenue, the gap between ticket revenue and costs (deficit of public transport) and ridership incentives. In the contracts studied, ticket revenues accrue to the local authority. The deficit of public transport is is defined as the operators costs less ticket revenue and reflects the negative profit of the operator. Ridership incentives are subsidies per passenger designed to induce the operator to increase patronage.

This working paper will discuss the implications of optimising ridership incentives based on an optimisation model leading to welfare optimisation for public authorities and profit maximising for operators under various budget constraints. The challenge is to identify the optimal incentive to the operator, seeking to maximise profits, to provide the socially optimal level of service for the public authority, seeking to provide the service within politically acceptable budget constraints. Optimal incentives depend on the possibilities open to the operator to influence passenger demand, and the fares and levels of service that are socially acceptable to the public authority. As an introduction, this section considers the public funding of passenger transport, the division of responsibility and financial risk between operators and public authorities, incentives in Swedish contracts and new contract design.

## 1.1. Public funding of public transport production

Market failures create a conflict between the socially optimal level of service derived by maximising social welfare and the operator's optimal allocation derived by maximising profits. A central issue for public authorities is how to ensure the efficient use of subsidies in motivating the operator to deliver a level of service close to the socially optimal level.

Subsidies are justified by the failure of the market for public transport. Due to economies of scale, the Mohring effect and external effects, the supply of public transport would be below the socially optimal level in a first-best solution. This market failure yields a second-best solution with public funding of public transport.

As public transport requires large initial infrastructure investments, the marginal operating cost is lower than the average cost. Without intervention from public authorities, economies of scale and large initial costs hinder competition and distort the market.

The Mohring effect is a network effect implying that not only new passengers but also all existing passengers benefit from increased supply, although this benefit to existing passengers is not included in the operator's economic assessments of an improvement measure. This implies that the price that ensures the socially optimal demand will not cover the operator's cost without public subsidies (e.g. Börjesson Fung and Proost, 2017).

Public transport measures also have external effects that are not included in the operator's economic assessments. Increased public transport production will reduce greenhouse gas emissions, local air pollution and congestion, although only if it reduces car use; otherwise, it will have the opposite effect.

Public funding may range from lump-sum subsidies for a fixed level of service, to output-based subsidies, such as ridership incentives, where the level of service is adjustable. Ridership incentives are one instrument to close the gap between the operator's allocation and the socially optimal level of service. The idea is that the operator receives a fixed sum or a share of ticket revenue for every new passenger and hence has an incentive to improve the service level in order to attract new passengers. The level of fixed and adjustable subsidies will be an important indicator in the contracts studied.

Previous theoretical and empirical studies of public transport conclude that there is a need for subsidies in order to achieve welfare-optimised service levels. These studies include Jara-Díaz and Gschwender (2008), who conclude that self-financial constraints on the part of a public transport operator provoke an inferior solution with reduced frequency and, under some circumstances, larger than optimal bus size. This is in line with the earlier results obtained by Jansson (1980) demonstrating that, for a given demand, social cost minimization results in more buses and smaller bus size compared to maximising profits. The studies show that, without public funding, public transport capacity, frequency and bus size fail to meet the socially optimal level.

These results are also found in empirical studies in Norway, such as Norheim (2005a), Norheim (2005b), Frizen and Norheim (2010) and Frizen and Norheim (2011). These studies derive the socially optimal levels of service in different areas and compare these to the profit-maximising operators' allocations with lower frequency and larger bus size.

## 1.2. Contractual division of risks and responsibilities

A number of new contractual forms have been developed for local public transport over recent years. These contracts are distinguished by the division of responsibilities, the distribution of financial risk and tendering procedures, as described by deVelde (2007) and discussed in Norheim (2017). Increased competition exposes a shift in the division of financial risk and responsibility between operators and public authorities. The transition from gross to net contracts and the establishment of new purchasing agencies are examples of this.

The revenue risk depends on the variations in patronage and the distribution of revenue between public authorities and the operator. Revenue risk depends on external factors affecting passenger demand and how ridership incentives are calculated. The revenue risk will depend on several public authorities; for example, those responsible for parking policy, zoning, traffic restrictions, etc. A high share of patronage-based subsidies will increase the external revenue risk and influence the balance between risks and responsibilities.

The production risk includes operating and investment costs and depends on the variation in external and internal costs and technological development. Investment costs include residual capital value at the end of the contract period. Operating costs include external factors such as variations in fuel costs, fees and wages, or internal factors such as variations in internal organisational costs, operating plans, sick leave, etc. during the contract period. Two important external production risks are the extent to which buses can be utilised for new contracts and fuel costs.

Van de Velde et al. (2008) divide current contracts between public authorities and operators into three main groups based on financial risk:

1. Management contracts where public authorities employ drivers, own vehicles and retain ticket income, while the operator manages the supply of public transport. In these contracts, most of the financial risk rests with the public authority.
2. Gross contracts where operators are responsible for the supply of public transport and shoulder the production risk while the public authorities retain ticket revenues. These contracts are common for tender contracts in Scandinavia.
3. Net contracts where operators are responsible for the supply of public transport and retain ticket income. In these contracts, most of the financial, production and revenue risk rests with the operator.

The list shows how financial risk is linked to responsibility in different contract types. The ability of an operator to influence revenue and production risks depends on the level of freedom in a given contract. The level of freedom decides at what level the operator can affect the supply of public transport, something that can be divided into three different decision-making levels; strategic, tactical and operational:

1. Strategic level applies to the overall objectives of public transport in terms of market share, mobility, environmental issues, etc. Public authorities are responsible for the strategic level and may include other social targets such as liveable cities, overall mobility for citizens, social inclusion and alternative use of public funding. For the purposes of this working paper, welfare optimum is used as an indicator for the public authority's objectives. The budget constraints and marginal cost of public funding is the financial framework for the contract linked to other sectors.
2. Tactical level applies to the concrete design of the route network and fares in order to achieve specific public transport objectives. These include the frequency of services, number of stops, bus size, fare level and the design of discount schemes. In many Swedish contracts, some level of tactical responsibility is transferred to the operator, and to some

extent, this is included in the evaluation of the tender. However, the level of fares and the system remain the responsibility of the public authority and, in most contracts, any changes in network design must be approved by the public authority. For the purposes of this working paper, the network design is fixed and any flexibility for the operator is related to headway-frequency, bus sizes and fares.

3. Operational level applies to the daily operation and delivered quality of the supply. This will primarily apply to cancelled or delayed services, but also the quality of information and service levels to passengers. The operator has operational responsibility as defined in the contract, and most contracts will include bonuses and penalties related to the delivered quality. This working paper will not focus on incentives related to the operational level.

The development of new contracts is linked to the conflict between the socioeconomic objectives of public authorities and the business objectives of operators. A net contract without restrictions will cause operators to alter supply in the direction of reduced frequency, larger buses and higher tariffs than can be considered socially optimal (Norheim 2005a). Economic incentives can correct for this conflict by moving towards more output-based subsidies and shifting the contractual balance between risk and responsibility.

By adding revenue or production incentives to contracts, some of the financial risk will shift from the public authority to the operator. When the operator receives subsidies per passenger, they are incentivised to attract more passengers. The operator can influence the numbers of passengers to a limited extent by adjusting the operational level. If the contract provides more freedom to make adjustments on the tactical level, the operator is able to increase the number of passengers and revenue to a larger degree. Therefore, the level of freedom granted to the operator must increase with new contractual forms.

The aim of new quality contracts, which includes incentives to the operator, is to increase the market efficiency of public transport provision. However, most European contracts awarded based on a quality approach have been at the operational level (QUATTRO 1998). This remains the case, although there have been a few exceptions of innovative contract development in recent years (van deVelde, 2007). This is related to the division of responsibility within local public transport in European countries, where public authorities are responsible for the strategic and tactical levels. The development of new and more innovative quality contracts must therefore be viewed in close connection with the division of responsibility at the various levels.

### 1.2.1. Classification of contracts

Any discussion regarding the optimisation of incentives in contracts should be related to the contractual framework for financial risk and responsibility as this affects public authorities and operators. Based on previous research, the operator's financial risk could be described as the level of external factors that may affect their total revenue. Transport Analysis (2018) has divided subsidies into four groups:

A. Fixed subsidies linked to a defined service level (revenue km/hours)
B. Subsidies per passenger
C. Other output-based subsidies (quality, satisfaction, etc.)
D. Reductions based on delivered quality (punctuality, cancellations, etc.)

**A**: A fixed subsidy linked to a defined service level entails a production risk for the operator. The external influence is first of all the cost of input factors such as fuel/energy and labour costs. Most contracts include a price indicator to adjust for this financial risk. Put simply, A may be regarded as entailing an internal financial risk based on production efficiency.

**B:** The risk related to subsidies per passenger depends on the operator's responsibility for various element at the tactical level, such as fares, frequency of service, network and bus type. The external influence is either local, for example traffic restrictions, zoning, parking policy, etc. or national/international influence such as economic growth, fuel costs, vehicle policy/taxation, etc. Put simply, B may be regarded as entailing external financial risk adjusted for the operator's level of responsibility (see below).

**C:** Other output-based subsidies are normally based on customer satisfaction indexes (CSI) and focus on elements that can be affected by the operator. Put simply, C is regarded as entailing an internal risk adjusted for the operator's level of responsibility (see below).

**D:** Reductions based on delivered quality are largely based on operationally-delivered service levels, taking into account factors such as delays, cancellations, etc., as well as customer satisfaction regarding specific service elements. Put simply, D may be regarded as entailing an internal financial risk.

Contractual financial risk can be divided into total financial risk and external financial risk. The total financial risk, or incentive share, is $(B + C - D)/(A + B + C - D)$. For all contracts in Sweden, the total financial risk, or incentive share, is estimated at 20 per cent as of 2015 (Transport Analysis 2018). Stockholm, Gävleborg and Skåne are the three counties (län) with the highest financial risk in their contracts, at between 30 and 40 percent. There is extensive variation in financial risk in the contracts within these counties (Transport Analysis 2018). In the Stockholm region, four contracts have a 100 per cent incentive share and in Skåne one contract has an incentive share of 93 per cent.

Financial risk can also represent an opportunity for the operator, depending on the market responsibility for the tactical level and demand elasticities for service improvements. The influence on passenger demand can be divided into three elements; **a**) internal public transport influence **b**) local authority influence and **c**) other external influence, and the operator's responsibility for service improvements can be defined as $\boldsymbol{\alpha}$. $\alpha$ is the share of generalised costs that the operator can influence.

The operators influence on service level and passenger demand will then be $(\alpha*a)/(a + b + c)$. The transport authorities influence will be $((1 - \alpha)*a)/(a + b + c)$ and other local authorities will be $b/(a + b + c)$. This can be used as an indicator of the responsibility for the outcome of contracts. It is important to design the contract so that the operator's level of responsibility and financial outcome are balanced.

To a certain extent, it is possible to adjust for the influence of local authorities on the contract design. One alternative is to define the external framework during the contract period and compensation if this is deviated from. All local decisions that may cause a positive or negative shift in passenger demand should be included; for example, any local-authority fare policy or parking policy.

This working paper will not go into details around contract design, although this section shows how a shift towards output-based subsidies affects the allocation of risk between public authorities and operators. Constraints of time prohibit a full risk analysis of the contract areas within this project; however, this is an interesting subject for further studies.

Focus will be on the consequences of different levels of responsibility for the operator, on optimisation of service levels and the level of ridership incentives. The different levels of responsibility ($\alpha$) will be based on fares, frequency of services and bus size, but not network design (trunk lines, etc) or bus type (electric buses, etc). The level of responsibility can also be regarded as a boundary for the minimum service level, e.g. the maximum fare level, minimum frequency, etc. If the intended service level is outside the boundary, the actual level of responsibility is not $\alpha$, but zero. For the purposes of this working paper, contracts are classified based on financial risk and responsibility, and the effect of various incentives and the balance between responsibility and financial risk in the contracts are studied.

The level of contractual freedom enjoyed by operators is difficult to describe accurately as these freedoms are not uniformly defined in contracts. Several contracts do not include the freedom to alter the frequency of services but do ask for proposals from operators while reserving decision-making powers for the public authority. This working paper may raise the discussion of whether there is a willingness to use the level of freedom for the operator, but not the authority's approval of the proposals. This should be studied over a longer period and a wider range of contracts. The modelling exercise can be used to investigate if the operator, in the interests of maximising profits, would be likely to alter the service level in an undesirable direction from the public authority's point of view; for instance, by increasing fares, reducing the frequency of services, or introducing smaller buses or differentiated fares.

## 1.3. Competitive tendering in Sweden

Since 1989, public transport contracts in Sweden have been awarded by competitive tender. Today, approximately 95 per cent of Swedish bus services are regulated by contracts between regional public transport authorities (PTA) and operators (Lidestam et.al. 2016).

Lidestam et al. (2016) have looked into different types of contracts and their impact on Swedish public transport. Despite extensive competition, between 1986 to 2009 cost-efficiency declined, perhaps due to the requirements and restrictions attached to public transport procurements and how these competitions are organised. Lidestam et al. point to a number of key challenges in terms of increasingly specific tender documentation and a lack of balance between incentives in the contracts and degrees of freedom granted to operators. A better balance between responsibility and financial risk for both public authorities and operators may be crucial to ensuring the efficient use of subsidies for public transport.

Within local public transport there are currently three main types of contracts (Transport Analysis 2015):

1. **Production Agreement or gross contract**. These are contracts where the operator takes on the production risk while the public authority retains ticket revenues. The public authority often defines the production, route network, bus sizes, etc., while the operator is able to affect the operational level.
2. **Incentive Agreement**. These are contracts where the operator takes on the production risk while the public authority retains ticket revenues (as in gross contracts), although the contract includes incentives such as subsidies per passenger. The operator's incentive to improve the level of service depends in the size of the subsidy.
3. **Service Concession Agreement**. These are contracts for commercial traffic which include significant market responsibility and financial risk to the operator.

There are a myriad of different contracts in Sweden and they are not easy to classify. The main difference between the different production and incentive agreements depends on the balance between responsibility and financial risk. We have listed the above types of contracts based on the level of risk and responsibility for the operator, with service concession agreements as the lowest commercial risk level. Incentive agreements include incentives related to the number of passengers, customer satisfaction, punctuality, cleanliness. etc. An overview of Swedish contracts distinguishes between ridership incentives above and below 25 percent of the total contract amount.

*Table 1-1: Types of incentive in Swedish public transport. 2015. Transport Analysis (2018).*

| **Incentives** | **Total number of contracts** |
|---|---|
| Passenger incentive <25% | 72 |
| Passenger incentive >25% | 42 |
| Customer satisfaction | 28 |
| Punctuality | 13 |
| Freight | 25 |
| Standard of vehicle | 22 |
| Others | 12 |
| No incentives | 167 |
| All contracts | 304 |

The table shows the use of incentives in public transport contracts in Sweden. In total, 228 of 304 contracts for the provision of public transport in Sweden do not include any incentives. Measured in the number of vehicle kilometers, 32 per cent of contracts include no incentives whatsoever, while only 19 per cent are highly incentivised (more than 25 per cent of total payments). Highly incentivised contracts are largely found in urban areas with a higher market potential (figure 1-1). The share of highly incentivised contracts increases from 7 to 19 per cent if we look at total number compared to total revenue, and 70 per cent of contracts are incentivised if we take into account the size of the contract.

However, for the majority of the contracts the level of incentives is low. For low-incentive contracts, 4 per cent of payments are made up of incentives, for medium-incentive contracts, 17 per cent and for high-incentive contracts 63 per cent.

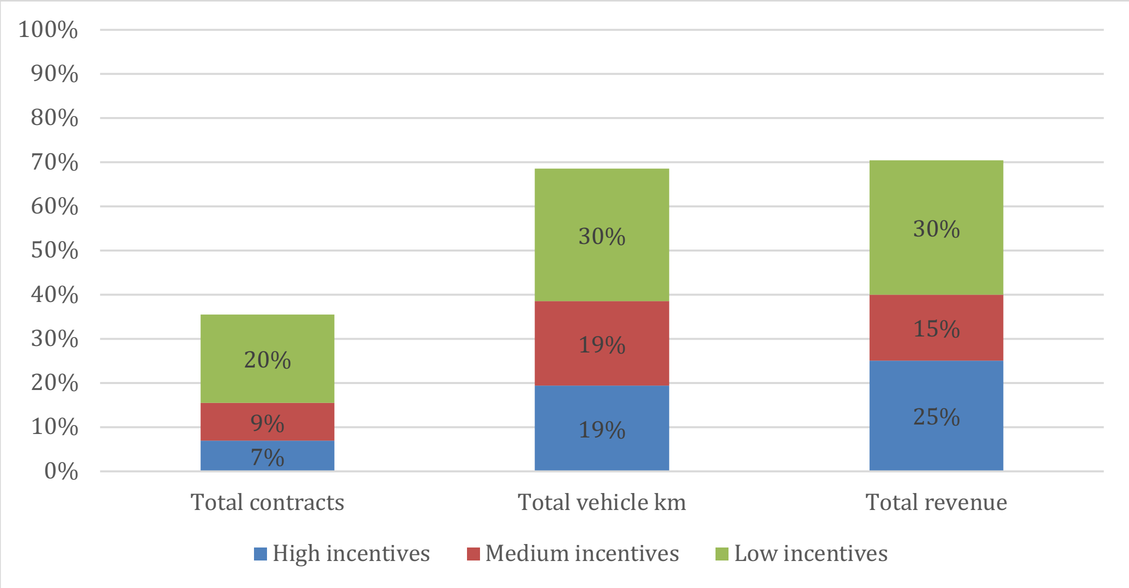


*Figure 1-1: Contracts with high and low incentives, share of total number of contracts, total vehicle km and total revenue. Transport Analysis 2018.*

There are a number of studies of the effect of incentives in Swedish public transport tendering showing that current demand incentives in Swedish contracts appear to be ineffective. Pyddoke and Swärdh (2017) find no significant influence from demand incentives in public transport contracts on patronage and costs in medium sized Swedish cities. The authors indicate that the combination of limited freedom for operators to influence variables affecting demand, and the low level of the demand incentives, were insufficient to give statistically significant effects.

Vigren (2017a and 2017b) has studied the effect of including ridership incentives in public transport contracts and finds that ridership incentives reduce the number of bids in the tendering process and reduces the probability of an operator participating in the tendering process. Vigren (2016) also showed that incentives contracts could not be proven to be more expensive than normal gross cost contracts.

## 1.4. Better contract design

Subsidies do not automatically generate an economically optimal service. Public transport providers operate according to profit maximising rather than maximising social welfare. In addition, due to budget constraints and political decisions regarding fares and service levels, public transport authorities will not necessarily recognise how the service should be developed in order to achieve welfare optimisation.

The question is therefore, whether it is possible to find an optimal funding mechanism for public transport contracts that reconciles incentivising of public transport providers with the welfare objectives of public authorities. The optimisation of incentives is dependent on the total amount of subsidies available and the level of freedom operators are granted to set fares and service levels.

In some cases, it will be possible to grant the public transport provider complete freedom to exploit the market knowledge they already have, while the public authority sets incentives and framework conditions.

### 1.4.1. Previous studies of optimal incentives in public transport contracts

Optimal contract design and the use of incentives are analysed in a number of Norwegian studies. Carlquist et al. (1999) study the potential of using incentives in public transport contracts in Hordaland and shows that it is possible to set fares and design subsidies so that operators will adapt approximately in line with the socially optimal level.

Bekken et al (2003) calculate optimal levels of subsidies per passenger, per vehicle kilometre and per seat kilometre, by studying operator's allocation to different levels of incentives in Grenland. The study concludes that a combination of incentives is likely to prove most efficient. Fearnley and Norheim (2002) conducted a similar analysis for the rail company NSB and found higher optimal levels of subsidies for railways than for buses.

Bekken and Norheim (2006) analyse the use of incentives in six Norwegian urban areas and find large potential gains in standard contract design with quality-dependent incentives. Calculated approximate optimal subsidies per passenger is NOK 5 as standard and NOK 10 in peak hours, in addition to ticket revenues accruing to the operator.

Norheim et al (2009) show that the public transport company Ruter in Oslo can increase ridership by 16 per cent without increasing subsidies by introducing performance-related subsidies. This analysis of contract design in competitive tendering argues for increased levels of freedom for the operator to ensure the desired effects of performance-related subsidies.

Most of these studies focus on welfare optimisation with a high level of freedom for the operator and combinations of passenger and production incentives. This study is more focussed on the implications of different levels of freedom in existing Swedish contracts and balancing risk and responsibilities through the level of incentives and the level of freedom. The study is therefore limited to increasing levels of ridership incentives.

### 1.4.2. Research questions and contribution

The public transport sector (the Partnership for Improved Public Transport and the Swedish Doubling Project) has prepared recommendations for the use of incentives in contracts. However, there is little research on the effects of insentives in Swedish public transport contracts, nor on the optimal level of such incentives.

To contribute to current knowledge in this area, the paper will investigate the following questions:

1. Is it possible to redistribute resources to increase social welfare from public transport, without increasing public funding?
2. How will the level of freedom for operators to set fares and service levels affect this goal?
3. What is the effect of operating without public funding, and what are the welfare gains of the current level of public funding?
4. What is the expected effect of existing incentives in the five contract areas, compared to the objective of increased service level and number of passengers?
5. Is it possible to design optimal incentives that combine maximising welfare and business profitability?

The conflict between socioeconomic and commercial profitability and the welfare benefits of subsidies has been the topic of several earlier studies, such as the examples highlighted in this introduction. In addition, there are a number of Norwegian studies of optimising the level of services and incentives. The main goal of this study is to contribute to current knowledge regarding the balancing of risks and responsibilities; that is, the balance of incentives and levels of freedom. This is done by investigating how the optimal level of ridership incentives relates to the operator's freedom to alter fares, frequency of service and bus sizes.

Five existing contracts are analysed to evaluate the potential of current incentives and the potential of optimising ridership incentives. The analysis is based on data in the public domain, and the contracts analysed will be approximations of the actual contract areas. This study will contribute to an understanding of the lack of effect of current ridership incentives in Swedish public transport contracts, and how incentives can be optimised to increase patronage. The level of service which maximises social welfare will be compared to the level of service provided by an operator seeking to maximise profits given the level of freedom included in the contract. The optimal incentive levels are investigated by studying the operator's allocation dependent on the level of incentives and level of freedom in the contract. These optimal incentives combine profit maximisation with the socially optimal level of service.

This study is part of the project *Contract procurement, management, and competition in public transport: a proposal to enhance knowledge for better contract design and improved transport services*, which is conducted with grant from K2.

The paper is organised into six sections. The five contracts evaluated are described in Section 2. The allocation for increasing levels of incentives is studied with the aid of an optimisation model for public transport, OPTMOD, which is described in Section 3. Section 4 contains results and a discussion while Section 5 is a conclusion.

# 2. Contract descriptions

Five different contracts from two Swedish regions were selected for the model simulations. The contract areas E22 and E23 are located in Stockholm County while the City of Lund, North East Skåne and Landskrona are located in Region Skåne.

## 2.1. Stockholm County

The Stockholm region is Sweden's largest in terms of population and consists of 26 municipalities with a total of 2.3 million inhabitants, situated in the mid-south part of Sweden. Stockholm County Council (SCC) is responsible for the provision of public transport in the Stockholm region and has procured such services since the early 1990s. SCC has used passenger incentive payment schemes for many years and the current contract form is called VPB-contracts (Verified Paid Boardings). VPB contracts have two distinguishing features compared to traditional gross-cost contracts.

Firstly, the operator is paid according to patronage on contracted lines. For each boarding passenger, the operator receives a pre-determined mode-specific payment. In addition to the VPB payment, the operator receives an annual fixed subsidy. Before the tender asking time, SCC will have determined what proportion of the total payment should be made up of the VPB payment. Operators then tender accordingly, specifying a VPB price and, where applicable, a fixed annual payment. In evaluating tenders, an evaluation price is calculated with these two components as the only revenue sources for the operator, excluding a start-up payment and minor quality incentives such as costumer satisfaction, etc. In the evaluation price, quality criteria are also graded.

Secondly, compared to a traditional gross-cost contract, the operator is given more freedom in designing the supply of traffic included in the VPB contract. Normally, the tender documentation will state that, with some exceptions, the operator has independent responsibility for planning traffic in the area, and that planning should aim for a development towards efficient public transport that increases patronage. SCC determine minimum requirements for the level of service and may veto or change the operator's annual plan. In addition, the operator is responsible for local marketing campaigns while SCC holds the overall marketing responsibility for the public transport network.

In essence, depending on its design, the VPB contract could be viewed as an intermediate stage between a net-cost and gross-cost contract. The operator is paid based on the number of passengers and has the freedom to change the level of service. Ticket revenues are collected by the public transport authority (SCC), which also sets fares and determines special and functional requirements for the contract. Because the operator's payment is based on verified paid boardings (paying passengers) the contract incentivises the validation of all tickets.

The operator's responsibility for public transport planning (with the exception of fares) and service levels constitutes a relatively high share of market responsibility.

### 2.1.1. E22 contract

The E22 contract entered into force in June 2014 and covers bus traffic in the most urbanised area of Stockholm, the inner city, and the island of Lidingö. The public transport network also includes the Metro, trams and commuter rail services, making it a multi-modal traffic environment. Traffic runs on 47 lines with a yearly production of 14.8 million vehicle kilometres.

The contract was awarded in 2013 to the French operator Keolis, with a winning tender of SEK 980 MSEK[1]. This was 19 per cent less than the second-lowest bid. In total, SCC looked at three tenders for the contract.

Of the operator's initial subsidy, 50 per cent is a fixed annual payment as quoted by the operator in their tender, while the other 50 per cent is made up of VPB payments. According to contract data obtained from Transport Analysis, the average cost to SCC per boarding passenger in 2015 was SEK 11, with 89.2 million passengers transported. The VPB payment is SEK 5.5, making the total incentive level in the contract 50 per cent.

### 2.1.2. E23 contract

The E23 contract covers bus traffic in the three local municipalities of Handen (Haninge), Nynäshamn, and Tyresö, suburban districts of Stockholm, and covers most of the traffic in these areas. The contract includes 62 lines with an annual production of 18 million vehicle kilometres. Many lines serve nearby commuter stations or the Metro network.

In 2014, the operator Nobina was awarded the contract with a winning tender of SEK 609 million. This was 9 per cent less than the second-lowest, and only competing tender.

Revenue is based solely on VPB payments, meaning that the only revenue stream for the operator is through boarding passengers. According to the contract data from Transport Analysis, in 2015, 31.2 million passengers were transported at a payment per passenger of SEK 22. The total incentive level in the contract is therefore 100 per cent.

## 2.2. Region Skåne

The Skåne region, with its 1.3 million inhabitants, is Sweden's southernmost and third largest region, and consists of 33 municipalities. While Region Skåne is the official public transport authority (PTA), operational responsibility (such as procurement, ticketing systems, marketing, etc.) rests with the Region's administrative agency Skånetrafiken. Skånetrafiken has been procuring public transport services for three decades. Contractual forms have shifted through traditional gross-cost contracts, to net-cost contracts (ex. Helsingborg), and since 2013, all new contracts have included ridership incentives. The

[1] 1 SEK = 0,1 Euro, september 2018.

contracts also include quality incentives based on cancelled departures and vehicle deviations.

The current contracts could be viewed as gross cost with ridership incentives, with the operator's revenue based on a two-part model with a fixed and a per-kilometre element. In addition, the contracts include a subsidy per passenger, fixed at SEK 5 per boarding passenger in urban traffic, and SEK 10 in suburban or rural traffic.

Generally, the operator is not involved in deciding fares, and Skånetrafiken sets contractual requirements for vehicles. However, to some extent the operator is able to affect the supply, with a cooperation agreement stating that the two parties will work together to agree timetables based on a detailed annual proposal from the operator.

### 2.2.1. City of Lund

Lund is the third largest city in the Skåne region and is characterized by its 36,000 students. Lund University is the fourth largest in Sweden and 40 per cent of the city's population are students. The procurement for the City of Lund covers traffic in urban areas, where buses provide the only public transport, and according to the tender documentation includes eight bus lines with an annual production of 2.73 million vehicle kilometres.

The current contract was awarded to Stadsbussarna Sverige in 2012. The operator's tender was less than 2 per cent lower than the second-lowest bid, with a total of four operators tendering.

The payment model to the operator is in line with the general description above. Annual payments in 2015 were SEK 119 million for 10.4 million boarding passengers, SEK 42 million of which was ridership incentives. The operator receives SEK 5 per boarding passenger, giving an incentive share of 35 per cent.

### 2.2.2. North East Skåne

This contract covers the northeast parts of Skåne and eight regional lines. These lines traffic what can roughly be described as a triangular area comprising Hässleholm, Sölvesborg, and Älmhult, feeding travellers to the nearby larger cities and commuter rail stations. According to the tender documentation, annual production totals 3.3 million vehicle-kilometres.

In the most recent procurement in 2012, Bergkvarabuss was the only operator to tender for the contract.

The payment model to the operator is in line with the general description above. The total payments from Skånetrafiken to the operator in 2015 was SEK 96 million, of which SEK 16 million was ridership incentives payment. The operator transported 1.7 million passengers during 2015. Because the contract serves less urbanised areas of Skåne, the passenger incentive is SEK 10, with an incentive share of 17 per cent.

### 2.2.3. Landskrona

The contract for Landskrona, Skåne's fifth largest city, covers urban bus traffic. The contract includes the only trolley bus system in Sweden. According to the tender documentation, the five lines have an annual production of 1.2 million vehicle-kilometres.

The procurement in 2013 was the subject of three tenders, with lowest bidder Nobina being awarded the contract to operate traffic for 10 years. The second-lowest bid was 2.3 per cent higher than Nobina's successful tender.

The payment model to the operator is in line with the general description above, with total contracted payments of SEK 38 million for 2015, approximately 25 per cent of which was paid in accordance with a ridership incentives scheme. In 2015, the operator transported 2.4 million passengers. The scheme provides the operator with a revenue of SEK 5 per boarding passenger.

## 2.3. Summary characteristics

As described in section 1.2.1, financial risk for the operator can be described as the level of external factors that can affect the total revenue. Transport Analysis (2018) has divided the subsidies into four groups:

A. Fixed subsidies linked to defined service levels
B. Subsidies per passenger
C. Other output-based subsidies (quality, satisfaction, etc.)
D. Reduction based on delivered quality (punctuality, cancellations, etc.)

The financial risk in the contracts can be described as the incentive share (B + C − D)/(A + B + C − D). For all contracts in Sweden the total financial risk, or incentive share, is estimated to 20 per cent for 2015 (Transport Analysis 2018). Stockholm, Gävleborg and Skåne are the three counties with the highest financial risk in their contracts. There is extensive variation in financial risk in the contracts within these counties (Transport Analysis 2018), but all contracts analysed in this paper has a relatively high incentive share.

The E23 contract is 100 per cent incentive based, while Landskrona and North East Skåne have only a small fixed subsidy, making the contracts 96 and 94 per cent incentive-based respectively. This implies high financial risk for the operator. The significant difference between these contracts is that the E23 contract is based on subsidies per passenger which implies considerable external risk, while the Landskrona and North East Skåne contracts are mainly based on other output-based subsidies. In these contracts, other output-based subsidies are mainly subsidies per vehicle-kilometre, implying internal risk.

The E22 contract is based on 50 per cent fixed subsidies and 50 per cent subsidies per passenger. This is the contract with the lowest incentive share but implies relatively high external financial risk as the incentive per passenger share is high compared to the Skåne contracts. Lund has a high incentive share and incentive-per-passenger share compared to the national average but is in the middle among the five contracts analysed.

*Table 2-1: Total financial risk described as the incentive share in the contracts. MSEK.*

| | E22 | E23 | Lund | North East Skåne | Landskrona |
|---|---|---|---|---|---|
| Fixed subsidy (MSEK) | 498.1 | 0.0 | 21.6 | 5.6 | 1.4 |
| Ridership incentives (MSEK) | 485.1 | 347.6 | 42.4 | 16.4 | 10.7 |
| Other output-based subsidies (MSEK) | 0.0 | 10.1 | 55.5 | 73.9 | 26.1 |
| Reduction based on delivered quality (MSEK) | 8.3 | 3.0 | 0.4 | 0.2 | 0.0 |
| Incentive share | 49% | 100% | 82% | 94% | 96% |
| Ridership incentive share | 50% | 98% | 36% | 17% | 28% |

The five contracts have various divisions between subsidies and incentives, they cover operations in different types of environment and they differ in scope in terms of subsidies and patronage. This is to capture any variations in results across the different contracts. The table below summarises the characteristics of the five contracts.

*Table 2-2: Summary characteristics.*

| | E22 | E23 | Lund | NE Skåne | Landskrona |
|---|---|---|---|---|---|
| Environment | Urban | Suburban | Urban | Rural | Urban |
| Patronage per year (million) | 89 | 16 | 10 | 2 | 2 |
| Vehicle km (million) | 14 | 9 | 3 | 3 | 1 |
| Total contract sum (MSEK) | 980 | 609 | 119 | 96 | 38 |

# 3. Method

The objective of this research is to find optimal ridership incentives that combine profit maximisation for the operator with welfare optimisation for the public authority. If public authorities wish to give operators more freedom in designing services in order to achieve the doubling target, a method will be required to analyse how operators are likely to adapt to different contractual incentives and regulatory frameworks.

Most contracts cover a period of 6-10 years and their original service levels will inevitably need to be adjusted during this period; either because of demographic changes or because of changes in the framework for public transport in the area. It is important to create a dynamic contract that allows for cooperation between the operator and public authority in order to adapt to market changes. This is only possible if any solution is positive for both parties; providing welfare benefits for the public authority and profitability for the operator.

The ability to understand the likely effects of new incentive-based contracts will depend on a model that can predict how operators will adapt to different incentives under various financial or regulatory frameworks. For the purposes of this study, a stepwise method has been chosen:

1. Step one is to understand the differences between social welfare optimisation and profit maximisation under different budget constraints.
2. Step two is to identify the optimal service level with regard to social welfare within specific budget constraints.
3. Step three is to identify the necessary ridership incentives to achieve this welfare optimal service level.
4. Step four is to investigate the effects of existing contractual incentives so that possible outcomes can be predicted.

For each of these steps, an optimisation model (OPTMOD) is used, in which it is possible to change:

1. The optimisation criteria (social welfare or profit maximisation)
2. Budget constraints (subsidy level)
3. Regulatory issues (min/max level, or fixed service level for public transport, including frequency of service, fares and capacity/bus sizes)

OPTMOD is a nonlinear optimisation model under non-linear constraints and is very useful in investigating the balance between financial incentives and level of freedom in contracts. The model is aggregated for the various contract areas, with the only divisions being between peak, below-capacity peak and off-peak periods. The optimisation procedure results in some limitation on possible analysis:

1. It is not a network model and cannot be used to investigate the effects of trunk lines, etc. This must be done in network models such as Sampers, Visum, etc.

2. It is not possible to analyse the effects of a fixed service level if it is not optimal. However, it is possible to analyse the effect of certain service-level parameters, for example maximum fare level, minimum bus size, minimum frequency, etc.
3. All the elements included in the model must have a benefit and cost for passengers and operators. More detailed service improvements, such as punctuality, reliability, etc. can only be included if there are studies demonstrating the cost of such improvements.

The optimal level of service depends on budget constraints as well as the characteristics of the area in question. The operator maximises profits in line with production efficiency, taking only traffic revenue, subsidies and operating costs into account. The public authority maximises social welfare in line with general economic efficiency and includes user benefits, the marginal cost of public funds and external costs in the equation[2]. The optimal service level may therefore be different for each party.

A subsidy scheme is optimal if it causes the profit-maximising behaviour of the operator to resemble the situation of maximum social surplus. By identifying the socially optimal service level and simulating the profit-maximising behaviour of the operator when offered different incentives, variations in allocation are visible and the incentives can then be adjusted until the profit-maximising operator behaves in a socially optimal manner.

Fixed grants are disregarded in the analysis as the study focuses on the relationship between the level of incentives and the level of freedom. Fixed subsidies are linked to a fixed production and cannot be combined with a higher level of freedom for the operator. It is however possible to include fixed grants in the model linked to a minimum service level, with the only option being to increase the frequency and level of services.

Ridership incentives are the only subsidies included in the calculations, even though most contracts combine a set of different incentives and a fixed subsidy. Again, this is to cultivate the relationship between the operator's level of freedom and the optimal level of ridership incentives. All five contracts analysed include bonus/penalty clauses based on criteria such as cancellations, which are not included in the analysis.

Furthermore, the operator may take other measures to increase patronage which are not included in the model; for example, measures to increase customer satisfaction through improved customer service. Earlier studies indicate that hard measures such as frequency of service and fares are the main drivers of customer satisfaction (Norheim el al. 2013). This supports the idea that an operator's ability to increase patronage depends on their level of freedom to alter parameters such as frequency of service, fares and capacity.

However, all types of measure that may increase patronage will be reviewed if the operator regards it as profitable. The model cannot predict the effects of other measures, but all measures that are more profitable than frequency of service, fares and capacity will take precedence. These include the introduction of trunk lines and improved punctuality, as well as improved information and courtesy from the driver.

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[2] This assumption is not necessary true, and many other criteria can be incuded in public transport planning. Welfare optimum must be regarded as an indicator and benchmark for the public authority's objectives in providing public transport.

## 3.1. Optimising public transport supply

Optimal service levels and incentives are analysed with the use of an optimisation model for public transport, OPTMOD. Previous versions of this model were used in studies by, inter alia, Carlquist et al. (1999), Bekken et al (2003), Norheim (2005), and Bekken and Norheim (2006). Although the model has been developed over recent years, its basic principles and a comprehensive analytical presentation of the mathematical solution is presented in Larsen (2004).

To solve the model, the OPTMUM module in GAUSS is used together with an objective function constructed as an augmented Lagrangian. The augmented Lagrangian deals with the constraints on optimisation. This procedure solves the optimisation problem using non-linear programming with non-linear constraints.

OPTMOD is a strategic model, providing the direction of effects rather than an accurate solution to the design of an optimal level of service. Its strength is that it can handle combinations of constraints on funding and the operator's degrees of freedom simultaneously. This makes it possible to calculate the economic consequences of various funding constraints and compare alternative strategies.

Incentives are used to induce the operator to behave as if it is internalising the external effects of levels of service and fare setting. The benefit to existing passengers can be included, as well as additional costs and benefits related to the transfer of car traffic. The model also reflects the fact that public funds have a marginal cost and alternative uses. Furthermore, the model allows for the inclusion of constraints related to capacity, fares, total amount of subsidies and minimum levels of service. The model calculates changes from a reference point using non-linear programming with non-linear constraints.

The *normal* planning procedure for public transport authorities will be to maximise welfare within a specified budget and under constraints imposed by political decisions regarding fare level and differentiation. The main benefit of using a non-linear optimisation procedure for the calculation of different combinations of incentives will be to obtain an overview of the consequences of this interrelation and different financial constraints. Partial consideration of the effects of incentives will not take such cross-effects into account and may therefore underestimate potential conflicts between the various effects of constraints.

Within the model, changes in net social surplus are:

1. Changes in the operator's profit (producer surplus);
2. Changes in passenger benefits (consumer surplus);
3. Changes in environmental and congestion costs (externalities), and
4. Marginal cost of public funds.

## 3.2. Model structure

The model determines socially optimal levels for 7 variables; (i) fare levels for three periods of demand; (ii) vehicle-kilometres per hour produced in basic services and additional peak services; and (iii) bus size, or the number of seats and standing places in basic services and additional peak services. There are three types of agents; the operator, the public authority and passengers.

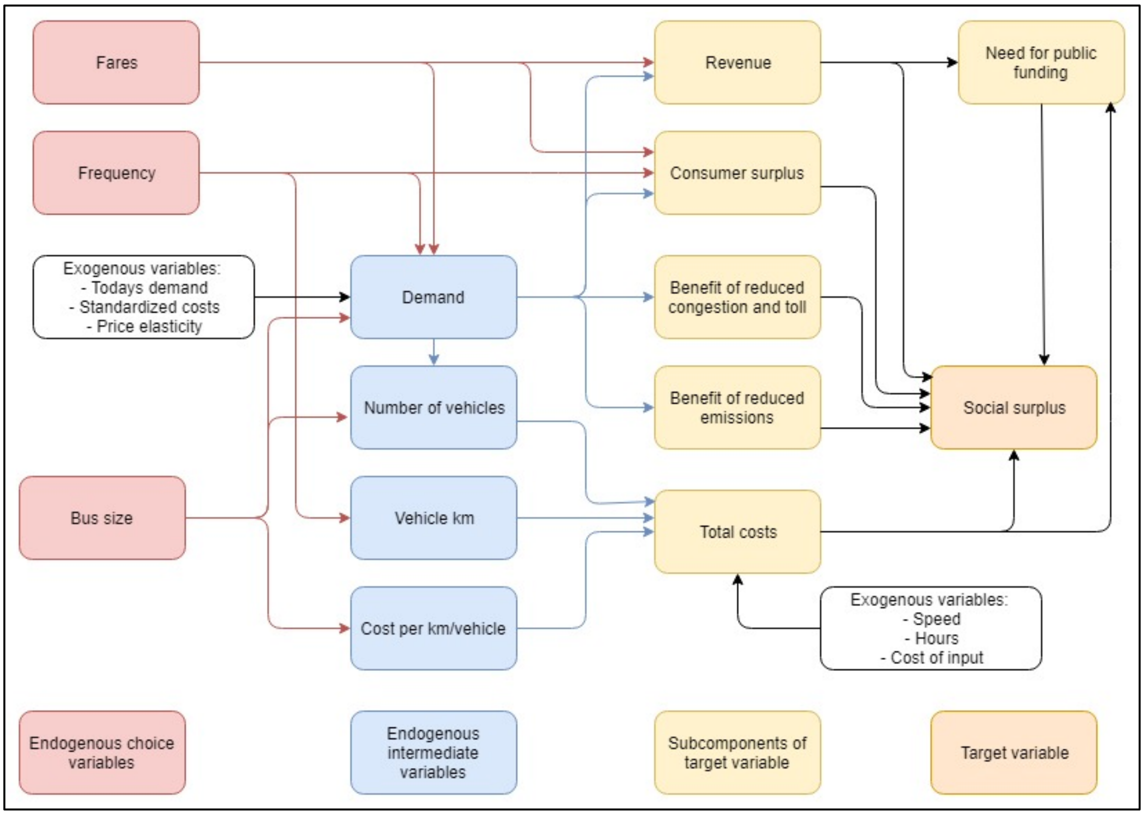



*Figure 3-1: Schematic overview of the steps in the optimisation module.*

**The operator maximises profits:**

*Profit* = *farebox revenue + incentives – cost*

=*fare*passengers + ridership incentives*passengers - cost*

$$Profit = \big(FR(Pa, Pb, Pc, Ya, Yb, Yc) \\ - C(VKMbasic, VKMadd, Bbasic, Badd, Ya, Yb, Yc)\big) * \theta$$

Profits are fare revenue (FR) less the cost of public transport services (C) and depends on fares, the level of service, capacity and passengers. $Y_a$, $Y_b$ and $Y_c$ equals demand while $P_a$, $P_b$ and $P_c$ are fares in the three periods of time. $VKM_{basic}$ and $VKM_{add}$ equals vehicle-kilometre while $B_{basic}$ and $B_{add}$ are bus size in the two categories of supply. θ is the marginal cost of public funds.

**The authority maximises social welfare:**

*Social surplus = Subsidies*marginal cost of public funding*

*+ benefit for passengers*

*+ reduced car traffic*

*+ reduced emissions*

$$
\begin{aligned}
Social\ surplus &= \big(FR(Pa, Pb, Pc, Ya, Yb, Yc) \\
&- C(VKMbasic, VKMadd, Bbasic, Badd, Ya, Yb, Yc)\big) * \theta \\
&+ CS(Pa, Pb, Pc, VKMbasic, VKMadd) \\
&+ CO(Ya, Yb, Yc) \\
&+ EM(Ya, Yb, Yc, VKMbasic, VKMadd)
\end{aligned}
$$

As for the operator, profit equals fare revenue (FR) minus the cost of public transport services (C) and depends on fares, the level of service, capacity and passengers. Consumer surplus (CS) is the economic surplus of passengers which depends on fares and the level of supply of transport services. The benefits of reduced congestion and toll expenses (CO) depend on demand for public transport as a given share of the increased demand from transferred car drivers. If congestion charges are in place, with tolls equal to congestion costs, this part will be eliminated. The model includes the revenue from car tolls in the evaluation. Emissions (EM) from cars depend on demand while emissions from buses depend on the service level of public transport.

### 3.2.1. Passenger demand

Demand is divided into three periods; (i) demand during peak periods at full capacity; (ii) below-capacity peak-period demand; and (iii) off-peak demand. $Y_a$, $Y_b$ and $Y_c$ equals demand while $P_a$, $P_b$ and $P_c$ are fares in the three periods of time. $\theta$, the marginal cost of public funds, is included as public transport supply is subsidised by public funding.

For the purposes of this study, demand elasticities for frequency and fares are based on an international literature survey. Both Swedish and international studies show that price sensitivity is higher outside of peak times than during peak hours (Norheim et al., 2017). Meta-analysis of price elasticities for local public transport by time of travel conducted by Hensher (2008) indicates elasticity of -0.25 in peak hours and -0.34 for the whole day. Balcombe (red) (2004, p.58) indicates price elasticity at -0.26 in peak hours and -0.48 outside peak hours in the UK. Based on this data, the price elasticity in the benchmark situation is set to -0.25 in peak hours, -0.34 for other peak hours and -0.48 in low traffic.

Holmgren (2007) has estimated an average price elasticity based on 81 different price studies, estimated to -0,38 (Holmgren 2007). He also calculated the interaction between revenue and service level. When he includes the funding element in price elasticity, the effect is doubled from -0,38 to -0,75. The model will include the funding effect in the calculation and will therefore use the short-term effect.

Based on Preston (1998), elasticity with respect to supply, or the level of service, is set to 0.36 in peak hours, and 0.58 in low traffic. Low traffic is calculated as the average of early morning, evening, Saturday and Sunday. There is little information about the supply elasticity in other peak hours. The elasticity is expected to lie between the value of peak hours and low-traffic. Thus, the average between peak hours and low traffic at 0.47 is used.

Balcombe et al. (2004, pp.82-83) show elasticity for demand for bus travel with regard to travel time on board, waiting time and walking time are in the range between -0.3 and -0.4. The report shows that the elasticity is consistently lower for leisure trips than for work trips. Based on this, the elasticity is set to -0.4 in peak hours and -0.3 outside peak hours.

*Table 3-1: Elasticities in the benchmark situation. All elasticities are short term effects, about 1-2 year after changes.*

| | |
|---|---|
| Price elasticity peak hours | -0.25 |
| Price elasticity other peak hours | -0.34 |
| Price elasticity low traffic | -0.48 |
| Elasticity with respect to supply peak hours | 0.36 |
| Elasticity with respect to supply other peak hours | 0.47 |
| Elasticity with respect to supply low traffic | 0.58 |
| Elasticity with respect to generalized time peak hours | -0.4 |
| Elasticity with respect to generalized time low traffic | -0.3 |

**Calibration of demand elasticities**

Demand is determined, within the model, by fares and level of service (vehicle kilometres as a proxy for frequency), as well as by price elasticity and elasticity with respect to generalised travelling time. The functional form is presented below.

$$Y_i = A_i e^{-\lambda_i (P_i + \alpha_i VKM_i^{\beta i})}, \qquad i = a, b, c$$

$A_i$, $\lambda_i$, $\alpha_i$ and $\beta_i$ are parameters and $q_i$ is the fare and $X_i$ is the supply of services faced by the category of demand, i.e. either $X_{BASIC}$+$X_{ADD}$ or $X_{BASIC}$ (when i=c).

Consumers' surplus is given by:

$$CS_i = \frac{1}{\lambda_i} Y_i, \qquad i = a, b, c$$

The elasticity with respect to price increases with the fare level and is given by:

$$\varepsilon_i = -\lambda_i P_i, \qquad i = a, b, c$$

The elasticity with respect to the service level is given by:

$$\sigma_i = -\lambda_i \alpha_i \beta_i VKM_i, \qquad i = a, b, c$$

With $\alpha_i$ >0 and $\beta_i$<0 the elasticity is positive and decreases with the level of service and approaches zero for large values of $VKM_i$, which is reasonable to assume.

The demand function is calibrated for each of the three periods of demand. There is no cross elasticities between different categories of demand. Such effects may be small but disregarding them represents a simplification. Another simplification is that the level of service is equal to $VKM_{BAS}$ + $VKM_{ADD}$ for peak traffic and to $VKM_{BAS}$ for off-peak traffic. The level of service is rarely constant at all times outside of peak periods.

### 3.2.2. Costs

The level of service is divided into two categories; a base service level which runs throughout the operating hours, and the additional peak services that add to the basic services during peak hours. The peak period supply defines the bus fleet. $VKM_{basic}$ and $VKM_{add}$ equals vehicle-kilometres while $B_{basic}$ and $B_{add}$ are bus size in the two categories of supply.

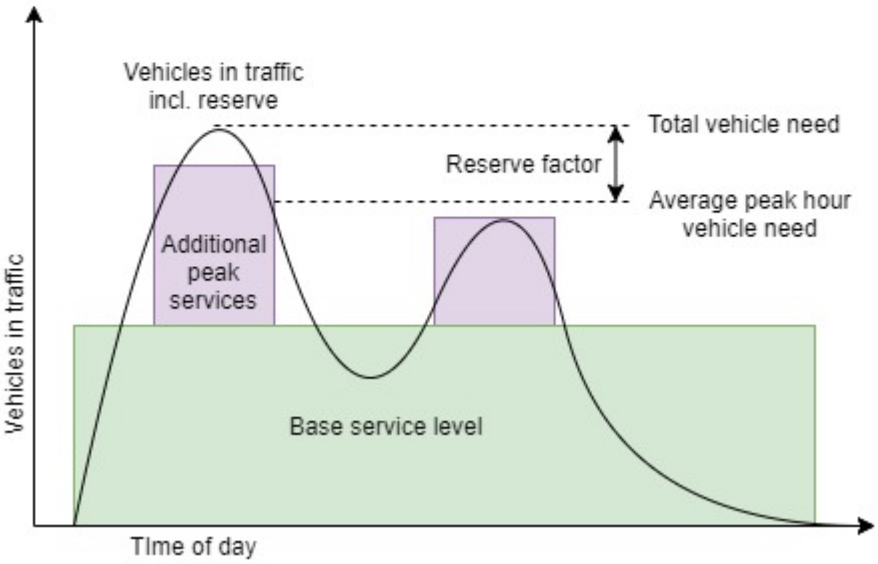



*Figure 3-2: Schematic representation of base and additional peak service level. Illustration based on Bekken 2004.*

The operating cost is to a large extent dependent of vehicle capacity during peak periods, and the number of buses and peak hours is used to calculate the division between peak and off-peak vehicle-kilometres and the marginal cost of increased service levels.

The cost structure is based on Bekken (2004). Operating costs include personnel (pc), maintenance (oc), fuel (fc) and cleaning (cc). These mileage-dependent costs increase with bus size and are higher during peak hours, mainly due to lower speeds and less efficient utilisation of labour and capital.

Capacity in this aggregated model is treated as continuous even though bus size increases in discreet jumps. This simplification is justified as any average capacity per vehicle-kilometre can be obtained by an appropriate combination of buses. Costs per vehicle-kilometre are assumed to be a linear function of capacity.

Capital costs (g) are determined by the peak-period demand for capital, and depend on the fleet size, its repurchase value, and the amortisation factor.

In addition to operating and capital costs there are administration costs (a) which are treated as an error term aligning calculated and actual costs of providing public transport services.

$$C = \left(pc\left(\frac{km}{h}\right) + oc\left(bus\ size, \frac{km}{h}\right) + fc\left(bus\ size, \frac{km}{h}\right) + cc(constant)\right) * vehicle\ km + g(\ fleet\ size, re - purchase\ value) + a$$

### 3.2.3. Benefit of transferring car drivers

The benefit of transferring car drivers consists of two parts; reduced congestion and tolls for car drivers, and the reduction in emissions from reduced car traffic. The benefits of reduced congestion and toll expenses (CO) depend on demand for public transport as a given share of the increased demand from transferred car drivers. If congestion charges are in place, with tolls equal to congestion costs, this part will be eliminated. The model includes the revenue from car tolls in the evaluation to estimate the net benefit of transferred car drivers, adjusted for internalised congestion costs.

The benefit of reduced congestion and toll expenses is described by the following formula:

$$CO\ =\ mccar * e^{\pi(-(Y_1^0 - Y_1)*b)}(Y_1^0 - Y_1) * b + bom * a * (Y_1^0 - Y_1) * b$$

*mccar* is the benefit of one additional public transport passenger due to reduced congestion in the benchmark situation and *b* is a parameter for the share of passengers transferred from car. *bom* is the consumer's toll cost while *a* is the share of car drivers paying tolls. *CO* is the benefit in terms of reduced congestion and tolls from a change in public transport trips of ($Y_1^0 - Y_1$), where $Y_1^0$ is the demand in the benchmark situation. The formula takes into account that queuing is reduced when patronage increases.

Transferring car drivers to public transport reduces emissions of greenhouse gases and local air pollution. An increase in the supply of public transport will increase emissions. The total benefit of reduced emissions is described by the following formulae:

$$EM\ =\ bec * (Y_1^0 - Y_1) * b\ * km -\ beb *\ (X_1^0 - X_1)$$

*EM* is the benefit of one additional public transport passenger due to reduced emissions from a change in public transport trips of ($Y_1^0 - Y_1$). *b* is a parameter for the share of passengers transferred from cars. *km* is the average length of car travel in kilometres. *bec* is the benefit of reduced emissions form cars per km while *beb* is the benefit of reduced emissions from buses per km. $X_1^0$-$X_1$ is the change in bus vehicle-kilometres. The benefit of reduced emissions from cars depends on the share of diesel, petrol and electric cars. It could be argued that smaller buses cause less emissions but we have used a fixed level in this model, for lack of empirical studies. An alternative could be to reduce the emissions relative to bus size. We have no evidence for this assumption at the moment.

### 3.2.4. Network efficiency

The model is aggregated for all areas studied, and with a fixed network. The model solves the optimisation procedure within the fixed network, but is not capable of solving network optimisations such as the introduction of trunk lines, etc.

In the model, level of service is determined by vehicle-kilometres and bus size. Efficiency measures such as changing the network, reducing the number of stops or altering external factors in order to increase speed are not included. The model is able to study the effect of car restrictions, external shifts in demand, public transport prioritisation measures and increased speeds, but these parameters are not used in this study.

## 3.3. Data

Input for the baseline year 2015 is gathered from three main sources:

1. Transport Analysis statistics on competitive tendering in public transport, and local and regional public transport.
2. RVU – the Swedish national transport survey.
3. HUT (Hållbara Urbane Transporter/ Sustainable Urban Transport) – analysis of development of public transport in Stockholm and the Malmö area.

Exact ticket revenue is unknown, as the operator revenue in Transport Analysis statistics on competitive tendering in public transport consists of both income and subsidies. The average income per passenger of the county is used as a proxy. This is a significant source of error given that ticket revenue presumably varies depending on the nature of the contract.

As operators' total costs in the five contract areas are unknown, standardised costs are used as a proxy for actual costs. These standardised costs are based on a set of functions dependent on bus size, speed and other characteristics of the service level. The calculations are run in the cost model described in the HUT documentation by Betanzo and Haraldsen (2016).

The use of standardised costs and average income will cause the model baseline situation to differ from the actual situation in the five contract areas. Hence, the results must be regarded as approximations of optimal levels in the contract areas rather that an exact analysis of the areas. The advantage of this method is that calculations are equal for all contract areas, while data from Traffic Analysis may depend on each area's subjective reporting.

The objective of the study is to compare and evaluate the effects of different ridership incentives in the five contract areas, and not to benchmark the cost-effectiveness and service level for the five operators. Using normalised costs and revenues will affect the starting point of the analysis, but not the general conclusions of the study regarding the impact of different incentives and balance between level of freedom and incentives.

The table below presents input to the model.

*Table 3-2: Input to the model. Year 2015.*

| | E22 | E23 | Lund | North East Skåne | Lands-krona | Source |
|---|---|---|---|---|---|---|
| Ticket revenue (MSEK) | 964.44 | 168.6 | 126.56 | 20.16 | 28.60 | Transport Analysis public transport |
| Standardised costs (MSEK) | 775 | 242 | 143 | 77 | 46 | Calculated |
| Number of passengers (mil.) | 89.2 | 15.6 | 10.5 | 1.67 | 2.4 | Transport Analysis contract |
| Vehicle km (mil.) | 14.0 | 9.2 | 3.28 | 3.33 | 1.0 | Transport Analysis contract |
| Passenger km (mil.) | 203 | 143 | 40 | 22.15 | 7 | Transport Analysis contract |
| Seat and standing km (mil.) | 1 424 | 936 | 246 | 249 | 75 | HUT/Transport Analysis contract |
| Bus fleet | 348 | 100* | 59 | 32 | 17 | Transport Analysis contract |
| Speed peak hours (km/h) | 13.2 | 27.8 | 14.7 | 31.77 | 13.8 | (90 percent of low traffic speed) |
| Speed low traffic (km/h) | 14.7 | 30.8 | 16.4 | 35.30 | 15.4 | Transport Analysis contract |
| Share of journeys during peak hours | 0.47 | 0.67 | 0.61 | 0.64 | 0.75 | RVU |
| Public transport share of peak hour traffic | 0.34 | 0.32 | 0.19 | 0.19 | 0.16 | RVU |
| Share of car journeys with toll costs | 0.45 | 0.37 | 0 | 0 | 0 | HUT |
| Average length of car journeys (km) | 7.5 | 7.5 | 5 | 5 | 5 | HUT |
| Congestion charge per car journey | 1.33 | 1.33 | 1.67 | 1.67 | 1.67 | HUT |
| Toll costs per journey | 11.75 | 11.75 | 0.00 | 0.00 | 0.00 | HUT |

*Bus fleet in E23 is calculated using the cost model.

## 3.4. Sensitivity tests of key assumptions

A number of assumptions are made in order to carry out the analysis. In this section, sensitivity tests of key assumptions are conducted to illustrate the effect of the values of marginal cost of public funds, price elasticity and elasticity of supply for the contract in Lund.

### 3.4.1. Marginal cost of public funds

An unrestricted social optimisation is modelled with increasing values for the marginal cost of public funds (MCPF). This is a sensitivity test to investigate the importance of the value of MCPF and the results are presented in the table below.

The results show that the results are quite sensitive to small changes in MCPF, which is important for inference of this study. An MCPF of 1 represents a situation where there is no external cost to public funding. This yields a large increase in the level of service and an increase in subsidy from SEK 16 to 206 million. At an MCPF of 1.3, as recommended by ASEK 5 and used in this study, the increase in service level is lower and the socially optimal subsidy level is SEK 52 million.

*Table 3-3*: *Changes from current level in social optimisation with increased value of marginal cost of public funds. Lund contract.*

| MCPF | 1.00 | 1.10 | 1.20 | 1.30 | 1.40 |
|---|---|---|---|---|---|
| Capacity basis | 78% | 48% | 26% | 9% | -4% |
| Capacity peak hours | 62% | 51% | 42% | 35% | 29% |
| Average fares | -77% | -52% | -30% | -11% | 5% |
| Patronage | 74% | 53% | 38% | 25% | 15% |
| Subsidy (MSEK.) | 206 | 136 | 88 | 52 | 26 |
| Consumer surplus (MSEK) | 280 | 207 | 152 | 108 | 73 |

The welfare optimal subsidy level will to a large extent depend on the cost of public funding. MCPF is the external cost of taxation of labour. With an optimal allocation of funding between public sectors, MCPF can be regarded as alternative use of subsidies for public transport. Using the ASEK recommendations of 1.3, the optimal subsidy level will be SEK 52 million, an increase of SEK 36 million from today's level. Without any additional cost of public funding (MCPF = 1.0), the optimal subsidy is almost four times higher. If public transport funding is based on tolls, the marginal cost of funding is internalised in the external cost of shift in car traffic.

### 3.4.2. Price elasticity

The table below presents the effect of the choice of price elasticity. The elasticities used in the analysis are -0.25 in dimensional peak hours, -0.34 for other peak hours and -0.48

in low traffic. If passengers are more price-sensitive, fare reductions will be larger as the return on price changes is larger. Likewise, the subsidy level will be lower.

*Table 3-4: Changes from current level in social optimisation with increased value of price elasticities.*

| | | | | | |
|---|---|---|---|---|---|
| Price elasticity peak hours | -0.15 | -0.2 | -0.25 | -0.3 | -0.35 |
| Price elasticity other peak hours | -0.24 | -0.29 | -0.34 | -0.39 | -0.44 |
| Price elasticity low traffic | -0.38 | -0.43 | -0.48 | -0.53 | -0.58 |
| Capacity base | 9% | 9% | 9% | 9% | 10% |
| Capacity peak hours | 40% | 36% | 35% | 35% | 36% |
| Average fares | 15% | -1% | -11% | -19% | -25% |
| Patronage | 28% | 26% | 25% | 25% | 26% |
| Subsidy (MSEK) | 62 | 56 | 52 | 49 | 46 |
| Consumer surplus (MSEK) | 187 | 136 | 108 | 92 | 81 |

### 3.4.3. Elasticity of supply

The table below presents the effect of the choice of supply elasticity. The elasticities used in the analysis are 0.36 in dimensional peak hours, 0.47 for other peak hours and 0.58 in low traffic. If passengers are more sensitive to changes in supply, service levels will be higher as the return on changes in supply are larger. The subsidy needed to fund the service level will be higher.

*Table 3-5: Changes from current level in social optimisation with increased value of supply elasticities.*

| | | | | | |
|---|---|---|---|---|---|
| Supply elasticity peak hours | 0.22 | 0.29 | 0.36 | 0.43 | 0.50 |
| Supply elasticity other peak hours | 0.33 | 0.40 | 0.47 | 0.54 | 0.61 |
| Supply elasticity low traffic | 0.46 | 0.52 | 0.58 | 0.64 | 0.70 |
| Capacity basis | -5% | 1% | 9% | 20% | 34% |
| Capacity peak hours | 13% | 22% | 35% | 51% | 71% |
| Average fares | -10.7% | -11.1% | -11.3% | -11.4% | -11.6% |
| Patronage | 5% | 14% | 25% | 39% | 57% |
| Subsidy (MSEK) | 15 | 33 | 52 | 74 | 99 |
| Consumer surplus (MSEK) | 28 | 63 | 108 | 165 | 237 |

# 4. Results and discussion

The results of the study are presented in three sections, each of which aims to answer some of the research questions posted in the introduction. The first section investigates how budget constraints affects the socially optimal level of service in the contract areas. This will demonstrate the potential for optimising the service level, and how this is affected by the subsidy level. Section 2 focuses on the target conflict between operator and public authority, and will show that increased subsidies not necessarily will induce the profit maximising operator to deliver the socially optimal service level. Then, section 3, shows how ridership incentives can induce the profit maximising operator to deliver the socially optimal service level. The section investigates how the operator's allocation are affected by increasing levels of ridership incentives and changing level of freedom. The three sections can be summarised as follows:

1. **Budget constraints**: The first section focus on the welfare optimal level of service with different budget constraints;
    1. Welfare optimisation with the existing subsidy level indicates the potential to adjust the balance between service level and fares to increase welfare and increase passenger numbers.
    2. Welfare optimisation without restrictions on subsidies is calculated to investigate how far today's level of service is from the social optimum, and the level of subsidy needed to reach the optimum level.
    3. Welfare optimisation without subsidies is calculated to investigate the welfare benefits of today's grants.

2. **Target conflict**: The second section focus on the target conflict between the profit-maximising operator and the public authority seeking to maximise social welfare. The analysis will provide knowledge about how the level of freedom for the operator affects this target conflict.

3. **Optimal incentives**: The third and final section will investigate how the operator's allocation is affected by increasing levels of ridership incentives. The aim is to answer how incentives can be designed to combine socioeconomic and commercial profitability. The incentives studied are subsidies per passenger, a common tool in Swedish public transport contracts. The delivered level of service depends on the operator's level of freedom to adjust vehicle kilometres, bus size and fares. Five different cases will be discussed:
    1. The operator can change the frequency of services
    2. The operator can set fares and change the frequency of services
    3. The operator can set fares
    4. The operator can set differentiated fares
    5. The operator is not constrained by constant deficit of public transport

The intention of these three sections is to understand the balance between optimal ridership incentives and level of freedom in the contracts, and to discuss the outcomes of the incentives in existing contracts. The results are summarised at the end of this section.

Five contract areas are analysed. Main results are presented for all five contract areas to show the differences caused by local characteristics. More results and discussions are presented for the City of Lund contract as this is the middle contract with respect to total contract sum, patronage, vehicle km and incentive share. Also, the results show small differences caused by local characteristics when it comes to the operator's response to increasing levels of ridership incentives. Results for the other contract areas are included as an appendix.

In brief, the results show that making the operator internalise the optimal service level through ridership incentives alone requires high ridership incentives for all analysed levels of freedom. High ridership incentives can lead to profit for the operator but given competitive pressure in the tendering process, operators will internalise the incentives in their tender for the contract. This implies that high incentives will not increase total public funding, as operators will pay to operate a contract. This is a new form of tendering procedure.

## 4.1. Welfare-optimal level of service

The evaluation criteria for the best possible service level is the maximisation of social benefit. The optimal level of fares and capacity is a two-step effect. The first step is the reallocation of fares and capacity to find the balance according to the initial contractual framework. This is the reallocation effect found by optimising within current budget constraints. The second step is optimisation of subsidies according to cost-benefit criteria.

This section focus on the optimal level of service with different budget constraints. The analysis consists of three different subsidy levels:

1. The case with current budget constraints
2. The case without budget constraints
3. The case without subsidies

### 4.1.1. Welfare optimisation with current budget constraints

In this section, the level of service is optimised given the current level of subsidy. In addition, the optimisation is constrained by existing restrictions in current contracts. In all contract areas, capped fares are set by the public authority while the operator to some extent can reallocate frequency of service and bus size. The subsidy level cannot be increased but may be reduced if socially optimal.

The changes in output variables are referred to as a *reallocation effect* as the analyses show the potential for optimisation within existing budget constraints, given available input data as described in Section 3. The reallocation effect reflects the balancing of capacity and fares, and the results are therefore strongly dependent on the input.

The figure below presents changes in off-peak capacity, peak capacity and the subsequent change in patronage from maximising social welfare under current restrictions. There is no change in average fares as fares are set by the public authority. The subsidy level is at its upper limit, the current level, in all contract areas except North East Skåne, given the available input data. The current level of service in North East Skåne seems to be at a higher level than is socially optimal, and this special feature is addressed in detail in Appendix 1.

In contract areas E22, E23, Lund and Landskrona the potential exists to increase patronage without increasing subsidies, by reallocating supply between peak and off-peak periods.

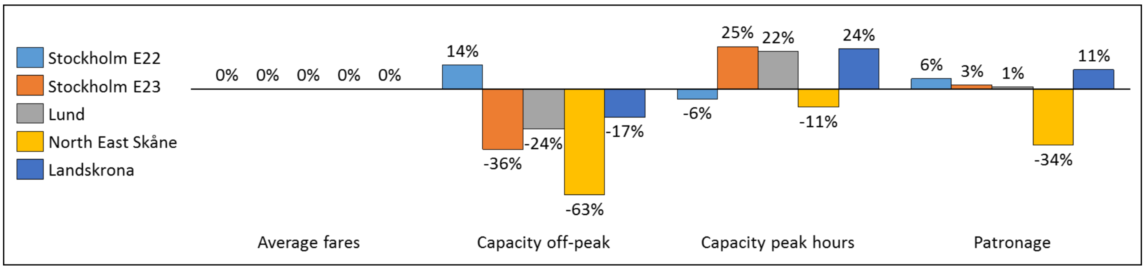



*Figure 4-1: Change in average fares, off-peak capacity, peak capacity and the subsequent change in patronage from maximising social welfare with current restrictions. Change from current level.*

The potential for reallocation may be due to incomplete information from public authority and the operator and restrictions on the operator's level of freedom. In addition, the results are based on approximations of the contract areas.

The optimisation includes a reallocation of capacity from off-peak to peak traffic. Within the model, the number of vehicles decides the distribution of supply between off-peak and peak traffic. This is based on the assumption that all vehicles are in use in peak hours as illustrated in section 3.2.2. If this is not the case, or the number of vehicles is incorrect, then the distribution may be incorrect at the point of departure. The Stockholm E22 contract appears to have a higher number of vehicles per vehicle-kilometre than the other contracts, which is may explain why the change in capacity takes a different direction than E23, Lund and Landskrona. For North East Skåne, capacity is reduced in both off-peak and peak traffic.

### 4.1.2. Welfare optimisation without budget constraints

Optimisation without constraints on subsidies indicates how far today's level of service is from the welfare-optimal level. This is an unconstrained optimisation and the results are gross effects including the reallocation effect of optimisation as well as the benefit of unlimited subsidies.

The figure below shows the percentage change in average fares, off-peak and peak capacity and the subsequent change in patronage from maximising social welfare in the five contract areas.

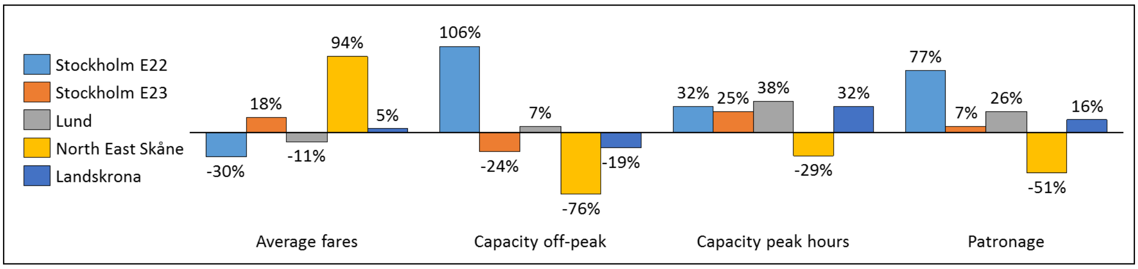



*Figure 4-2:Change in average fares, capacity in basis supply, capacity in peak hours and the subsequent change in patronage from maximising social welfare. Change from current level.*

This analysis implies that there is potential for increasing patronage by changing the fare level and reallocating resources between off-peak and peak capacity. North East Skåne is the exception where the level of service seems to be at a higher level than is socially optimal. This is discussed in Appendix 1. Note that the results represent an approximation as input to the model deviates from the actual situation in the contract areas.

The table below shows the level of subsidy necessary to ensure welfare-optimal service levels and compares this to the current subsidy level in the contract areas. The optimal subsidy level is higher than the current level in all contract areas, except North East Skåne. The necessary increase in subsidy is largest in Stockholm E22 and Lund, indicating an argument for increased subsidies in dense urban areas.

*Table 4-1: Current and subsidy ensuring the welfare optimal service level.*

| | | Stockholm E22 | Stockholm E23 | Lund | North East Skåne | Landskrona |
|---|---|---|---|---|---|---|
| Subsidy (MSEK) | Social optimisation | 691.5 | 80.4 | 72.2 | 20.1 | 20.6 |
| | Current situation | -189.1 | 73.7 | 16.3 | 57.1 | 17.4 |

In order to separate the effects of reallocation and increased subsidy, the approximation of the Lund contract is studied in greater detail. The effects are separated to investigate the net effect of increased subsidies. The reallocation effect, reflecting welfare optimisation within current budget constraints, is strongly dependent on the available input data. However, as it is describes the effect of increased subsidies on an efficient service level, the net effect of increased subsidies is not. The gross effect is the total effect including reallocation and the net effect of changed subsidies.

The net welfare optimisation of the service level will depend on the level of freedom for the operator and budget constraints for on the local authority, see table below. The *fare variation* scenario is a non-restricted optimisation in which it is possible to change the fare level. The *fare differentiation* scenario also allows for the differentiation of fares between the three periods of demand.

The gross effect is both reallocation and changes in subsidies, and the table indicates a cost-benefit ratio of 1.8 to 2 for a welfare-optimal service level. The optimisation ends up with a subsidy rate of approximately 30 per cent. The best effect is obtained in the *fare* *differentiation* scenario taking into account both variations in cost and passenger benefits between periods. The total welfare reallocation effect is between SEK 34 and 38 million, approximately one third of the welfare optimal effect.

*Table 4-2: Net changes in external cost and benefit due to reallocation, changes in subsidies and gross effect. Mill SEK per year Lund contract.*

| | Reallocation | | Without budget constraints | |
|---|---|---|---|---|
| **Gross effect** | **Fare variation** | **Fare differentiation** | **Fare variation** | **Fare differentiation** |
| Initial subsidy (MSEK) | 16.3 | 16.3 | 16.3 | 16.3 |
| Change of subsidies (MSEK) | - | - | 50.7 | 41.8 |
| Subsidy rate | 9% | 9% | 33% | 29% |
| Cost of public funding (MSEK) | - | - | (15.2) | (12.5) |
| Passenger benefit (MSEK) | 35.1 | 39.7 | 106.0 | 97.2 |
| External car cost (MSEK) | 0.5 | 0.2 | 1.0 | 0.6 |
| Environmental cost (MSEK) | (1.4) | (1.5) | (1.6) | (1.6) |
| Total (MSEK) | 34.2 | 38.5 | 90.2 | 83.7 |
| Gross cost benefit ratio | | | 1.78 | 2.00 |
| **Net effect** | **Fare variation** | **Fare differentiation** | **Fare variation** | **Fare differentiation** |
| Change of subsidies (MSEK) | | | 50.7 | 41.8 |
| Cost of public funding (MSEK) | | | -15.2 | -12.5 |
| Passenger benefit (MSEK) | | | 70.9 | 57.5 |
| External car cost (MSEK) | | | 0.4 | 0.4 |
| Environmental cost (MSEK) | | | -0.1 | -0.1 |
| Total (MSEK) | | | 55.9 | 45.2 |
| Net cost benefit ratio | | | 1.10 | 1.08 |

The welfare-optimal subsidy level will depend on the level of freedom in the contract. The ability to optimise the fare level between time periods will reduce the need for subsidies because passengers are willing to pay for a better service level or accept a reduced service level if fares are lower. If the balance between fares and service level is not optimised, there will be an additional benefit of increased public funding to compensate for this. Welfare-optimal fares imply a 12.6 per cent general reduction in fares if no allowance is made for fare differentiation. Optimisation with fare differentiation implies a fare increase of approximately 25% for peak periods and around 30 per cent for off-peak. The importance of the level of freedom in the contracts is studied more closely in Section 4.3.

*Table 4-3: Welfare-optimal fares depending on the level of freedom. Fares in SEK.*

| | **Optimised subsidy level** | |
|---|---|---|
| | Variation | Differentiation |
| Dimensioning Peak | -12.6 | 24.7 |
| Other peak | -12.6 | -35.3 |
| Off peak | -12.6 | -28.2 |

### 4.1.3. Welfare optimisation without subsidies

Welfare optimisation without constraints on subsidies indicates how far todays level of service is from the welfare-optimal level. This is an unconstrained optimisation and the results are gross effects including the reallocation effect of optimisation as well as the effect of removing subsidies. This implies that optimisation without subsidies may have positive effects on parameters such as patronage if the positive reallocation effect is larger than the negative effect of reduced subsidies.

The figure below shows the percentage change in average fares, off-peak capacity, peak capacity and the subsequent changes in patronage resulting from maximising social welfare in the five contract areas.

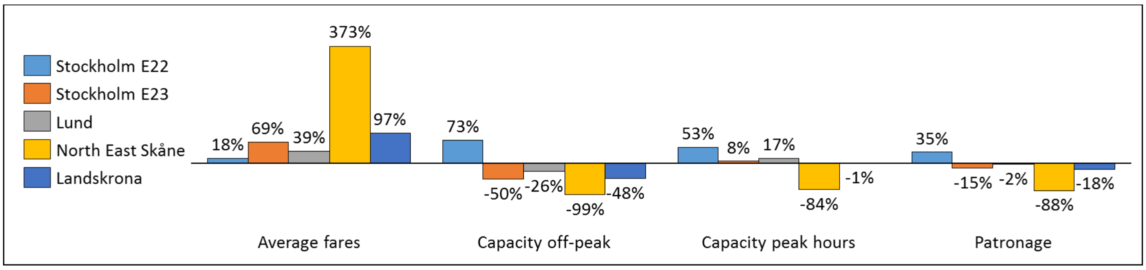



*Figure 4-3: Change in average fares, off-peak capacity, peak capacity and the subsequent change in patronage from maximising social welfare without subsidies. Change from current level.*

In the model analysis, E22 runs at a profit in the current situation. The restriction that sets subsidies to zero implies a decreased profit, i.e. the subsidy increases. This is why E22 stands out in the figure with increased off-peak capacity and increased patronage.

For the other contract areas, the restriction implies a decrease in subsidy which leads to reduced levels of service and patronage. The effects are strongest in North East Skåne, where the current subsidy level is very high. Without subsidies, public transport in this area would be characterised by high fares and low capacity.

To separate the effects of reallocation and increased subsidy, the approximation of the Lund contract is studied in greater detail. Optimisation without subsidies gives reduced patronage and an increased consumer surplus in Lund. The net welfare optimisation will depend on the level of freedom for the operator and budget constraints for the public authority, see table below. The *fare variation* scenario is a non-restricted optimisation in which it is possible to change the fare level. The *fare differentiation* scenario also allows for the differentiation of fares between the three periods of demand.

The gross effect is both reallocation and changes in subsidies. The reallocation effect is significant and the gross effect of optimisation without subsidies leads to overall welfare gains. This is because, due to a relatively low initial subsidy rate and high potential for reallocation, the reallocation effect is bigger than the welfare loss of reduced subsidies.

*Table 4-4: Net changes in external cost and benefit due to reallocation, changes in subsidies and gross effect. MSEK per year. Lund contract.*

| | Reallocation | | Without budget constraints | |
|---|---|---|---|---|
| **Gross effect** | **Fare variation** | **Fare differentiation** | Gross effect | **Fare variation** |
| Initial subsidy (MSEK) | 16.3 | 16.3 | 16.3 | 16.3 |
| Change of subsidies (MSEK) | - | - | -16.3 | -16.3 |
| Subsidy rate | 9% | 9% | 0% | 0% |
| Cost of public funding (MSEK) | - | - | 4.9 | 4.9 |
| Passenger benefit (MSEK) | 35.1 | 39.7 | 15.1 | 9.5 |
| External car cost (MSEK) | 0.5 | 0.2 | 0.1 | 0.4 |
| Environmental cost (MSEK) | -1.4 | -1.5 | -1.4 | -1.4 |
| Total (MSEK) | 34.2 | 38.5 | 18.6 | 13.3 |
| Gross cost benefit ratio | | | -1.15 | -0.82 |
| **Net effect** | **Fare variation** | **Fare differentiation** | **Fare variation** | **Fare differentiation** |
| Change of subsidies (MSEK) | | | -16.3 | -16.3 |
| Cost of public funding (MSEK) | | | 4.9 | 4.9 |
| Passenger benefit (MSEK) | | | -20.0 | -30.3 |
| External car cost (MSEK) | | | -0.5 | 0.1 |
| Environmental cost (MSEK) | | | 0.0 | 0.0 |
| Total (MSEK) | | | -15.6 | -25.2 |
| Net cost benefit ratio | | | 0.96 | 1.55 |

Social optimisation without subsidies shows the welfare loss due to ending public funding of public transport. It can therefore offer an indication of the welfare return to public funding. In Lund, however, subsidies are so small that a social optimisation of the current situation without subsidies would yield an increased consumer surplus. The current subsidy share of 11 per cent is the lowest of the analysed contract areas and is also extremely low when compared to the national average of approximately 50 per cent.

The figure below shows the reallocation of fares and capacity as well as the effect on patronage. Results are presented for capped fares and differentiated fares between the three periods of demand. In both cases, social optimisation without subsidies leads to increased fares. However, fares will increase less in the case of differentiated fares as this allows for the utilisation of the variation in passengers' willingness to pay to a larger extent than with capped fares.

Furthermore, capacity is decreased during off-peak hours and increased during peak hours, which can be regarded as targeting the supply of public transport in favour of passengers travelling at peak hours. This causes patronage to increase in the case of differentiated fares even when fares increase, while the reduction in patronage with capped fares is small.

The change in capacity involves a strong reduction in bus size for additional peak hours supply. Bus size is reduced by 49 and 64 per cent respectively for capped and differentiated fares. Bus size in base supply is close to current bus size, with a decrease of 10 per cent and an increase of 4 per cent respectively. This implies that base supply is trafficked with relatively large buses at all hours, while the additional supply in peak hours is provided using smaller buses. Smaller buses have lower costs, both initially and per km.

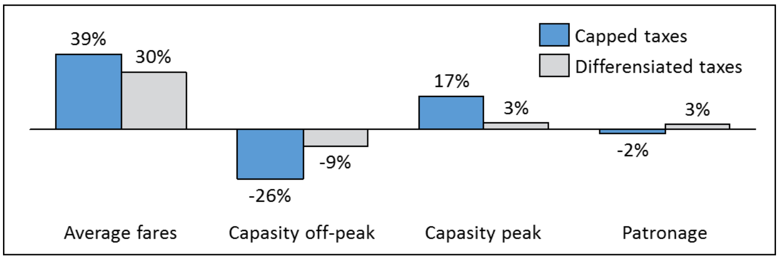



*Figure 4-4:Percentage change in average fares, capacity and patronage. Social optimisation without subsidies. Change from current level. Lund contract.*

Targeting capacity also causes an increase in consumer surplus, by 9 and 15 per cent for capped and differentiated fares respectively. Public funding is reduced by SEK 16 million. The change in patronage is so small that there is practically no change in external costs for congestion and tolls. In both cases, external costs for emissions decrease by approximately SEK 2 million due to reduced capacity in base supply and changes in patronage.

With capped fares, consumer surplus increases despite reduced patronage. This is due to increased peak-hour patronage and the fact that the consumer surplus for these passengers is higher than for those travelling off-peak. Within the model, this is due to differences in price elasticity in peak hours, other peak hours demand and low traffic. The table below shows changes in patronage and consumer surplus for the three periods of demand.

*Table 4-5: Change in patronage and consumer surplus for three periods of demand. Million passengers per year and consumer surplus in million kr. Lund contract.*

| | Patronage (mil.) | | Consumer surplus (MSEK) | |
|---|---|---|---|---|
| | Capped fares | Differentiated fares | Capped fares | Differentiated fares |
| Peak hours | 0.5 | 0.1 | 26.0 | 4.2 |
| Other peak hour demand | 0.3 | 0.6 | 10.5 | 19.9 |
| Low traffic | -1.1 | -0.4 | -27.1 | -9.1 |
| Sum | -0.2 | 0.3 | 9.4 | 15.1 |

Here. the implication for policy is not to remove subsidies, but to optimise the level of service. With capped fares, capacity is 31 and 15 per cent lower during off-peak and peak hours respectively in comparison to the optimal level without subsidy restrictions. Patronage is 22 per cent lower. This implies that even though optimisation without subsidies leads to a better outcome with respect to profits and consumer surplus, there is potential for a higher level of service with even better outcomes if funding is made available. The following section presents an analysis of the optimal level of service given current subsidies and contractual constraints.

## 4.2. Welfare optimisation vs. profit maximisation

Given the requisite level of freedom, a profit-maximising operator would act as a monopolist, setting higher fares and reducing the frequency of services and capacity to below the socially optimal level. This target conflict is often ameliorated by limiting the operator's level of freedom. Section 4.3 focuses on how incentives can reduce this conflict by inducing the profit-maximising operator to allocate resources in line with the welfare optimal level of service. This section investigates the conflict between the interests of the profit-maximising operator and the socially optimal level of service.

The table below presents the results obtained from profit-maximising optimisation, social welfare optimisation and the current situation given the available input in the situation without subsidy constraints. Profit optimisation without constraints shows a monopolist's allocation and hence the potential of commercial public transport. There will be negative subsidies in this case, representing the monopolist's profit. Social welfare optimisation shows the potential of allocating fares and capacity in order to attract more passengers and maximise social welfare without budget constraints.

*Table 4-6: Optimal levels from profit-maximisation and social optimisation, and the current situation in five contract areas.*

| | | Stockholm E22 | Stockholm E23 | Lund | North East Skåne | Landskrona |
|---|---|---|---|---|---|---|
| Subsidy | Profit-maximisation | -707.0 | -107.5 | -83.3 | 9.8 | -9.9 |
| (MEK) | Social optimisation | 691.5 | 80.4 | 72.2 | 20.1 | 20.6 |
| | Current situation | -189.1 | 73.7 | 16.3 | 57.1 | 17.4 |
| Subsidy share | Profit-maximisation | - | - | - | - | - |
| | Social optimisation | 39% | 27% | 34% | 51% | 37% |
| | Current situation | -24% | 30% | 11% | 74% | 38% |
| Average fares (SEK) | Profit-maximisation | 31.8 | 44.9 | 44.1 | 56.2 | 44.0 |
| | Social optimisation | 7.5 | 18.1 | 10.8 | 23.5 | 12.6 |
| | Current situation | 10.8 | 10.8 | 12.1 | 12.1 | 12.1 |
| Capacity off-peak | Profit-maximisation | 69 108 | 3 229 | 3 132 | 1 922 | 2 380 |

| | | | | | | |
|---|---|---|---|---|---|---|
| (seat/standing km per hour) | Social optimisation | 332 366 | 85 053 | 33 710 | 7 017 | 8 272 |
| | Current situation | 161 038 | 111 823 | 31 628 | 29 618 | 10 178 |
| Capacity peak hours | Profit-maximisation | 273 889 | 130 795 | 35 270 | 16 490 | 9 226 |
| (seat/standing km per hour) | Social optimisation | 562 306 | 322 879 | 81 924 | 49 458 | 21 219 |
| | Current situation | 426 329 | 257 438 | 59 310 | 69 315 | 16 028 |
| Vehicle km basis | Profit-maximisation | 2.0 | 0.1 | 0.1 | 0.1 | 0.1 |
| (1000, per hour) | Social optimisation | 5.2 | 0.8 | 0.4 | 0.1 | 0.1 |
| | Current situation | 1.6 | 1.1 | 0.4 | 0.4 | 0.1 |
| Vehicle km additional peak hours | Profit-maximisation | 2.4 | 2.5 | 0.8 | 0.2 | 0.1 |
| (1000, per hour) | Social optimisation | 4.2 | 4.5 | 1.5 | 0.5 | 0.4 |
| | Current situation | 2.6 | 1.4 | 0.4 | 0.5 | 0.1 |

The results shows that profit maximisation yields no subsidies as the operator will increase fares and reduce costs through reduced capacity to make a profit. A profit maximisation without constraints on the operator's degrees of freedom yields the same solution without constraints on subsidies and without subsidies, as the operator will behave as a monopolist and reallocate resources to increase profits.

In the Stockholm E22 contract, the operator can make a profit of SEK 707 million according to the model analysis, while the model analysis indicates that there is no potential for commercial public transport in North East Skåne. Note that these results depend on the available input as well as the model feature of constant occupancy rate. With the current input, the occupancy rate is very low, ensuring a deficit for the operator. This special feature is discussed in Appendix 1.

Social optimisation implies increased levels of subsidy for public transport. Again, North East Skåne is the exception, with a lower subsidy level, as the model analysis suggests that the current level of service is too high. The subsidy share shows how much of the costs are covered by the subsidy and depend on an optimised subsidy level and costs. Social optimisation pulls the subsidy share in E22, Lund and North East Skåne in the direction of the national average level of 50 per cent, while there is only a small reduction in the subsidy share in E23 and Landskrona.

For all contract areas, profit maximisation implies higher average fares and reduced capacity in comparison to both the current situation and the socially optimal level. This is in line with earlier studies. To investigate the conflict between operator and public authority, the approximation of the Lund contract is studied in greater detail.

### 4.2.1. Optimal level of service in Lund given current constraints

In this section, the level of service is optimised given the existing restrictions in current contracts. The socially optimal level of service is compared to a profit-maximising operator's allocation for given subsidies and levels of freedom. Results from Lund reflect the general findings.

In all contract areas, capped fares are set by the public authority while, to some extent, the operator is free to reallocate frequency of service and bus size. The subsidy level cannot be increased. For all contract areas, the profit maximising analysis show that if the operator is unable to affect frequency by reallocating vehicle-kilometres, there will be no change in the level of service. If vehicle-kilometres can be reduced by 50 per cent, the operator will reduce vehicle-kilometres by 50 per cent.

In the model analysis, the operator's ticket revenue will be equal to the current subsidy per passenger and they do not receive any other subsidy. The outcome will therefore not reproduce the current situation in the contract areas but will rather reflect the effect of restricting the operator's level of freedom.

Results from Lund reflect the general findings. Social optimisation of the current situation yields a redistribution of capacity from off-peak to peak, increasing patronage by 1.3 per cent and generating a 25 per cent increase in consumer surplus. This implies that, given the quality of input to the model, there is potential for improving the level of service without increasing subsidies in the City of Lund.

The profit-maximising operator will reduce frequency (vehicle-kilometres) and increase bus size. Base supply of vehicle-kilometres will be reduced by 76 per cent while additional peak-hour supply will be reduced by 73 per cent. Bus size in the current situation has a seating and standing capacity of 75, which will be increased to 111 for base supply and 208 for additional services. This will reduce total off-peak capacity by 65 per cent and peak capacity by 46 per cent.

Figure 4-5 shows the results. The conflict between social welfare and profit maximisation is evident. Restrictions on the operator's freedom to change capacity will only make the percentage change smaller, not change the direction in line with social optimisation. The use of ridership incentives to induce the operator to reallocate in line with social optimisation is the focus of the following section.

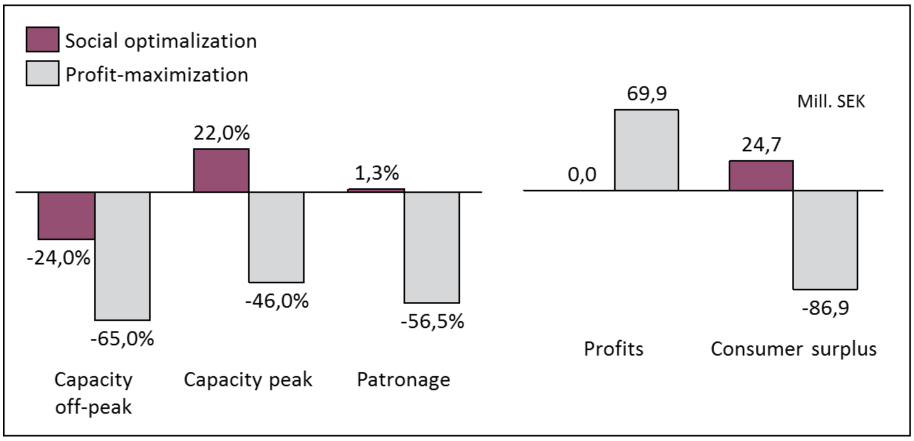



*Figure 4-5: Percentages change in capacity and patronage as well as actual change in profits and consumer surplus given social optimisation and profit-maximisation with constraints. Change from current level. Lund contract.*

*Table 4-7: Outcome from optimisation in absolute terms. Lund constract.*

| | Profit maximisation | Social optimisation | Current situation |
|---|---|---|---|
| **Average fares** | 12.1 | 12.1 | 12.1 |
| **Vehicle km basis (1000, per hour)** | 0.1 | 0.3 | 0.4 |
| **Vehicle km add. (1000, per hour)** | 0.1 | 1 | 0.4 |
| **Bus sizs base** | 111 | 90 | 75 |
| **Bus sizs add** | 208 | 48 | 75 |
| **Patronage** | 4.5 | 10.6 | 10.5 |

## 4.3. Increasing incentives to the operator

Optimising the level of service in the contract areas demonstrates the conflict between social welfare optimisation and profit maximisation. The focus of this section is to analyse the operator’s reaction to increasing levels of incentives given the level of freedom provided by the contract. The aim is to show that incentives per passenger can reduce or remove the gap between the socially optimal and profit-maximising level of service.

As in the previous section, the profit-maximising operator is restricted to the current deficit of public transport. This means that the deficit (costs-fare box revenue) cannot increase in order to ensure economic sustainability.

To investigate the importance of the level of freedom granted to operators, four analyses were conducted:

1. Freedom to change the frequency of services
2. Freedom to set fares and change the frequency of services
3. Freedom to set fares
4. Freedom to set differentiated fares

These analyses were also conducted without a upper limit on the deficit of public transport. The results are summarized at the end of the section. Main results are presented for all contract areas, with further results in appendix. Results from Lund reflect the general findings and are described and discussed in further detail.

### 4.3.1. Freedom to change the frequency of services

First, a situation in which the contract grants the operator freedom to change the frequency of services is considered. The table below shows the optimal incentive level, i.e. the incentive level that induces the operator to achieve the socially optimal service level. Optimal incentive is presented as both a percentage of ticket revenue and in SEK. The optimal ridership incentive in Stockholm E23  is SEK 16 or 150 per cent of the average fare of SEK 10.8. The table also includes changes to consumer surplus which describes the gain for passengers of a changed service level. In North East Skåne the effect is negative, as it would be optimal to reduce the level of service.

The incentive level is lower in the dense urban areas of E22 and Lund than in less urbanised areas, and highest in rural North East Skåne. This implies that environment affects the need for subsidies.

*Table 4-8: Optimal incentive level and change in consumer surplus (CS) for all contract areas.*

| | Stockholm E22 | Stockholm E23 | Lund | North East Skåne | Landskrona |
|---|---|---|---|---|---|
| Incentive level | 150% | 300% | 221% | 350% | 300% |
| Incentive SEK | 16.2 | 32.4 | 26.7 | 42.3 | 36.3 |
| Change in CS (MSEK) | 70.8 | 38.9 | 20.5 | -18.2 | 13.3 |

The operator’s allocation of capacity through frequency of service and bus size as a response to increasing levels of incentives has the shape of a stair case and is similar for all contract areas. The central difference between the areas is the level of incentive as displayed above. The results obtained from studying the operator’s allocation to increasing levels of incentives are presented for the example contract, Lund.

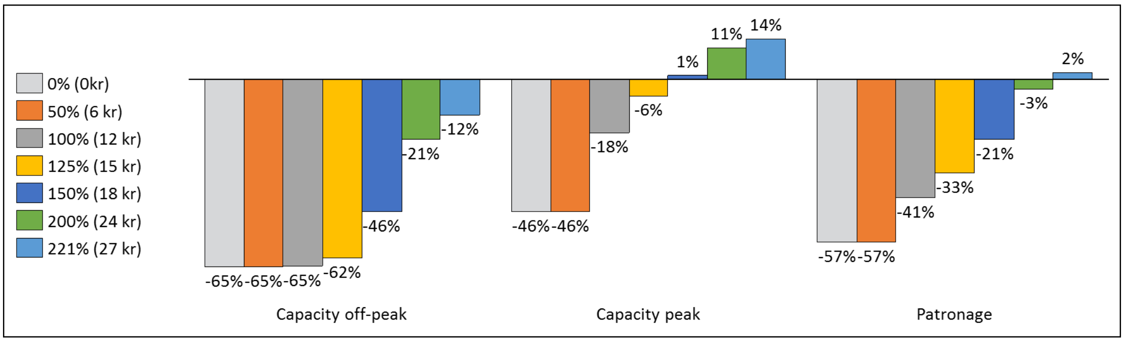



*Figure 4-6:Operator's allocation for given levels of subsidies per person in Lund. Change from current level.*

The previous section showed that the operator will reduce the level of service in Lund given the freedom to make changes to the frequency of services. The figure above shows how incentives per passenger induce the operator to shift its allocation of resources toward the socially optimal level.

The level of incentives is defined both as a percentage of the average fare and in SEK. In Lund, where the average fare is SEK 12, an incentive of 100 per cent means that the operator receives the full ticket revenue of SEK 12. An incentive of 200 per cent means that the operator receives the full ticket revenue plus an additional subsidy of SEK 12, giving a total of SEK 24 per passenger. This gives the operator an incentive to increase patronage.

A subsidy of 0-50 per cent of ticket revenue will have no effect on the operator's allocation, as the incentive is too small. If the operator is allowed to keep 100 per cent of ticket revenue the reduction in peak-hour capacity will be lower and the reduction in patronage less than without incentives per passenger. Increasing incentives will gradually shift the allocation of resources toward the socially optimal level.

*Table 4-9: Operator's allocation in absolute terms for given levels of subsidies.*

| **Freedom to change frequencies** | **Current situation** | **100 %** | **125 %** | **150 %** | **200 %** | **221 %** |
|---|---|---|---|---|---|---|
| Average fare (SEK) | 12 | 12 | 12 | 12 | 12 | 12 |
| Vehicle km base (1000) | 0.4217 | 0.1 | 0.1096 | 0.1681 | 0.2878 | 0.3385 |
| Vehicle km add. (1000) | 0.3691 | 0.3084 | 0.4511 | 0.5334 | 0.68 | 0.7359 |
| Vehicle km peak (base+add) (1000) | 0.79 | 0.41 | 0.56 | 0.70 | 0.97 | 1.07 |
| Bus size base | 75 | 111 | 110 | 102 | 87 | 82 |
| Bus size peak | 75 | 121 | 97 | 80 | 60 | 54 |
| Patronage (mil.) | 10.5 | 6.2 | 7.1 | 8.3 | 10.1 | 10.7 |
| Subsidy (excl. farebox recovery) (MSEK) | 16.3 | 0.0 | 21.3 | 50.0 | 122.2 | 159.7 |
| Subsidy per passenger | 13.7 | 12.1 | 15.1 | 18.1 | 24.2 | 27 |

The level of incentive at which the operator behaves as if internalising external effects, thus providing a service close to the socially optimal level, is 221 per cent of average fare or a subsidy of SEK 27 per passenger. The operator will increase capacity until total costs equal ticket revenue. Ticket revenue per passenger is SEK 12 and operating costs per passenger are SEK 12. The rest of the subsidy, SEK 14.6, will be profits to the operator. This is why the operator will be willing to pay to operate the contract. A higher incentive level will not affect the service level, it will simply be a transfer of resources from the public authority to the operator.

Figure 4-7 compares the outcomes of social optimisation and profit-maximisation with incentives of SEK 27 per passenger. The operator's allocation of resources is close to the socially optimal level, although the reallocation from off-peak to peak-hour capacity will be lower. This is because the operator does not fully internalise the fact that consumer surplus is higher during peak hours. Patronage will be somewhat higher in the profit-maximisation scenario, although consumer surplus is higher with social optimisation.

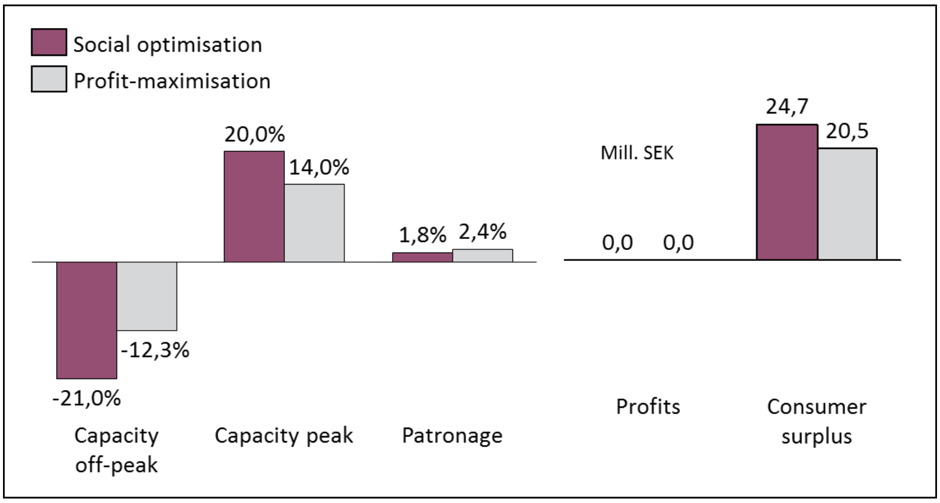



*Figure 4-7:Comparison of outcome of social optimisation and profit maximisation with incentives of 27 SEK per passenger. Change from current level.*

The analysis shows that incentives per passenger can be used to induce the operator to allocate resources in line with the socially optimal level. However, it comes at a cost; the subsidy for public transport will increase by SEK 160 million, or 880 per cent, compared to the current level. This SEK 160 million will be profit to the operator. This implies a need to change the tendering process, with one alternative being to allow potential operators to tender for the contract as discussed in Fearnly et al. (2004). In this way, the operators will exploit their market knowledge. while incentives and framework conditions are set by the public authority. Given free and fair competition, the operator will bid the expected profit to operate the contract, meaning that public spending will not increase.

### 4.3.2. Freedom to set fares and change the frequency of services

In the case of freedom to set fares and change the frequency of services, the incentive must be higher than with restricted fares in order to combine the socially optimal and profit-maximizing level of service. This is due to the greater opportunities available to the operator to increase profits, either by increasing fares or reducing the level of service.

The table below shows the optimal incentive level both as a percentage of ticket revenue and in SEK. The optimal ridership incentive in Stockholm E23 is SEK 27 or 250 per cent of the average fare of SEK 10.8. In the case of freedom to change only the frequency of services, the optimal incentive was SEK 16 or 150 per cent. However, the change in consumer surplus is far greater in this case, showing the effects of increased subsidies and freedom for the operator.

The incentive level is lower in the dense urban areas of E22 and Lund than in less urbanised areas. This implies that environment affects the need for subsidies.

*Table 4-10: Optimal incentive level and change in consumer surplus (CS) for all contract areas.*

| | Stockholm E22 | Stockholm E23 | Lund | North East Skåne | Lands-krona |
|---|---|---|---|---|---|
| Incentive level | 250% | 350% | 300% | 350% | 350% |
| Incentive SEK | 27.0 | 37.8 | 36.3 | 42.3 | 42.3 |
| Change in CS (MSEK) | 487.7 | 50.7 | 31.3 | -28.5 | 14.3 |

The operator's allocation of capacity and fares as a response to increasing levels of incentives has the shape of a stair case and is similar for all contract areas. The central difference between the areas is the level of incentive as displayed above. The results of studying the operator's response to increasing levels of incentives are presented for the example contract, Lund.

In Lund, the incentive needs to be approximately 300 per cent of average ticket revenue, or SEK 36, in order to bring the operator's allocation of resources to the socially optimal level.

Figure 4-8 below shows how incentives per passenger induce the operator to shift its allocation toward the socially optimal level, given the freedom to change both fares and capacity. If the operator keep 100 per cent of ticket revenue, the profit-maximising solution is to increase fares by 265 per cent from SEK 12 to 44. Off-peak capacity is reduced by 90 per cent, the result of a 76 per cent reduction in frequency and a 58 per cent reduction in bus size. Capacity in peak hours is reduced by only 41 per cent as additional peak hour frequency is increased by 111 per cent. These changes result in a 66 per cent reduction in patronage where in the case of the operator keeping 100 per cent of ticket revenue.

The fare increase from the current level diminishes with increasing levels of incentive in the contract. Likewise, the reduction in capacity diminishes as frequency of service and bus size increase with the level of incentives.

At the optimal incentive level of 300 per cent, the capacity in peak hours increase from the current level. At a subsidy of SEK36 per passenger, the operator will increase average fares by 27 per cent (SEK 25), reduce base capacity by 6 per cent and increase peak capacity by 15 per cent. This leads to a 6 per cent increase in patronage.

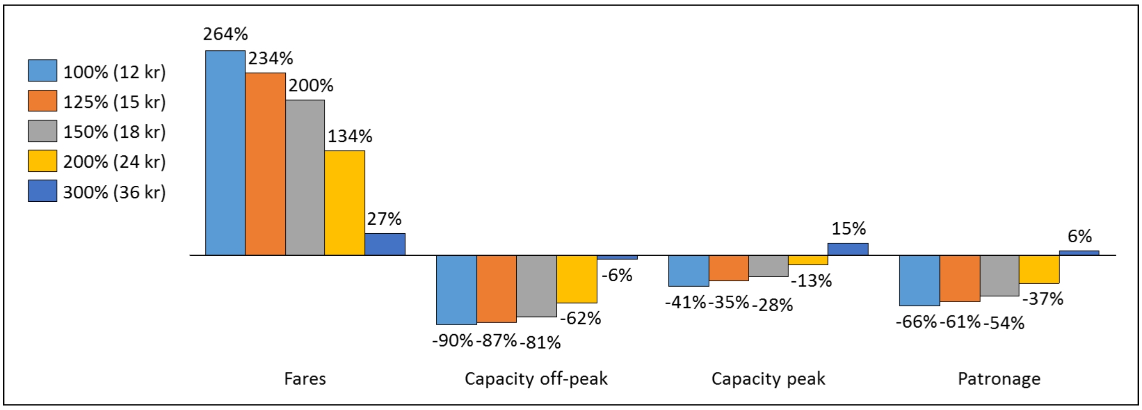



*Figure 4-8: Operator's allocation for given levels of subsidies per person. Freedom to change fares and capacity. Change from current level.*

*Table 4-11: Operator's allocation in absolute terms for given levels of subsidies.*

| **Freedom to set fares and frequencies** | **Current situation** | **100%** | **125%** | **150%** | **200%** | **300%** |
|---|---|---|---|---|---|---|
| Average fares | 12 | 44 | 40 | 36 | 28 | 15 |
| Vehicle km basis (1000) | 0.4217 | 0.1 | 0.1159 | 0.154 | 0.2472 | 0.4721 |
| Vehicle km add. (1000) | 0.3691 | 0.7802 | 0.8264 | 0.8535 | 0.9007 | 0.9439 |
| Bus size basis | 75 | 31 | 36 | 40 | 48 | 63 |
| Bus size add. | 75 | 41 | 42 | 43 | 44 | 41 |
| Patronage (mill) | 10.5 | 3.6 | 4.1 | 4.8 | 6.6 | 11.1 |
| Subsidy (excl. ticket income) (MSEK) | 16.3 | 0.0 | 12.4 | 29.0 | 79.4 | 267.7 |
| Subsidy per passenger | 13.7 | 12.1 | 15.1 | 18.1 | 24.2 | 36.3 |

Figure 4-9 compares the outcome of social optimisation and profit maximisation with incentives of 36 SEK per passenger. The operator's allocation is close to the socially optimal level, but the reallocation from off-peak to peak supply will be lower. This is because the operator does not fully internalises the fact that consumer surplus is higher in peak hours. Patronage will be somewhat higher in the profit-maximisation scenario.

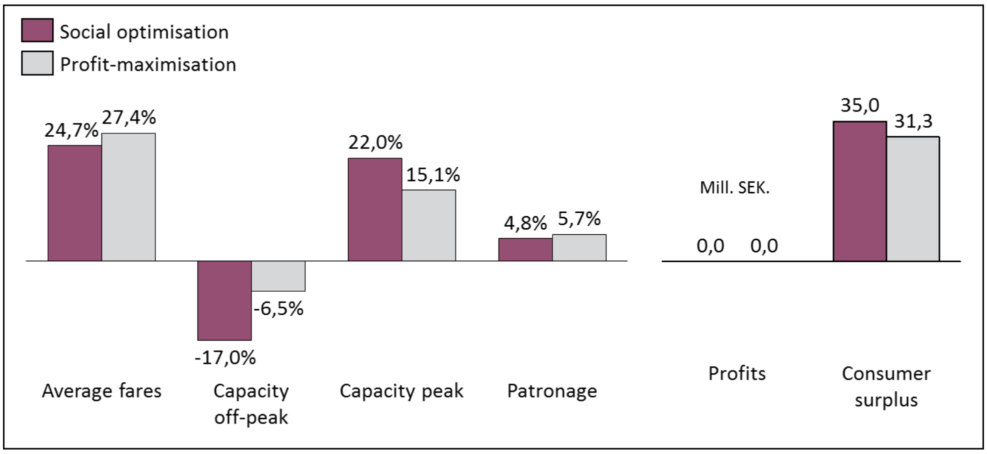



*Figure 4-9: Comparison of outcome of social optimisation and profit maximisation with incentives of SEK 36 per passenger. Change from current level.*

The analysis shows that incentives per passenger can be used to induce the operator to allocate resources in line with the socially optimal level. The subsidy for public transport in this case will increase by approximately SEK 250 million compared to today's level. SEK 250 million will therefore be the optimal bid from potential operators in the revised tendering process.

### 4.3.3. Freedom to set fares

In this case the operator can set fares, but the supply of public transport in vehicle-kilometres is restricted. If vehicle-kilometres is restricted to the current level, the social optimal outcome given by the model will be no change in fares or bus size, and therefore no effect on consumer surplus. This is illustrated in the table below.

*Table 4-12: Optimal incentive level and change in consumer surplus (CS) for all contract areas.*

| | Stockholm E22 | Stockholm E23 | Lund | North East Skåne | Landskrona |
|---|---|---|---|---|---|
| Incentive level | 300% | 350% | 350% | 400% | 350% |
| Incentive SEK | 32.4 | 37.8 | 42.3 | 48.4 | 42.3 |
| Change in CS | 0 | 0 | 0 | 0 | 0 |

If vehicle-kilometres has a lower limit, but not an upper limit, the socially optimal outcome will produce significant economic benefits. Therefore, the analysis below is conducted with a lower limit on frequency rather than a definitive restriction on the current level.

The operator's allocation of capacity and fares as a response to increasing levels of incentives has the shape of a stair case and is similar for all contract areas. The figure below shows how incentives per passenger induce the operator to shift its allocation of resources toward the socially optimal level given the freedom to set fares in the Lund contract.

Average fares are increased in order to increase profits. There is a lower bound on vehicle km, but the operator can changes capacity through bus size and trough increased frequency. With a ridership incentive of 36 kr (300 percent of current ticket revenue), the operator will balance fares and capacity in order to increase patronage.

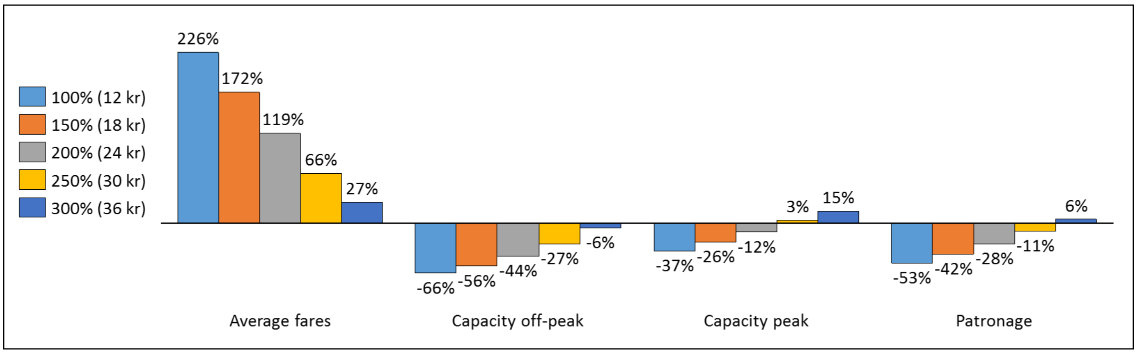



*Figure 4-10: Operator's allocation for given levels of subsidies per person. Freedom to change fares. The change in capacity is caused by changes in bus size. Change from current level.*

*Table 4-13: Operator's allocation in absolute terms for given levels of subsidies.*

| **Freedom to set fares** | **Current situation** | **100%** | **150%** | **200%** | **250%** | **300%** |
|---|---|---|---|---|---|---|
| Average fares | 12 | 39 | 33 | 27 | 20 | 15 |
| Vehicle km basis (1000) | 0.4217 | 0.4217 | 0.4217 | 0.4217 | 0.4217 | 0.472 |
| Vehicle km add. (1000) | 0.3691 | 0.4632 | 0.5839 | 0.7217 | 0.8784 | 0.944 |
| Bus size basis | 75 | 25 | 33 | 42 | 55 | 63 |
| Bus size add. | 75 | 57 | 52 | 47 | 44 | 41 |
| Patronage (mil.) | 10.5 | 4.9 | 6.1 | 7.5 | 9.3 | 11.1 |
| Subsidy (excl. ticket income) (MSEK) | 16.3 | 0.0 | 37.0 | 91.2 | 168.7 | 267.7 |
| Subsidy per passenger | 13.7 | 12.1 | 18.1 | 24.2 | 30.2 | 36.3 |

Figure 4-11 compares the operator's allocation of resources to the socially optimal level given the operator's level of freedom. The operator's allocation is close to the socially optimal level, but the reallocation from off-peak to peak hour supply is somewhat lower. This is because the operator does not fully internalises the fact that consumer surplus is higher during peak hours. Patronage will be marginally higher in the profit-maximisation scenario, although consumer surplus is higher with social optimisation.

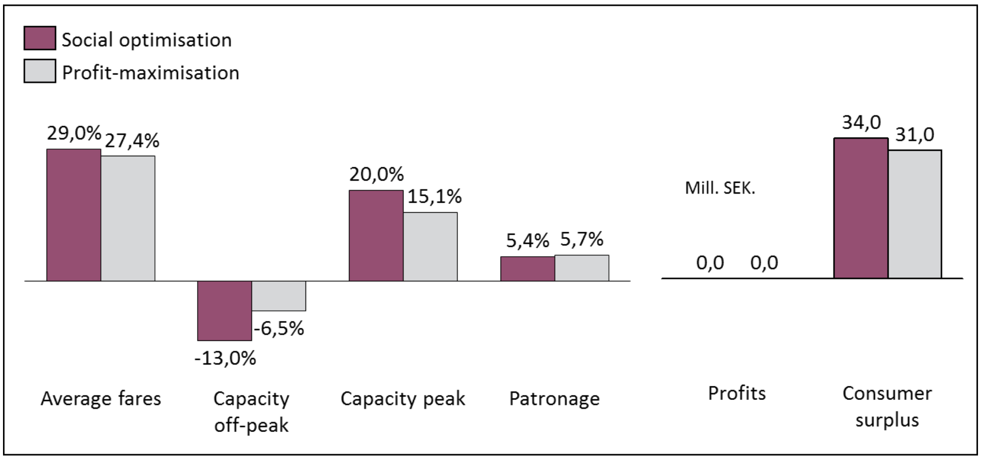



*Figure 4-11: Comparison of outcome of social optimisation and profit maximisation with incentives of SEK 36 per passenger. Change from current level.*

The public transport subsidy in this case will increase by approximately SEK 250 million compared to today's level. 250 million will therefore be the optimal bid from potential operators in the revised tendering process.

### 4.3.4. Freedom to set differentiated fares

When fares are capped, it is not possible to earn the full potential revenue from new passengers. In this case the operator can set differentiated fares, but the supply of public transport in vehicle-kilometres is restricted by a lower limit at the current level.

If vehicle-kilometres is restricted to the current level, the operator's allocation will reduce the consumer surplus. This is because the operator has a limited ability to balance fares and capacity, as illustrated in the table below.

*Table 4-14: Optimal incentive level and change in consumer surplus (CS) for all contract areas.*

| | | Stockholm E22 | Stockholm E23 | Lund | North East Skåne | Lands-krona |
|---|---|---|---|---|---|---|
| Incentive level | Profit-max. | 300% | 400% | 320% | 350% | 350% |
| Incentive SEK | Profit-max. | 32.4 | 43.2 | 38.7 | 42.4 | 42.4 |
| Change in CS | Profit-max. | -15.4 | -8 | -2.4 | -10.9 | 1.25 |

If vehicle-kilometres has a lower limit, but not an upper limit, the socially optimal outcome will produce significant economic benefits. Therefore, the analysis below is conducted with a lower limit on frequency rather than a definitive restriction on the current level.

The operator's allocation of capacity and fares as a response to increasing levels of incentives has the shape of a stair case and is similar for all contract areas. The central difference between the areas is the level of incentive as shown above. The results obtained by studying the operator's reaction to increasing levels of incentives are presented for the example contract, Lund.

The figure below shows how incentives per passenger induce the operator to shift its allocation of resources toward the socially optimal level, given the freedom to set differentiated fares. The operator can now balance fares to exctract passengers willingness to pay for the expencive peak capacity. By increasing fares in peak and reducing fares off-peak, all increase in patronage is in off-peak capacity.

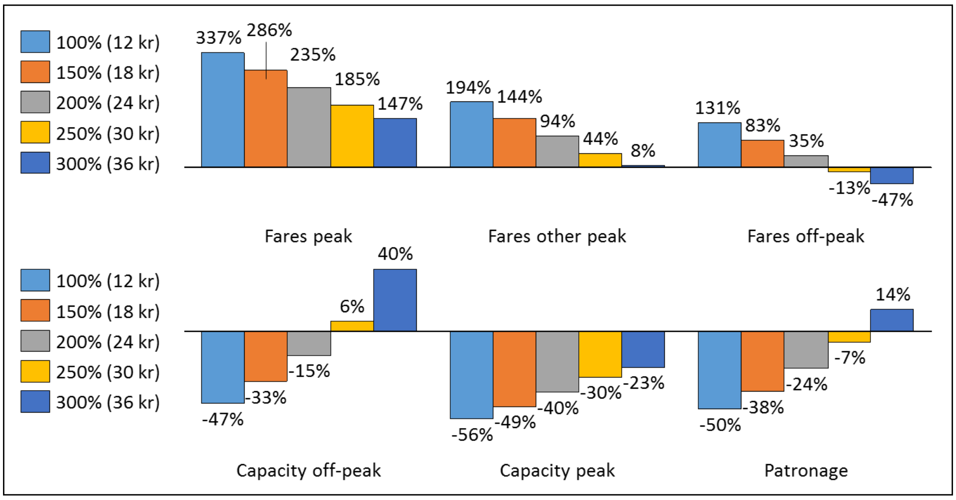



*Figure 4-12:Operator's allocation for given levels of subsidies per person. Freedom to set differentiated fares. The change in capacity is caused by changes in bus size. Change from current level.*

*Table 4-15: Operator's allocation in absolute terms for given levels of subsidies. Lund constract.*

| **Freedom to set differentiated fares** | **Current situation** | **100%** | **150%** | **200%** | **250%** | **300%** |
|---|---|---|---|---|---|---|
| Fares peak traffic | 12 | 53 | 47 | 41 | 34 | 30 |
| Fares other peak | 12 | 36 | 30 | 23 | 17 | 13 |
| Fares off-peak | 12 | 28 | 22 | 16 | 11 | 6 |
| Vehicle km basis (1000) | 0.4217 | 0.4217 | 0.4217 | 0.4217 | 0.4217 | 0.5118 |
| Vehicle km add. (1000) | 0.3691 | 0.4658 | 0.5944 | 0.7401 | 0.9047 | 0.9499 |
| Bus size basis | 75 | 40 | 50 | 63 | 80 | 86 |
| Bus size add. | 75 | 19 | 16 | 12 | 9 | 2 |
| Patronage (mil.) | 10.5 | 5.2 | 6.4 | 7.9 | 9.7 | 11.9 |
| Subsidy (excl. ticket income) (MSEK) | 16.3 | 0.0 | 39.0 | 95.9 | 176.6 | 287.9 |
| Subsidy per passenger | 13.7 | 12.1 | 18.1 | 24.2 | 30.2 | 36.3 |

Figure 4-13 compares the operator's allocation of resources to the socially optimal level, given the operator's level of freedom. The operator's allocation is not as close to the socially optimal level as in the other cases. The increased level of freedom provides more points of division between the operator and the public authority. The division is caused by the operator not fully internalising the fact that consumer surplus is higher in peak hours. Patronage will be somewhat higher in the profit-maximisation scenario, although consumer surplus is significantly higher with social optimisation.

Patronage increases by almost 14 per cent compared to the current situation. In the case of freedom to change the frequency of services, the increase for profit-maximisation is 1.8 per cent. In the case of freedom to set fares and change the frequency of services, it increases by 4.8 per cent, and in the case of freedom to set capped fares the increase is 5.4 per cent. Differentiated fares offers the opportunity to earn the full potential revenue from new passengers.

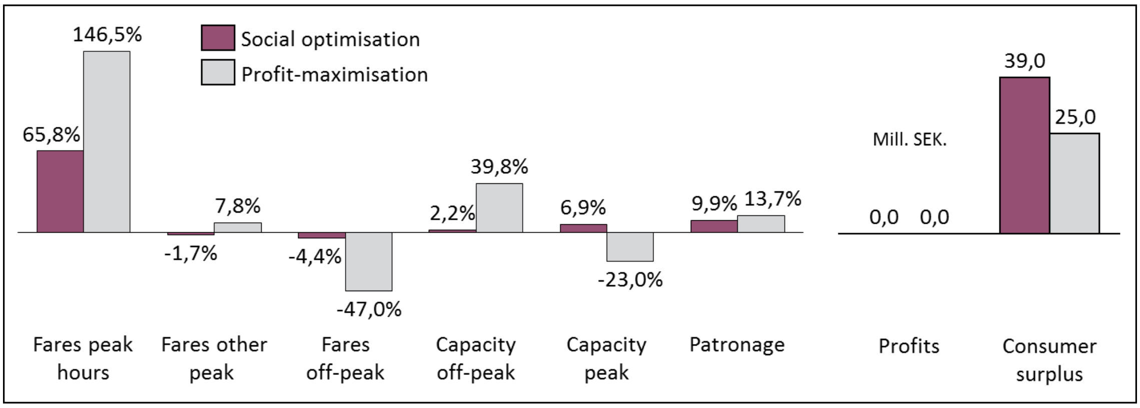



*Figure 4-13: Comparison of outcome of social optimisation and profit maximisation with incentives of SEK 36 per passenger. Change from current level. Lund contract.*

The subsidy for public transport in this case will increase by approximately SEK 270 million compared to today's level. SEK 270 million will therefore be the optimal bid from potential operators in the revised tendering process.

#### 4.3.5. Without constraint on the deficit of public transport

This section deals with a scenario in which the operator can increase the deficit of public transport, i.e. the gap between farebox revenue and costs. This subsidy is kept constant in the earlier analysis to ensure economic sustainability. This affects the operator's response to increasing incentives. In an altered tendering process, the deficit of public may increase without increasing public spending, as long as the operator's tender for the contract includes expected profits.

Fares are set, while the operator can change the frequency of services. To investigate the importance of the level of freedom the analysis is conducted both without any constraints on frequency and with current lower limits. The table and figures below show the results.

*Table 4-16: Profit optimisation for a net cost contract with ridership incentives and different level of constraints. Lund contract, percentage change in patronage and MSEK per year.*

| | | 100% | 125% | 200% | 250% | 300% |
|---|---|---|---|---|---|---|
| Incentive share | | 89% | 111% | 177% | 220% | 264% |
| Cost/passenger | | 13.7 | 13.7 | 13.7 | 13.7 | 13.7 |
| Patronage (mil.) | Without constraints | 6.2 | 7.1 | 10.1 | 11.4 | 12.5 |
| | With lower constraints | 10.5 | 10.5 | 11.0 | 11.5 | 12.5 |
| Subsidy (excl. ticket income) (MSEK) | Without constraints | -15.06 | -13.66 | 7.82 | 28.16 | 50.96 |
| | With lower constraints | 16.27 | 16.27 | 21.14 | 29.65 | 50.96 |
| Ridership incentives (MSEK) | Without constraints | 0 | 21.2 | 121.0 | 206.1 | 300.9 |
| | With lower constraints | 0 | 31.4 | 131.5 | 207.5 | 300.9 |
| Total subsidies (MSEK) | Without constraints | -15.06 | 7.49 | 128.78 | 234.22 | 351.88 |
| | With lower constraints | 16.27 | 47.66 | 152.61 | 237.18 | 351.88 |

The figure below shows the change in patronage from increasing incentives and dependent on the level of freedom. It is clear that incentives per passenger can result in increased patronage. An incentive level of 200 per cent (SEK 12 in ticket revenue plus SEK 12 in subsidy per ticket) will induce the operator to supply a level of service ensuring increased patronage given the freedom to increase the frequency of services.

It may be worth noting that even strong incentives, for example SEK 36 (SEK 12 in ticket revenue plus SEK 24 in ridership incentives), do not lead to an increase in patronage in excess of 20 per cent, which is far from the target of doubling public transport patronage (cf. the Swedish Doubling Project).

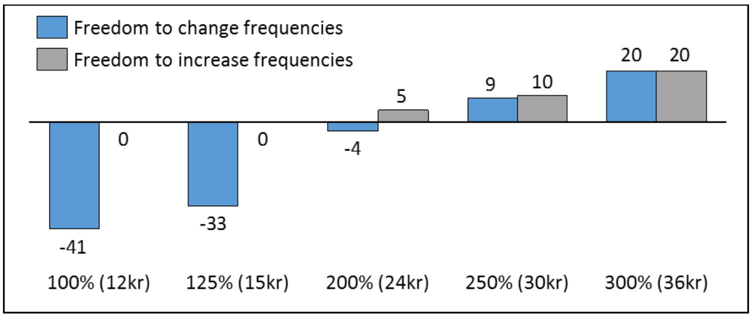



*Figure 4 14: percentage change in patronage with increasing levels of ridership incentives. Change from current level. Lund contract.*

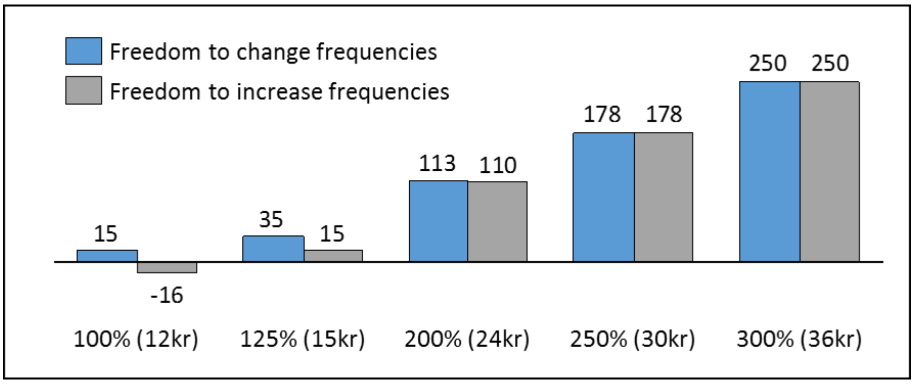



*Figure 4 15: Operator's gross profit with different level of incentives Incenties per all passengers MSEK per year. Change from current level. Lund contract.*

The figure above shows the operators gross profit with increasing levels of incentive. Already at SEK 15 (SEK 12 in ticket revenue plus SEK 3 in ridership incentives), operators will make an annual profit of SEK 15 million and this increases sharply in line with the level of incentive. At the same time, this surplus will be the basis for the operator's tender to operate the contract, including normal returns. For example, at a level of SEK 12 in ridership incentives, operators may be willing to pay in the region of $100m to operate the contract, although it will involve a high financial risk because passenger revenues are high and many external factors can affect the result.

The next figure therefore shows the effects of providing subsidies based on changes to the number of passengers, thereby reducing the financial risk. This is a contract where operators tenders based on an initial subsidy level and receive subsidies per passenger and ticket income based on changes in relation to this level. This requires symmetry, i.e. any reduction in patronage will imply reduced subsidies.

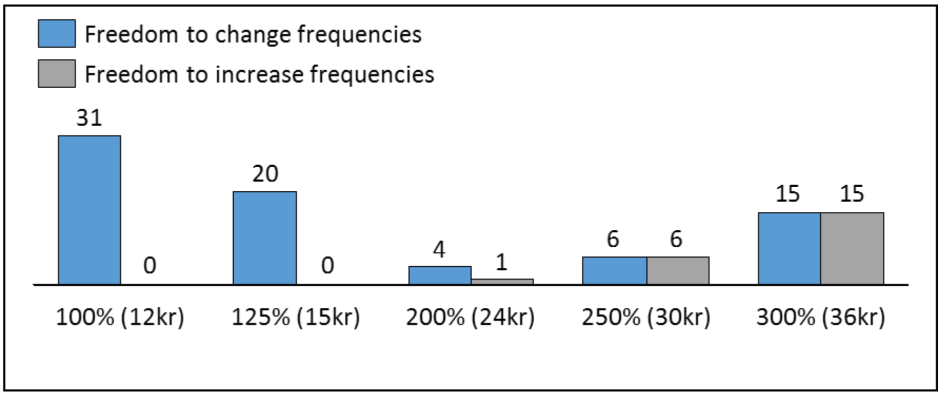



*Figure 4 16: Operators net change in profit, deviation from initial subsidy level depending of level of freedom in the contract Incenties per new passenger MSEK/year. Change from current level. Lund contract.*

The figure below shows estimated tendering price based on initial subsidy level and changes in profits for the operator. Estimated tender price will be the change in profit less the original subsidy level (SEK 16.3 million). Both the profit and the bid price will have a U-shape if there is no lower limit on frequency. This is because operators can profit by reducing the level of service.

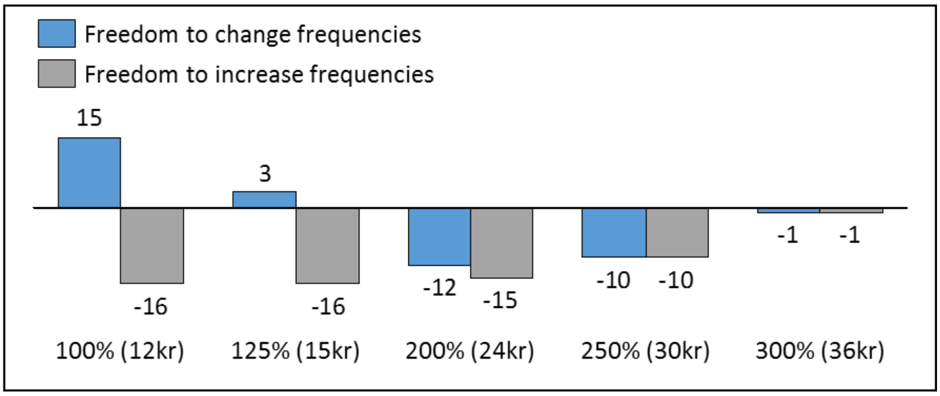



*Figure 4 17: Estimated tendering price based on initial subsidy level and change in profit for the opretor. MSEK per year. Change from current level. Lund contract.*

The actual subsidy demand is calculated on the basis of the difference between costs and farebox recovery and describes public spending. As mentioned, ridership incentives will not be included in this figure as this is a transaction between the public authority and operator in order to achieve transport policy objectives in the tendering process.

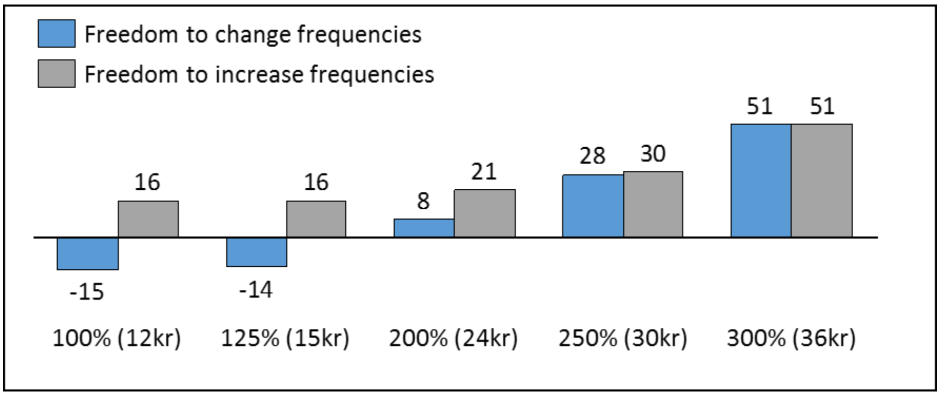



*Figure 4 18: Estimated subsidy level with different ridership incentives Mill SEK per yhear Lund stad. Change from current level. Lund contract.*

It is worth emphasising that high incentives will give operators large profits in the event of a restrictive Government transport policy aimed at reducing car traffic. Net surplus of external shift in demand is total revenue per passenger less the cost per passenger (which in this analysis is only SEK 13 per passenger). This gives a net gain of SEK 12 + SEK 24

– SEK 13 = SEK 23 per new passenger if the frequency is increased in line with passenger growth and a total of SEK 12.6 million with a passenger incentive of SEK 36.

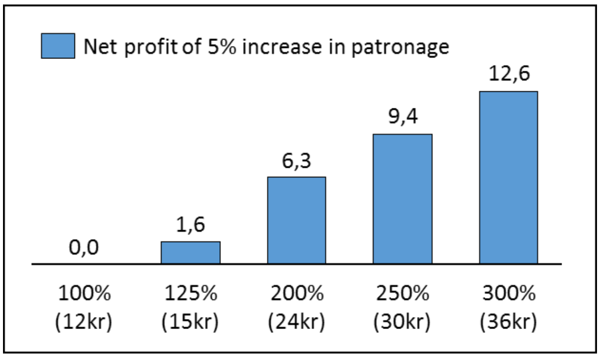



*Figure 4 19: net profit for operators of external shift of 5 per cent with different ridership incentives and fixed load factor Mill SEK per year Lund contract. Change from current level.*

### 4.3.6. Summary table

| | Freedom to change | 100% (12 kr) | 200% (24 kr) | 300% (36 kr) |
|---|---|---|---|---|
| **Patronage -** current 10.5 | | | | |
| | Frequencies | 6.2 | 10.1 | 10.7* |
| | Fares and frequencies | 3.6 | 6.6 | 11.1 |
| | Fares | 4.9 | 7.5 | 11.1 |
| | Differentiated fares | 5.2 | 7.9 | 11.9 |
| **Total subsidy (without ticket revenue)** | | | | |
| | Frequencies | 0 | 122 | 259* |
| | Fares and frequencies | 0 | 79 | 268 |
| | Fares | 0 | 91 | 268 |
| | Differentiated fares | 0 | 96 | 288 |

## 4.4. Need for further studies

Any optimal incentive structure must be fine-tuned to a degree beyond the scope of this project. However, these analyses show that output-based funding can produce significant economic benefits and increased patronage.

Further studies are needed to investigate the potential of differentiating subsidies per passenger between peak hours, other peak hour traffic and low traffic.

The use of subsidies per passenger alone is costly, and a combination of different incentives could be more efficient, i.e. inducing the operator to deliver a level of service close to the socially optimal level at a lower subsidy level.

# 5. Conclusions

Subsidies do not automatically generate a socioeconomically optimal level of service. Private public transport operators will maximise profit and not the socioeconomic benefits. Even public authorities will not necessarily recognise how the service should be developed in order to achieve optimal socioeconomic benefits. A central question is therefore, whether it is possible to find an optimal funding mechanism for public transport providers, which reconciles the incentivisation of the public transport operator with the socioeconomic objectives of the public authority.

In order to achieve increased patronage from subisied per passenger, the operator must have the degrees of freedom to affect patronage. In this paper, degrees of freedom are exemplified with the possibility to change and differentiate fares, and change frequency. If the operator is not permitted to change fares or reallocate supply, there will be no change in their allocation of resources or the number of passengers using public transport. This implies that incentives contracts, in order to drive patronage, need to include greater degrees of freedom than today so that operators gain responsibility on the tactical level.

Similarly, ridership incentives must be much larger than the current level to have an effect on patronage, and to take into account the social benefit for existing passengers. Without a base subsidy, subsidies per passenger must be 220-300% of revenue per passenger in order to induce the operator to deliver the socially optimal level of service.

A contract where subsidies are provided only as ridership incentives per passenger will need an altered tendering process. As the operator must be incentivised to internalise external costs, the incentives must be high, generating the opportunity for large profits for the operator. An alternative tendering process allows potential operators to tender on the contract by exploiting their market knowledge, while incentives and framework conditions are set by the public transport authority. Public funding can stay at the current level or even be reduced.

This study is based on a non-linear optimisation model with constraints on the level of freedom within the contract. Five contracts in the Stockholm and Skåne regions are analysed. These analyses show that output-based funding in the form of subsidies per passenger can produce significant economic benefits and increased patronage with the same overall level of subsidy.

Public transport provision without subsidies can be profitable; however, depending on the degree of freedom granted to operators, this will involve higher fares, reduced levels of service and larger buses. It can therefore be concluded that a failure to subsidise public transport will result in socioeconomic losses.

Further studies is needed to investigate the full potential of ridership incentives. The use of ridership incentives alone is costly, and a combination of different incentives could be more efficient in order to increase patronage.

# 6. Appendix

## 6.1. Reduced subsidy in North East Skåne

Given existing restrictions in the current contract in North East Skåne, achieving the socially optimal supply requires reducing off-peak capacity by 63 per cent and peak capacity by 11 per cent. This will lead to a 34 per cent reduction in patronage and an SEK 18 million reduction in social surplus. This result shows that it is not always optimal to increase the supply of public transport.

There are two central conditions separating North East Skåne from the other areas in this study. Firstly, their subsidy is 74 per cent of total costs, while this share is considerably lower in the other areas (the next-largest share is 38 per cent in Landskrona). The results indicate that current subsidies and levels of service in North East Skåne are above the socially optimal level. Optimisation brings the subsidy from down from SEK 57 to 30 million, and from 74 to 69 per cent of total costs. The share of total cost is still higher than in the other areas but is closer to the national average of approximately 50%. One reason for this high share is long routes with few passengers. The use of average income per passenger in Skåne as a proxy for ticket revenue contributes to the high share, as in all likelihood it underestimates fares in this rural area.

The second factor is that the occupancy rate is low compared to the other areas as vehicle and seat kilometres are high relative to passenger kilometres. The table below shows load factors for the different areas. The load factor represents the average number of passengers per place (seated and standing). It has not been possible to conduct a full quality assurance of the load factor or occupancy rate within the timeframe of this project. All results are dependent on publicly available data.

*Table 5.3: Load factor in the contract areas.*

| Load | Stockholm E22 | Stockholm E23 | Lund | North East Skåne | Landskrona |
|---|---|---|---|---|---|
| Peak hours | 0.0657 | 0.0289 | 0.05 | 0.0047 | 0.0342 |
| Low traffic | 0.0829 | 0.0138 | 0.0263 | 0.0026 | 0.0081 |
| Aevrage load factor | 0.07 | 0.02 | 0.04 | 0.00 | 0.03 |
| Deviation from Lund | 74% | -44% | 0% | -91% | -36% |

North East Skåne can be expected to have the lowest load factor as it is the most rural area. Load in peak hours is only 13 per cent of Landskrona, the area with second lowest occupancy rate. This is because place kilometres (seated and standing) are higher in North East Skåne, as vehicle kilometres are three times as high while bus size is the same as in Landskrona. On average, the load factor in Stockholm E22 is 74% higher than in Lund, while in Stockholm E23, it is 44 per cent lower. Please note that these are modelled load factors and may deviate from actual figures.

## 6.2. Optimal level of service given existing restrictions

Table 7.1: Optimal level of service given existing restrictions in all contract areas.

| | | Stockholm E22 | Stockholm E23 | Lund | North East Skåne | Lands-krona |
|---|---|---|---|---|---|---|
| Subsidy (MSEK) | Social opt. | -189.1 | 73.7 | 16.3 | 30.0 | 17.4 |
| | Current situation | -189.1 | 73.7 | 16.3 | 57.1 | 17.4 |
| Subsidy share | Social opt. | -24% | 30% | 11% | 69% | 38% |
| | Current situation | -24% | 30% | 11% | 74% | 38% |
| Average fares | Profit-max. | 10.8 | 10.8 | 12.1 | 12.1 | 12.1 |
| | Social opt. | 10.8 | 10.8 | 12.1 | 12.1 | 12.1 |
| | Current situation | 10.8 | 10.8 | 12.1 | 12.1 | 12.1 |
| Capacity basis | Profit-max. | 14 390 | 63 030 | 11 136 | 11 052 | 8 455 |
| | Social opt. | 184 343 | 71 791 | 23 170 | 11 052 | 8 455 |
| | Current situation | 161 038 | 111 823 | 31 628 | 29 618 | 10 178 |
| Capacity rush | Profit-max. | 109 623 | 281 990 | 31 966 | 33 112 | 16 012 |
| | Social opt. | 400 781 | 322 612 | 72 990 | 61 796 | 19 919 |
| | Current situation | 426 329 | 257 438 | 59 310 | 69 315 | 16 028 |
| Vehicle km basis | Profit-max. | 0.1 | 0.5 | 0.1 | 0.1 | 0.1 |
| (1000, per hour) | Social opt. | 2.0 | 0.6 | 0.3 | 0.1 | 0.1 |
| | Current situation | 1.6 | 1.1 | 0.4 | 0.4 | 0.1 |
| Vehicle km extra rush | Profit-max. | 0.3 | 2.4 | 0.1 | 0.1 | 0.1 |
| (1000, per hour) | Social opt. | 1.7 | 3.8 | 1.0 | 0.7 | 0.3 |
| | Current situation | 2.6 | 1.4 | 0.4 | 0.5 | 0.1 |
| Bus size basis | Profit-max. | 135 | 137 | 111 | 111 | 85 |
| | Social opt. | 91 | 130 | 90 | 111 | 85 |
| | Current situation | 102 | 102 | 75 | 75 | 75 |
| Bus size rush | Profit-max. | 224 | 92 | 208 | 220 | 76 |
| | Social opt. | 126 | 66 | 48 | 86 | 44 |
| | Current situation | 102 | 102 | 75 | 75 | 75 |

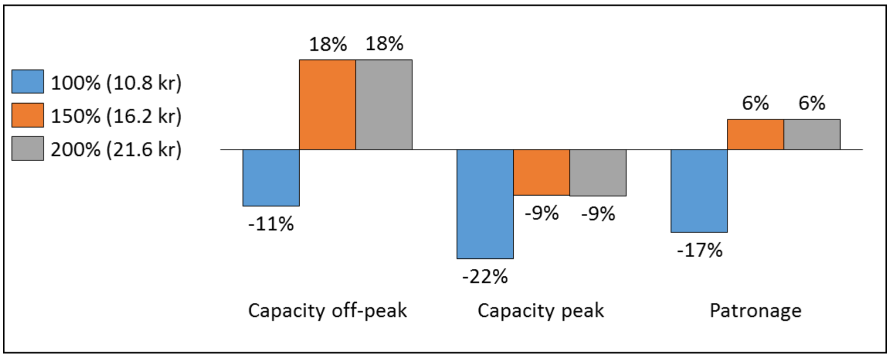
## 6.3. Operator's allocation to increasing levels of incentive

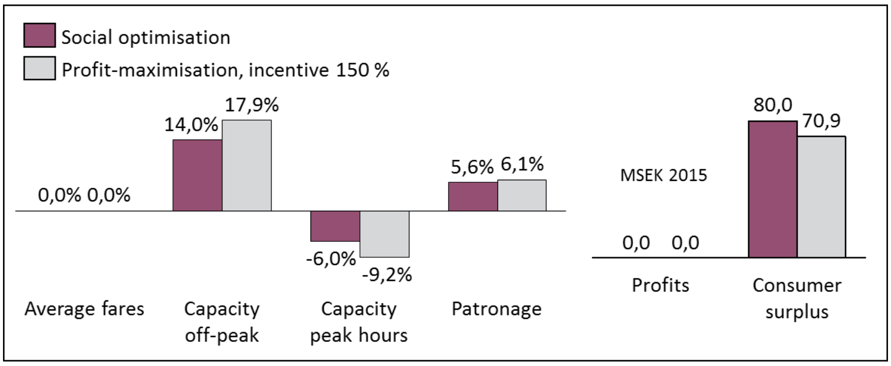
### 6.3.1. Freedom to change frequencies

| | | Stockholm E22 | Stockholm E23 | Lund | North East Skåne* | Lands-krona |
|---|---|---|---|---|---|---|
| Incentive level | Profit-max. | 150% | 300% | 221% | 350% | 300% |
| Incentive SEK | Profit-max. | 16.2 | 32.4 | 26.7 | 42.3 | 36.3 |
| Change in CS | Profit-max. | 70.8 | 38.9 | 20.5 | -18.2 | 13.3 |
| Subsidy (MSEK) | Profit-max. | 511.0 | 349.0 | 259.0 | 33.0 | 63.5 |
| | Social opt. | -189.1 | 73.7 | 16.3 | 30.0 | 17.4 |
| | Current situation | -189.1 | 73.7 | 16.3 | 57.1 | 17.4 |
| Subsidy share | Profit-max. | 61% | 141% | 178% | 77% | 129% |
| | Social opt. | -24% | 30% | 11% | 69% | 38% |
| | Current situation | -24% | 30% | 11% | 74% | 38% |
| Average fares | Profit-max. | 10.8 | 10.8 | 12.1 | 12.1 | 12.1 |
| | Social opt. | 10.8 | 10.8 | 12.1 | 12.1 | 12.1 |
| | Current situation | 10.8 | 10.8 | 12.1 | 12.1 | 12.1 |
| Capacity basis | Profit-max. | 189 802 | 89 812 | 27 722 | 11 052 | 8 455 |
| | Social opt. | 184 343 | 71 791 | 23 170 | 11 052 | 8 455 |
| | Current situation | 161 038 | 111 823 | 31 628 | 29 618 | 10 178 |
| Capacity rush | Profit-max. | 387 292 | 302 116 | 67 639 | 60 882 | 19 922 |
| | Social opt. | 400 781 | 322 612 | 72 990 | 61 796 | 19 919 |
| | Current situation | 426 329 | 257 438 | 59 310 | 69 315 | 16 028 |
| Vehicle km basis (1000, per hour) | Profit-max. | 2.1 | 0.8 | 0.3 | 0.1 | 0.1 |
| | Social opt. | 2.0 | 0.6 | 0.3 | 0.1 | 0.1 |
| | Current situation | 1.6 | 1.1 | 0.4 | 0.4 | 0.1 |
| Vehicle km extra rush (1000, per hour) | Profit-max. | 1.3 | 2.9 | 0.7 | 0.5 | 0.3 |
| | Social opt. | 1.7 | 3.8 | 1.0 | 0.7 | 0.3 |
| | Current situation | 2.6 | 1.4 | 0.4 | 0.5 | 0.1 |
| Bus size basis | Profit-max. | 89 | 117 | 82 | 111 | 85 |
| | Social opt. | 91 | 130 | 90 | 111 | 85 |
| | Current situation | 102 | 102 | 75 | 75 | 75 |
| Bus size rush | Profit-max. | 148 | 72 | 54 | 105 | 44 |
| | Social opt. | 126 | 66 | 48 | 86 | 44 |
| | Current situation | 102 | 102 | 75 | 75 | 75 |

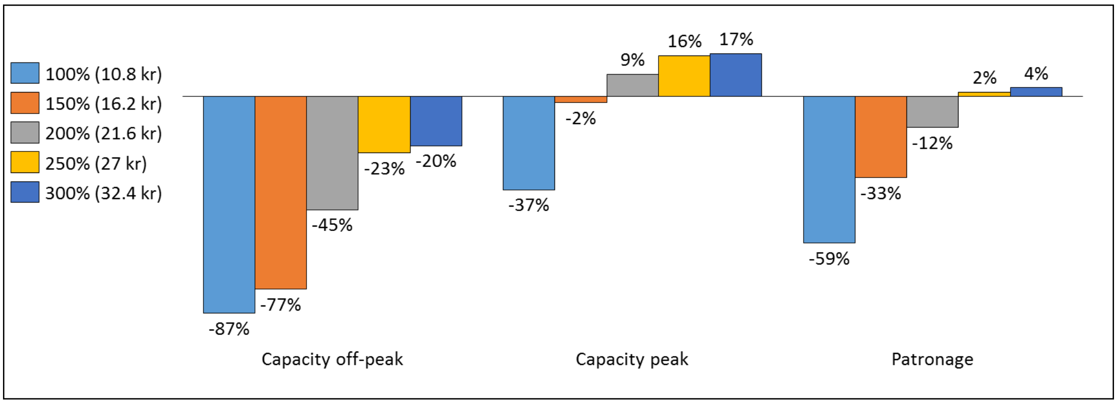
*Due to the reduction of the level of service in North East Skåne, the incentive level of 350 percent is the level that ensures greatest similarity between profit-maximisation and social optimising, while in order to equal cost and income per passenger excl. ridership incentives, the subsidy level must be 550 percent.

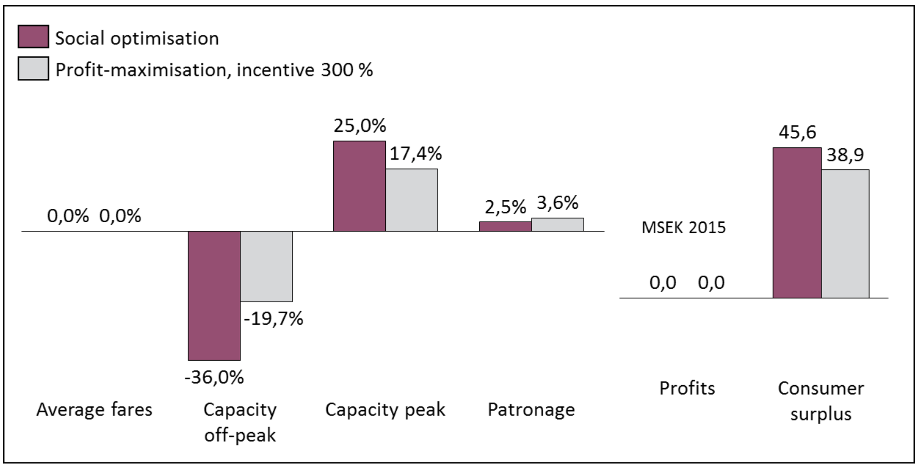
Stockholm E22 figures. Freedom to change frequencies:



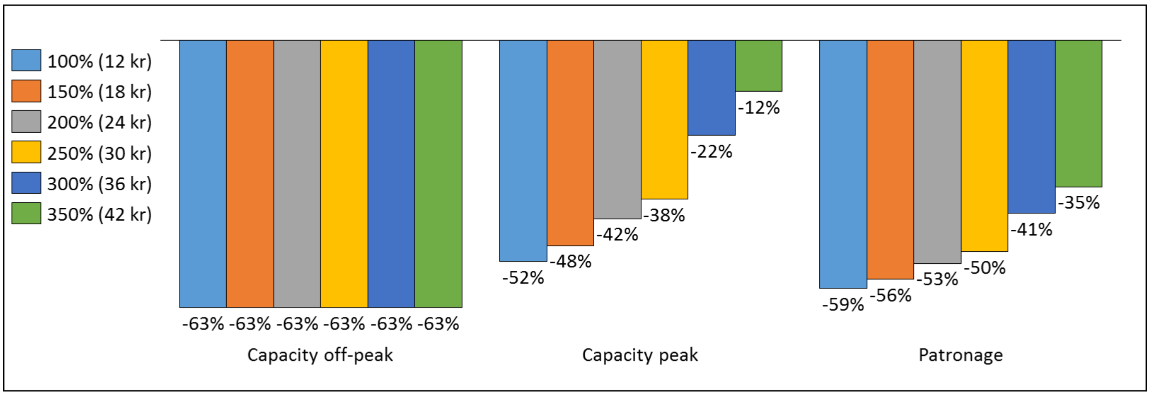



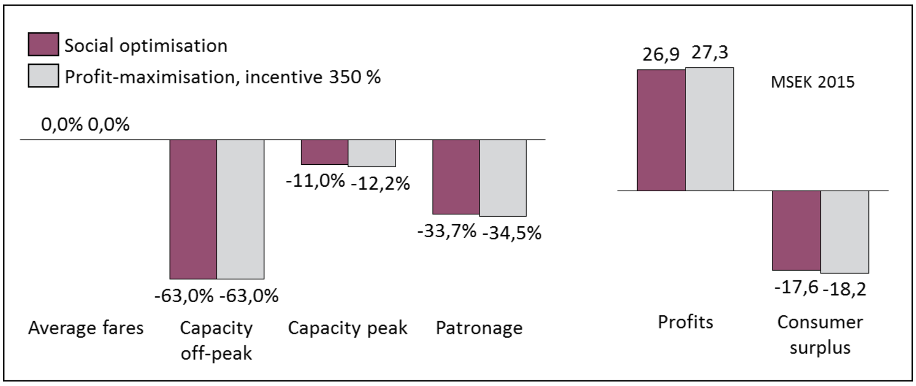

Stocholm E23 figures. Freedom to change frequencies:



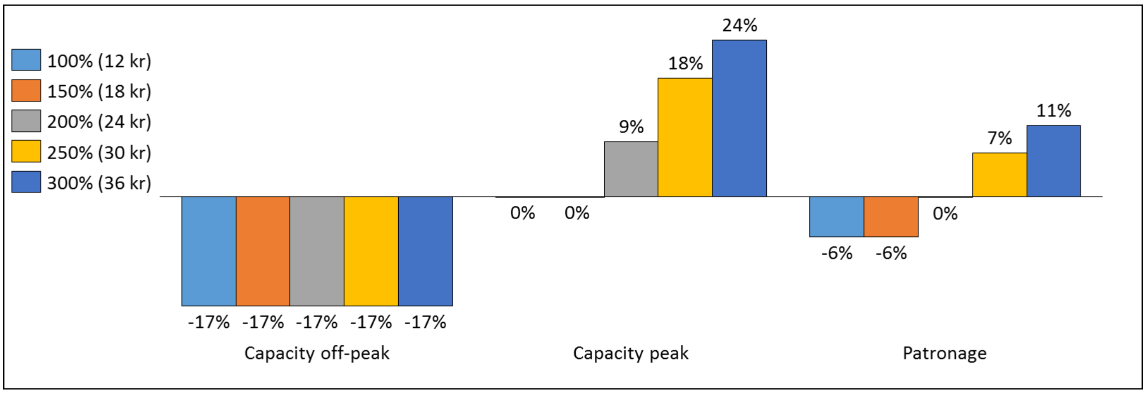



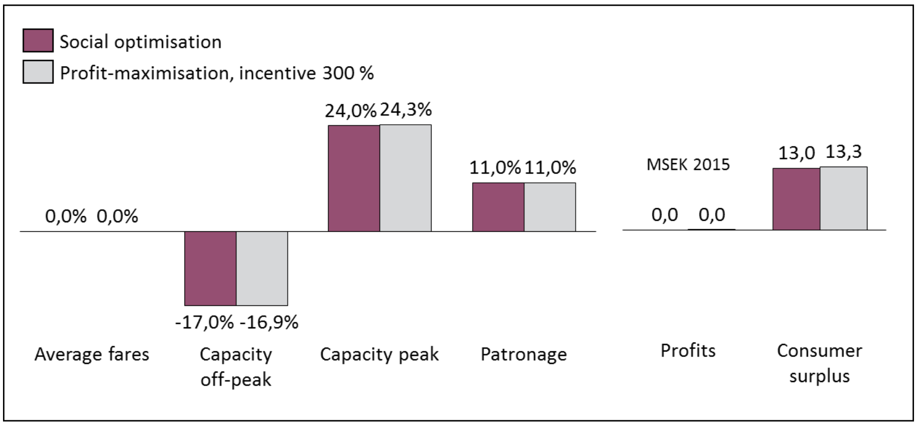
North East Skåne figures. Freedom to change frequencies:




Landskrona figures. Freedom to change frequencies:

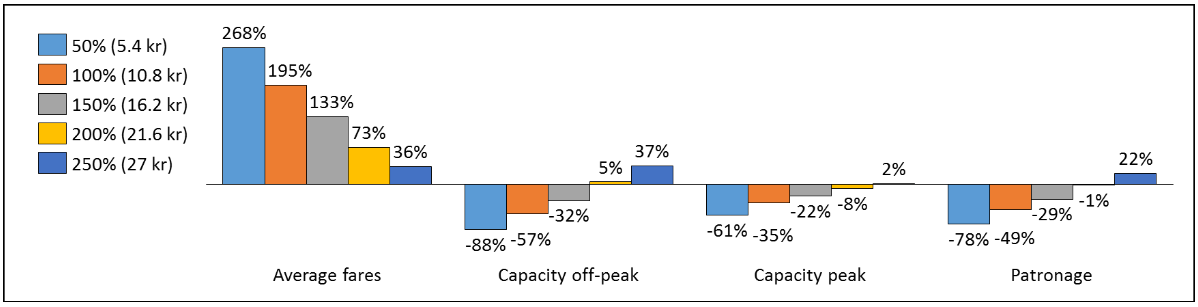


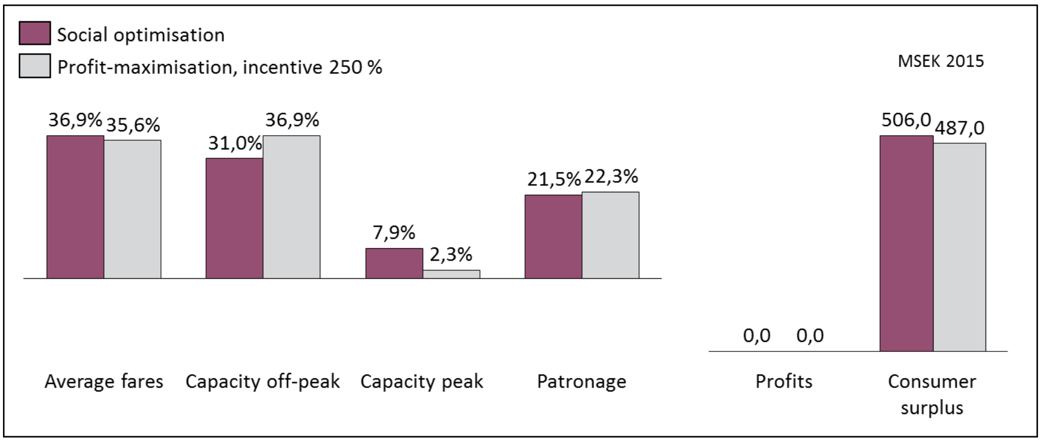



### 6.3.2. Freedom to set fares and frequencies

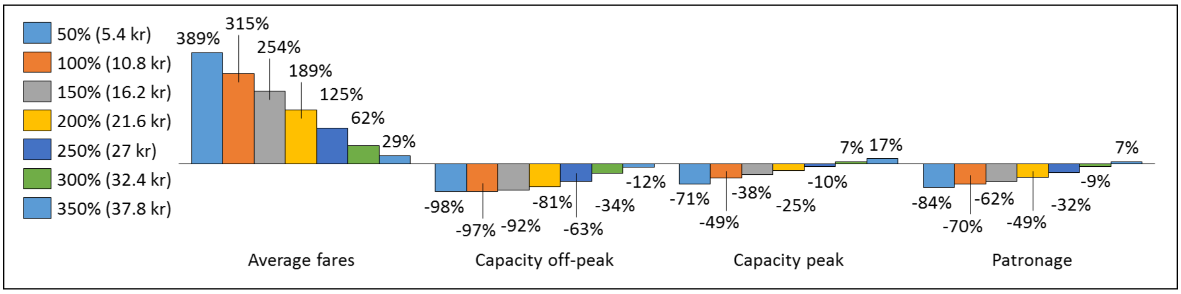
| | | Stockholm E22 | Stockholm E23 | Lund | North East Skåne | Lands-krona |
|---|---|---|---|---|---|---|
| Incentive level | Profit-max. | 250% | 350% | 300% | 350% | 350% |
| Incentive SEK | Profit-max. | 27.0 | 37.8 | 36.3 | 42.3 | 42.3 |
| Change in CS | Profit-max. | 487.7 | 50.7 | 31.3 | -28.5 | 14.3 |
| Subsidy (MSEK) | Profit-max. | 1769.6 | 449.2 | 267.7 | 24.8 | 79.8 |
| | Social opt. | -189.1 | 73.7 | 16.3 | 20.0 | 17.4 |
| | Current situation | -189.1 | 73.7 | 16.3 | 57.1 | 17.4 |
| Subsidy share | Profit-max. | 125% | 147% | 143% | 145% | 150% |
| | Social opt. | -13% | 30% | 9% | 51% | 32% |
| | Current situation | -24% | 25% | 11% | 74% | 38% |
| Average fares | Profit-max. | 35.6 | 28.5 | 27.4 | 96.2 | 13.5 |
| | Social opt. | 14.8 | 10.8 | 24.7 | 94.6 | 13.9 |
| | Current situation | 10.8 | 10.8 | 12.1 | 12.1 | 12.1 |
| Capacity basis | Profit-max. | 220 487 | 98 173 | 29 578 | 6 963 | 7 999 |
| | Social opt. | 210 993 | 82 700 | 26 179 | 7 017 | 7 864 |
| | Current situation | 161 038 | 111 823 | 31 628 | 29 618 | 10 178 |
| Capacity rush | Profit-max. | 435 993 | 302 297 | 68 292 | 49 219 | 20 438 |
| | Social opt. | 459 797 | 319 686 | 72 432 | 49 458 | 20 536 |
| | Current situation | 426 329 | 257 438 | 59 310 | 69 315 | 16 028 |
| Vehicle km basis (1000, per hour) | Profit-max. | 4.1 | 1.1 | 0.5 | 0.1 | 0.1 |
| | Social opt. | 3.8 | 0.8 | 0.4 | 0.1 | 0.1 |
| | Current situation | 1.6 | 1.1 | 0.4 | 0.4 | 0.1 |
| Vehicle km extra rush (1000, per hour) | Profit-max. | 2.2 | 3.7 | 0.9 | 0.5 | 0.3 |
| | Social opt. | 3.6 | 4.5 | 1.2 | 0.5 | 0.3 |
| | Current situation | 2.6 | 1.4 | 0.4 | 0.5 | 0.1 |
| Bus size basis | Profit-max. | 53 | 89 | 63 | 70 | 80 |
| | Social opt. | 56 | 104 | 70 | 70 | 79 |
| | Current situation | 102 | 102 | 75 | 75 | 75 |
| Bus size rush | Profit-max. | 96 | 55 | 41 | 84 | 38 |
| | Social opt. | 68 | 53 | 37 | 84 | 37 |
| | Current situation | 102 | 102 | 75 | 75 | 75 |

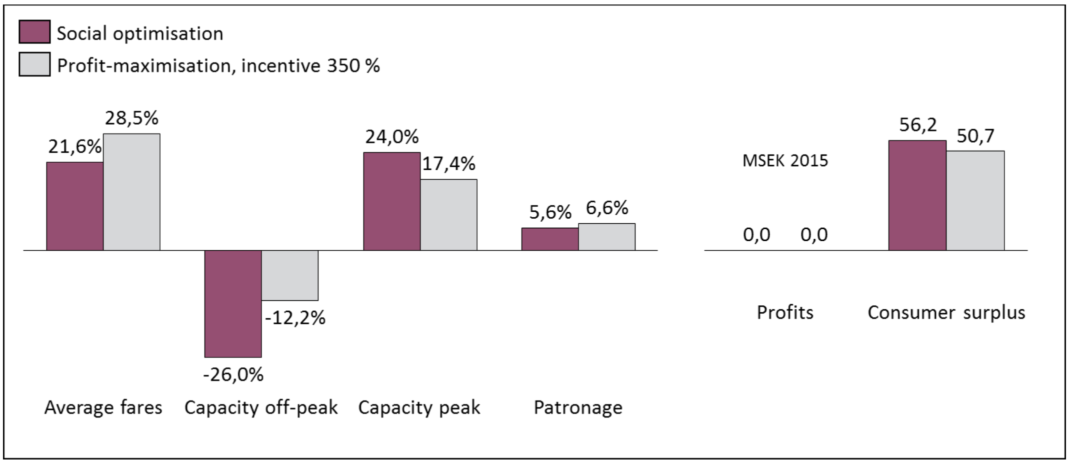
Stockholm E22 figures. Freedom to change fares and frequencies:



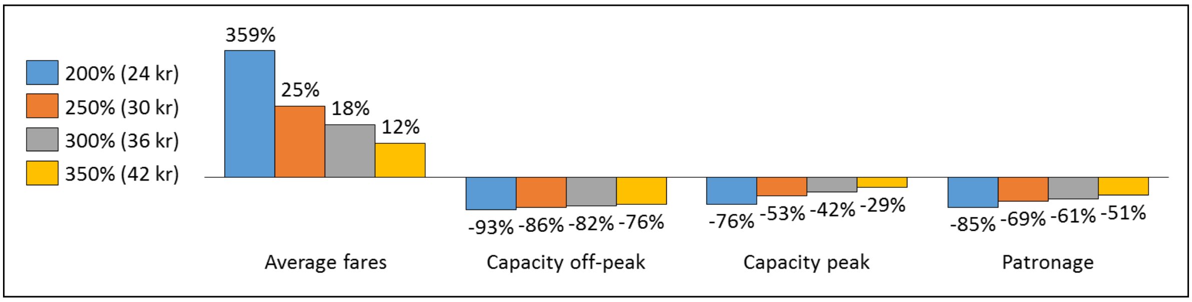



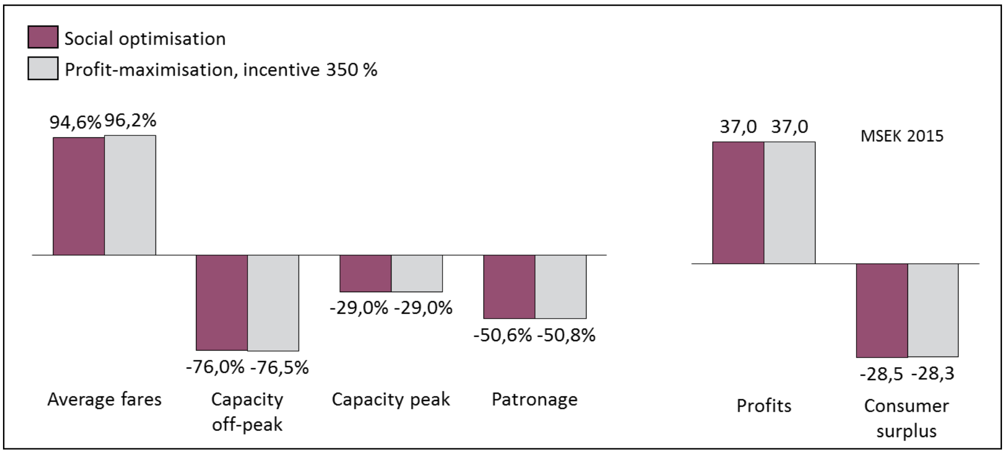

Stocholm E23 figures. Freedom to change fares and frequencies:



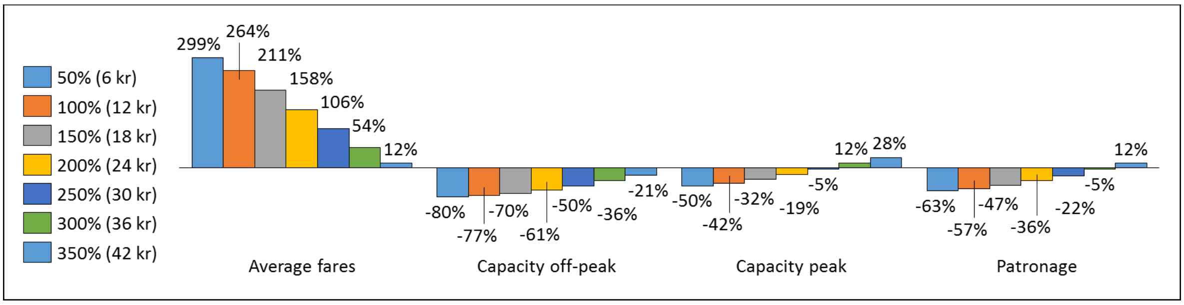



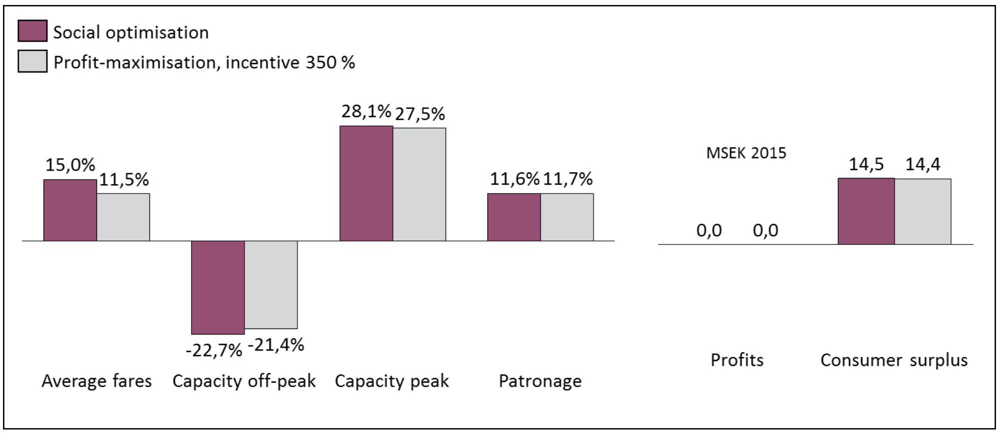
North East Skåne figures. Freedom to change fares and frequencies:




Landskrona figures. Freedom to change fares and frequencies:

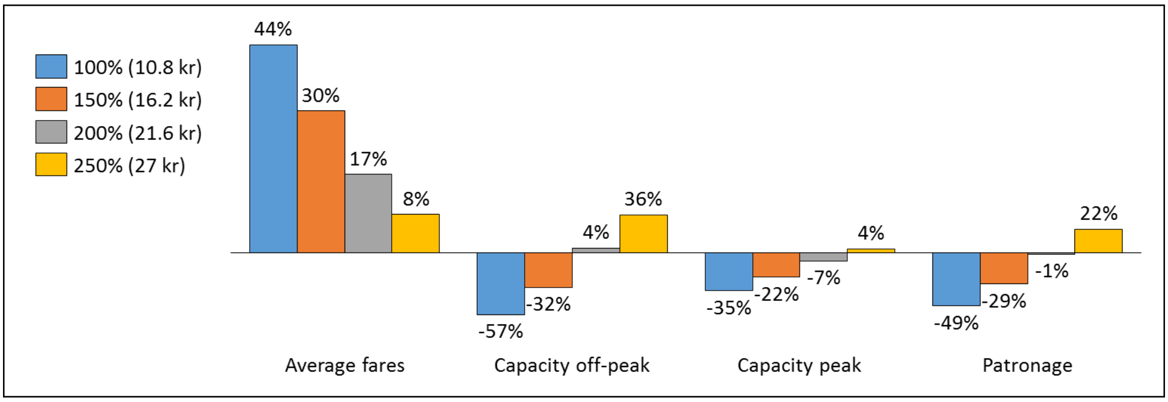


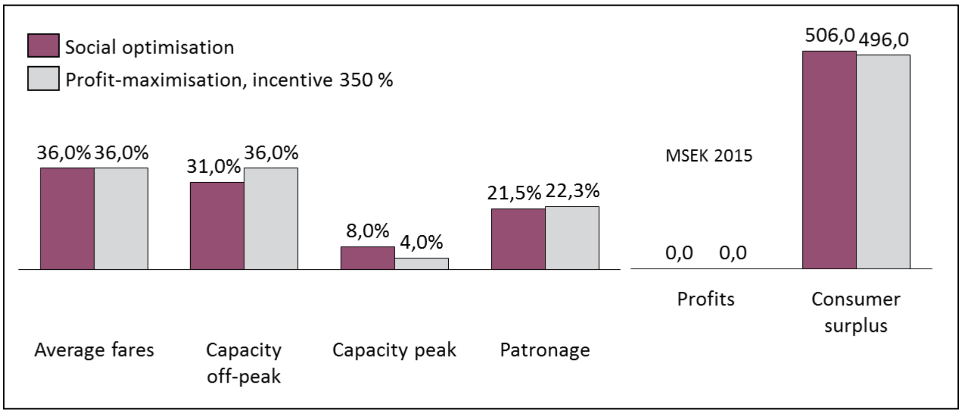



### 6.3.3. Freedom to set fares

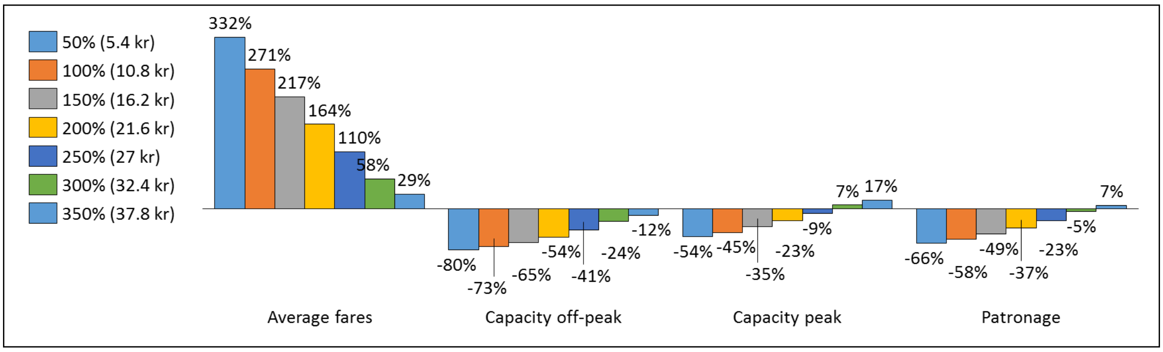
| | | Stockholm E22 | Stockholm E23 | Lund | North East Skåne | Lands-krona |
|---|---|---|---|---|---|---|
| Incentive level | Profit-max. | 300% | 350% | 350% | 400% | 350% |
| Incentive SEK | Profit-max. | 32.4 | 37.8 | 42.3 | 48.4 | 42.3 |
| Change in CS | Profit-max. | 0 | 0 | 0 | 0 | 0 |
| Subsidy | Profit-max. | 1928.9 | 421.0 | 316.0 | 60.0 | 42.9 |
| (MSEK) | Social opt. | -189.1 | 73.7 | 16.3 | 57.1 | 17.4 |
| | Current situation | -189.1 | 73.7 | 16.3 | 57.1 | 17.4 |
| Subsidy share | Profit-max. | 249% | 172% | 221% | 78% | 93% |
| | Social opt. | -24% | 25% | 11% | 74% | 38% |
| | Current situation | -24% | 25% | 11% | 74% | 38% |
| Average fares | Profit-max. | 10.8 | 10.8 | 12.1 | 12.1 | 12.1 |
| | Social opt. | 10.8 | 10.8 | 12.1 | 12.1 | 12.1 |
| | Current situation | 10.8 | 10.8 | 12.1 | 12.1 | 12.1 |
| Capacity basis | Profit-max. | 161 038 | 111 823 | 31 628 | 29 618 | 10 178 |
| | Social opt. | 161 038 | 111 823 | 31 628 | 29 618 | 10 178 |
| | Current situation | 161 038 | 111 823 | 31 628 | 29 618 | 10 178 |
| Capacity rush | Profit-max. | 426 329 | 257 438 | 59 310 | 69 315 | 16 028 |
| | Social opt. | 426 329 | 257 438 | 59 310 | 69 315 | 16 028 |
| | Current situation | 426 329 | 257 438 | 59 310 | 69 315 | 16 028 |
| Vehicle km basis | Profit-max. | 1.6 | 1.1 | 0.4 | 0.4 | 0.1 |
| (1000, per hour) | Social opt. | 1.6 | 1.1 | 0.4 | 0.4 | 0.1 |
| | Current situation | 1.6 | 1.1 | 0.4 | 0.4 | 0.1 |
| Vehicle km extra rush | Profit-max. | 2.6 | 1.4 | 0.4 | 0.5 | 0.1 |
| (1000, per hour) | Social opt. | 2.6 | 1.4 | 0.4 | 0.5 | 0.1 |
| | Current situation | 2.6 | 1.4 | 0.4 | 0.5 | 0.1 |
| Bus size basis | Profit-max. | 102 | 102 | 75 | 75 | 75 |
| | Social opt. | 102 | 102 | 75 | 75 | 75 |
| | Current situation | 102 | 102 | 75 | 75 | 75 |
| Bus size rush | Profit-max. | 102 | 102 | 75 | 75 | 75 |
| | Social opt. | 102 | 102 | 75 | 75 | 75 |
| | Current situation | 102 | 102 | 75 | 75 | 75 |

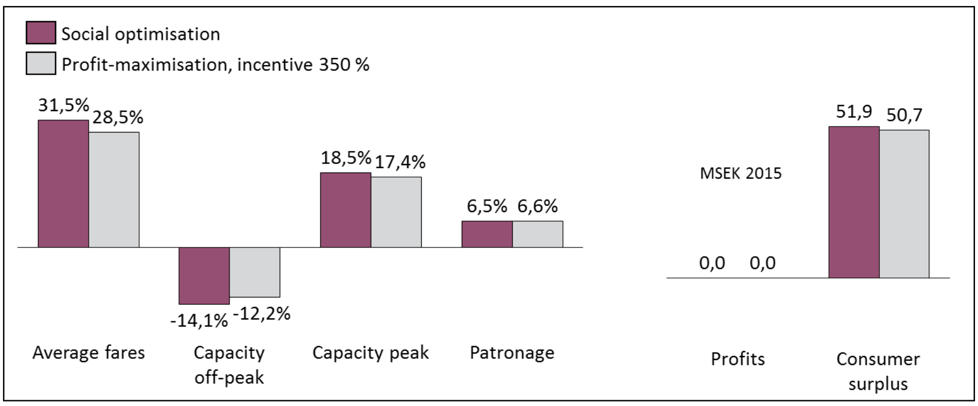
Stockholm E22 figures. Freedom to set fares:



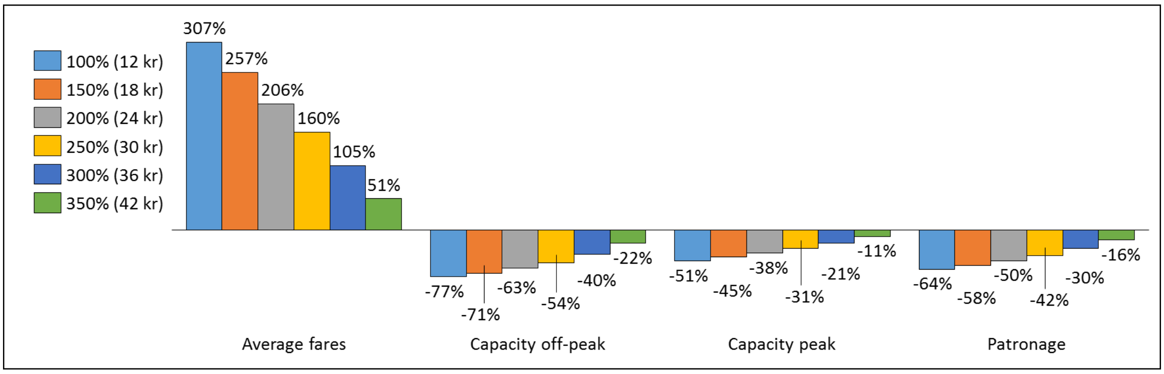



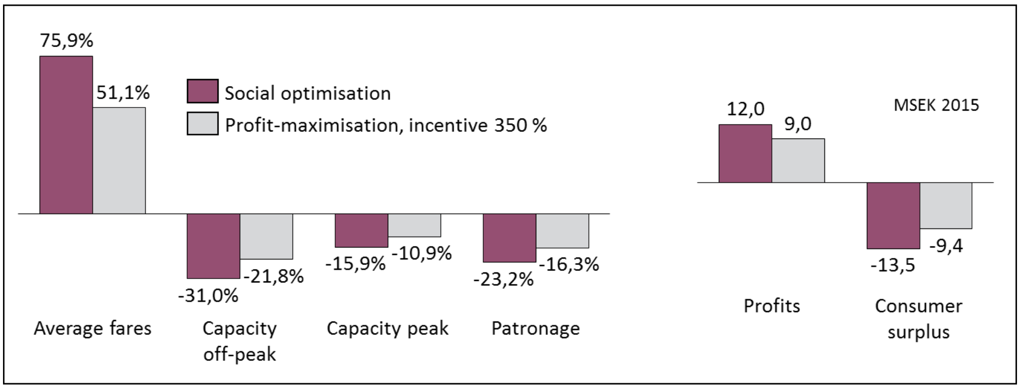

Stocholm E23 figures. Freedom to set fares:



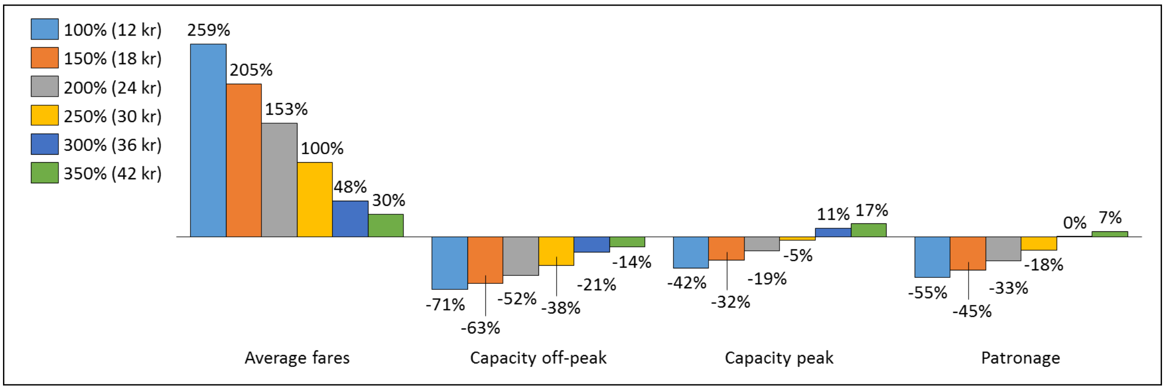



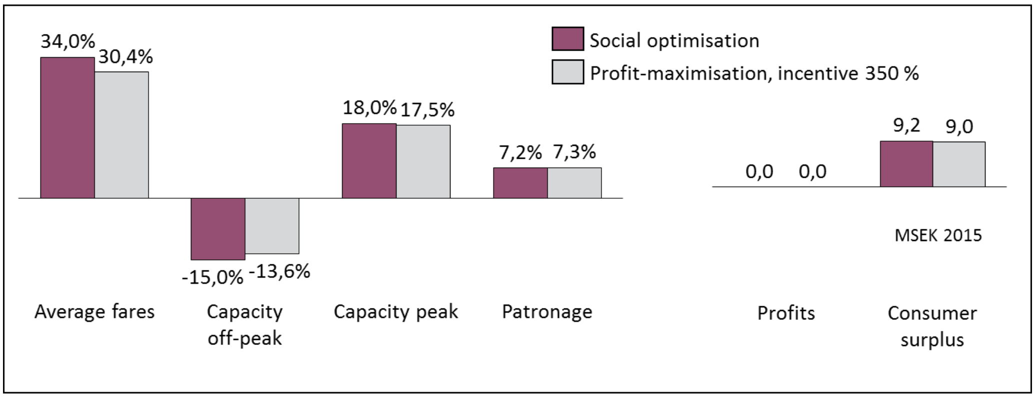
North East Skåne figures. Freedom to set fares:




Landskrona figures. Freedom to set fares:

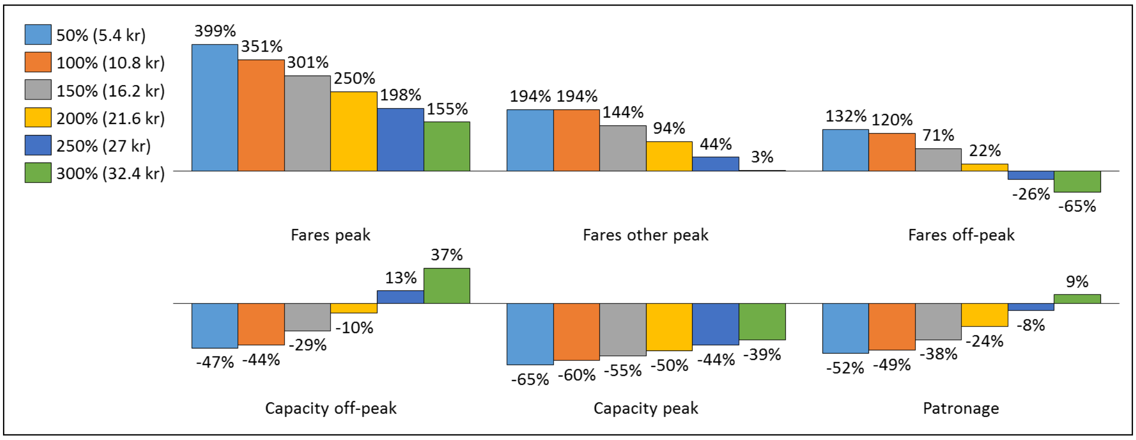


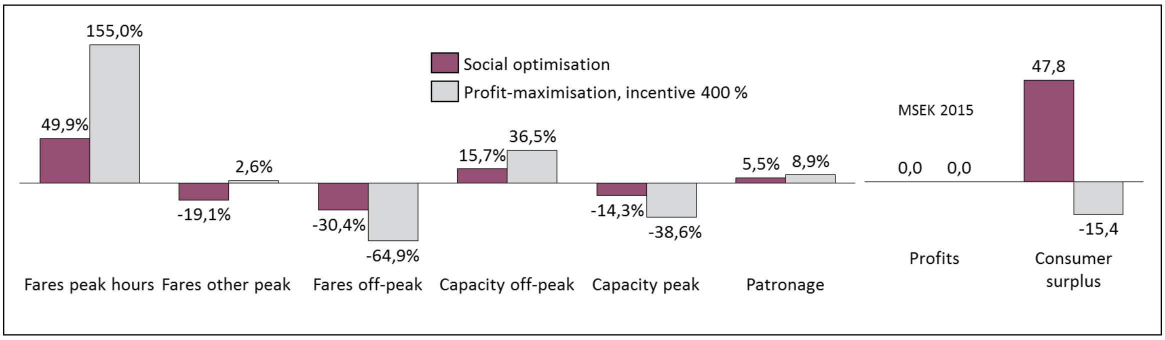



### 6.3.4. Freedom to set differentiated fares

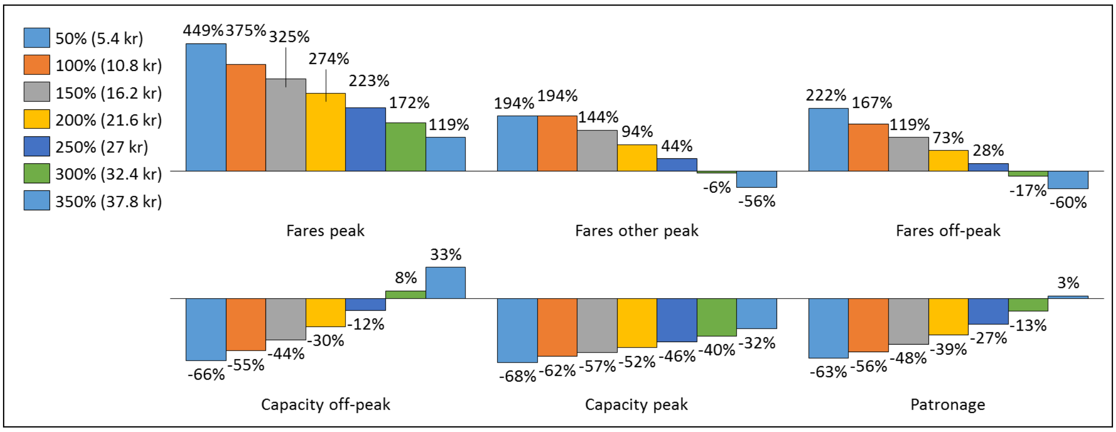
| | | Stockholm E22 | Stockholm E23 | Lund | North East Skåne | Lands-krona |
|---|---|---|---|---|---|---|
| Incentive level | Profit-max. | 300% | 400% | 320% | 350% | 350% |
| Incentive SEK | Profit-max. | 32.4 | 43.2 | 38.7 | 42.4 | 42.4 |
| Change in CS | Profit-max. | -15.4 | -8 | -2.4 | -10.9 | 1.25 |
| Subsidy (MSEK) | Profit-max. | 2027.4 | 536.6 | 296.0 | 44.5 | 75.8 |
| | Social opt. | -189.1 | 73.7 | 16.3 | 57.1 | 17.4 |
| | Current sit. | -189.1 | 73.7 | 16.3 | 57.1 | 17.4 |
| Subsidy share | Profit-max. | 274% | 223% | 207% | 62% | 159% |
| | Social opt. | -25% | 31% | 11% | 74% | 37% |
| | Current sit. | -24% | 25% | 11% | 74% | 38% |
| Fares rush | Profit-max. | 27.6 | 22.8 | 23.3 | 36.0 | 20.5 |
| | Social opt. | 16.2 | 13.9 | 16.1 | 30.9 | 15.2 |
| | Current sit. | 10.8 | 10.8 | 12.1 | 12.1 | 12.1 |
| Fares other rush | Profit-max. | 11.1 | 3.8 | 9.2 | 5.3 | 5.3 |
| | Social opt. | 8.7 | 4.7 | 8.6 | 8.2 | 7.3 |
| | Current sit. | 10.8 | 10.8 | 12.1 | 12.1 | 12.1 |
| Fares off-peak | Profit-max. | 3.8 | 3.6 | 4.6 | 10.9 | 6.1 |
| | Social opt. | 7.5 | 9.7 | 9.0 | 19.2 | 11.2 |
| | Current sit. | 10.8 | 10.8 | 12.1 | 12.1 | 12.1 |
| Capacity basis | Profit-max. | 219 881 | 154 284 | 42 644 | 30 988 | 12 904 |
| | Social opt. | 186 350 | 117 638 | 35 776 | 22 368 | 10 565 |
| | Current sit. | 161 038 | 111 823 | 31 628 | 29 618 | 10 178 |
| Capacity rush | Profit-max. | 261 743 | 177 970 | 42 681 | 39 041 | 12 914 |
| | Social opt. | 365 261 | 236 359 | 52 890 | 46 368 | 15 400 |
| | Current sit. | 426 329 | 257 438 | 59 310 | 69 315 | 16 028 |
| Vehicle km basis (1000, per hour) | Profit-max. | 1.6 | 1.1 | 0.4 | 0.4 | 0.1 |
| | Social opt. | 1.6 | 1.1 | 0.4 | 0.4 | 0.1 |
| | Current sit. | 1.6 | 1.1 | 0.4 | 0.4 | 0.1 |
| Veh. km ex. rush (1000, per hour) | Profit-max. | 2.6 | 1.4 | 0.4 | 0.5 | 0.1 |
| | Social opt. | 2.6 | 1.4 | 0.4 | 0.5 | 0.1 |
| | Current sit. | 2.6 | 1.4 | 0.4 | 0.5 | 0.1 |
| Bus size basis | Profit-max. | 139 | 141 | 101 | 78 | 95 |
| | Social opt. | 118 | 107 | 85 | 57 | 78 |
| | Current sit. | 102 | 102 | 75 | 75 | 75 |
| Bus size rush | Profit-max. | 16 | 17 | 0.1 | 15 | 0.1 |
| | Social opt. | 69 | 83 | 46 | 45 | 48 |
| | Current sit. | 102 | 102 | 75 | 75 | 75 |

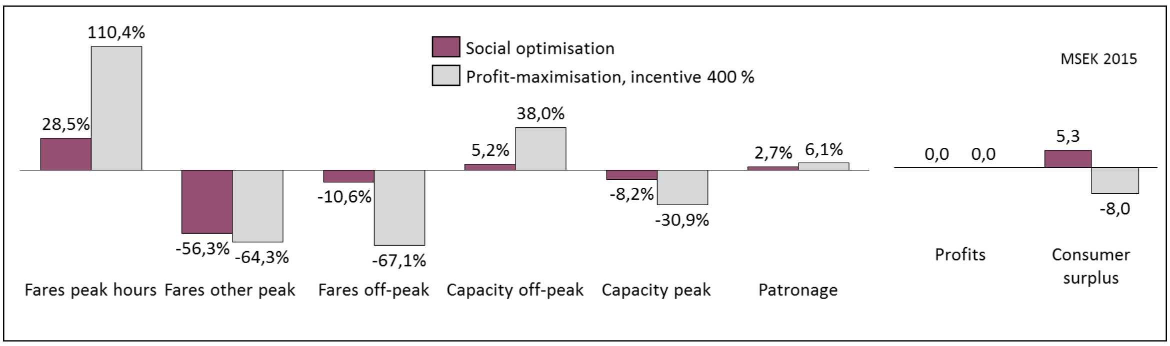
Stockholm E22 figures. Freedom to set differentiated fares:



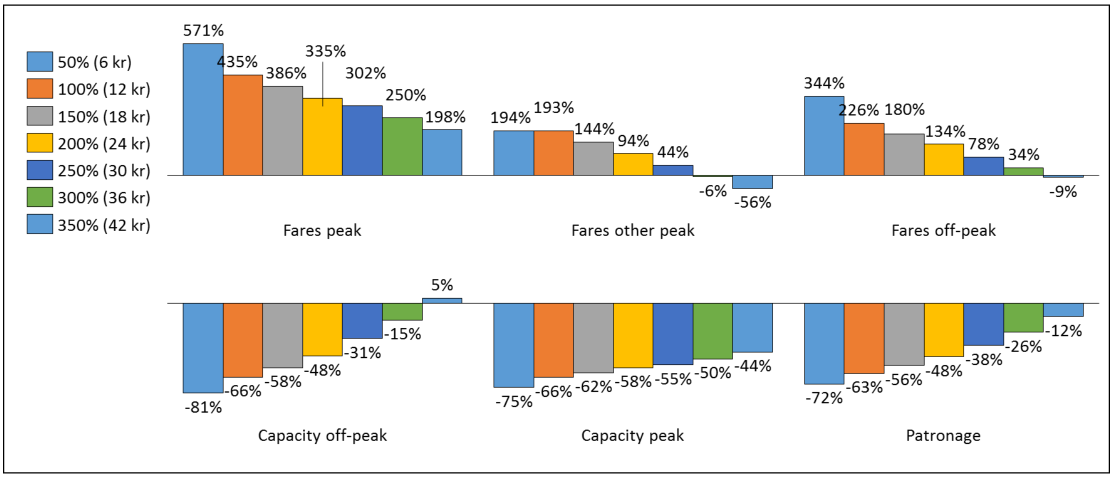



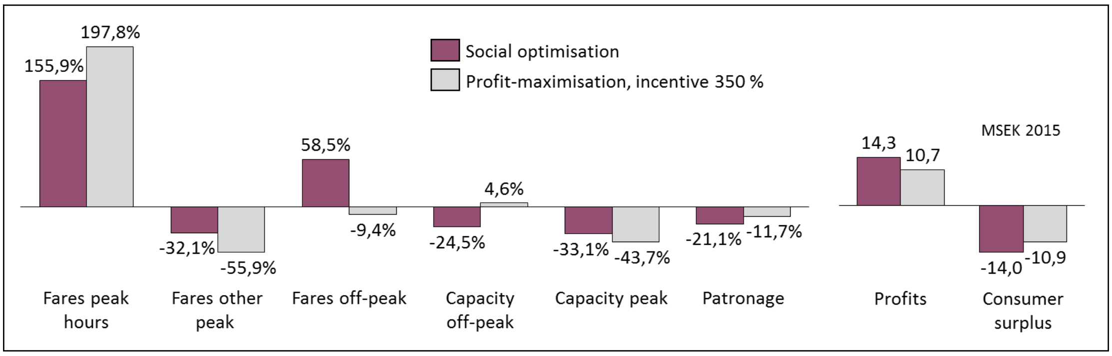

Stocholm E23 figures. Freedom to set differentiated fares:



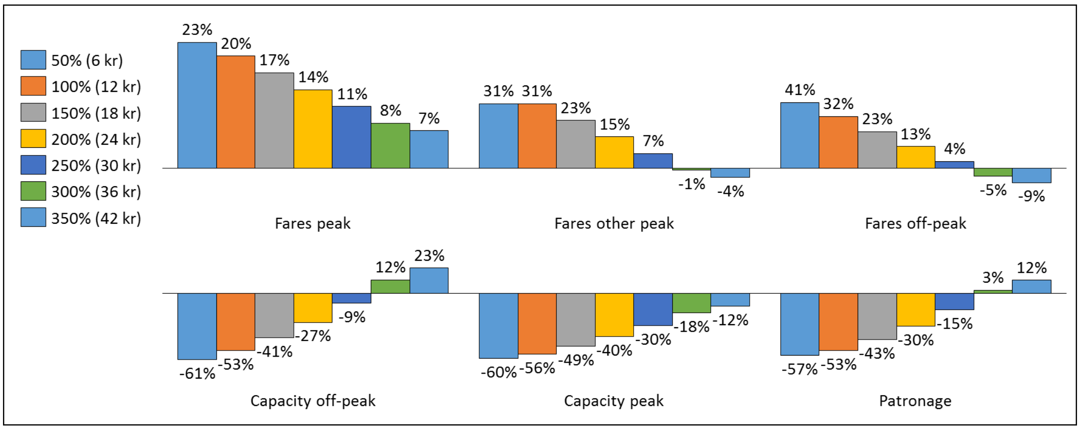



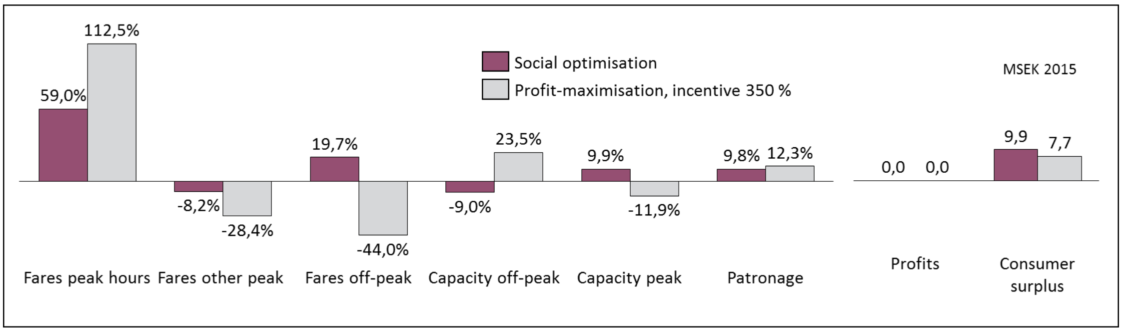
North East Skåne figures. Freedom to set differentiated fares:




Landskrona figures. Freedom to set differentiated fares:



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K2 är Sveriges nationella centrum för forskning och utbildning om kollektivtrafik. Här möts akademi, offentliga aktörer och näringsliv för att tillsammans diskutera och utveckla kollektivtrafikens roll i Sverige.

Vi forskar om hur kollektivtrafiken kan bidra till framtidens attraktiva och hållbara storstadsregioner. Vi utbildar kollektivtrafikens aktörer och sprider kunskap till beslutsfattare så att debatten om kollektivtrafik förs på vetenskaplig grund.

K2 drivs och finansieras av Lunds universitet, Malmö universitet och VTI i samarbete med Stockholms läns landsting, Västra Götalandsregionen och Region Skåne. Vi får stöd av Vinnova, Formas och Trafikverket.

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