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Increased patronage for urban bus transport with net-cost contracts

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Abstract

Simulations of net cost contracts augmented with a subsidy per passenger for public transport bus operators in Sweden indicate that such contracts may shift the operators profit maximising price and frequency combination in a direction that yields an increased patronage. The calculations suggest that a subsidised increase in patronage is welfare improving. The simulations unfortunately also indicate that such contracts may become very costly for the public transport authority. In a system with franchised contracts we however suggest that a large part of these costs may be recovered as a bid for the contract. In this study we can not calculate all the potential adaptations that the operator may undertake to optimise the supply. We therefore conjecture that a net cost contract augmented with a subsidy may well be a reasonable policy to achieve increased patronage.

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1 Introduction

In 1988 a new act in Sweden allowed local and regional public transport authorities to procure public transport services under competition. After that the share of public transport that was procured increased rapidly and now virtually all public transport contract are being tendered (Alexandersson and Pyddoke, 2003). Most contracts have even been tendered at least two times.

There is a multitude of different contract forms in public transport. The most common form is a gross contract. This is a contract where the public transport authority (PTA) keeps revenues and compensates the operator for the total operating costs. In many cases some kinds of incentives have been added to the gross contract. Pure net contracts, where the operator keeps the revenue and where the PTA only pays some fixed compensation to cover the costs for some level of service, are rare. Contracts where the operator is incentivised with parts of the revenue are more common (Pyddoke et.al. 2009, Supplement 1).

The purpose of this paper is to explore the possibility of approaching the policy objectives of a PTA with a net cost contract amended with an incentive in the form of a per journey subsidy. This is done by calculating the behavioural responses of a single public transport operator in both the city and the county of Örebro to variations in a per passenger subsidy in an extensive demand model.

An advantage with the approach to calculate behavioural responses in a full scale demand model is that the results may be considered to give realistic indications of welfare and patronage effects. The reason is that we have a well calibrated demand model with high geographical resolution for both for the city and the county of Örebro, which allows us to calculate patronage effects of price and frequency changes. A disadvantage is that the model we use is not suitable for computational optimisation. Therefore only a limited number of computations are possible to perform. But such calculations may nevertheless give interesting indications of the profitability and welfare implications of the studied policies.

Many Swedish public transport authorities have official objectives which in many cases include an objective to increase patronage. Recently this has been highlighted by the campaign by the Swedish public transport association to double patronage in public transport. In the county of Örebro there was no official objective for the studied period against which changed contract structure could be evaluated.

The county of Örebro was chosen because of availability of data and because the city of Örebro represents an interesting case where a net cost contract could hypothetically work. There are two reasons why net cost contracts for a medium sized town like Örebro. Experienced procurers at Swedish PTA:s have argued net contracts may be expected to work best in contracts were revenues are above or at least closet to costs. The contracts were this is most likely to be the case are contracts for urban areas. In larger cities problems arise regarding the incentives to care for neighbouring areas. The procurers have therefore argued that towns with one operator are the ideal case to try net contracts. The first is that net cost contracts could work for contract areas where revenues could cover the costs. The second is that most synergies between different lines could be captured by a single contract for such a town.

The desire to increase patronage raises the question if this can be achieved in a welfare improving way. In this paper welfare is defined as the net of consumer surplus over social costs, where the social costs are calculated according to the norm for the Swedish transport planning cost benefit analysis (CBA) conventions. A further objective of this paper is to examine the consequences for public finance and operator profitability of introducing incentives to increase patronage.

A parallel issue that will only be touched on briefly is dynamic efficiency. An observation from both the building and the public transport industries, where competitive tendering is frequent, is that these industries have weak productivity development. A hypothesis is that the incentives for developing technology, processes and organisation are weak since the potential stream of revenues from an innovation cease when the contract is terminated. This observation is however difficult to verify as there are few examples of comparable activities without competitive tendering.

In most gross contracts the pricing decision for the tendered transport services lies exclusively with the PTA. This is the most frequent arrangement in the case of net contracts also. But the net contract implies incentives for the operator to initiate price increases. In some Swedish cases it is clear that the PTA has invited initiatives from the operators to suggest price adjustments while keeping the control of the decision with the PTA.

Some theoretical advantages with an incentive for patronage is that this makes the operator more keen to adapt to changing market conditions and to care about attracting passengers and that revenues are really collected. The main disadvantages are that it makes the operator take a substantial risk which he has only small possibilities to influence. This risk will lead operators to add a risk premium to bids, which – everything else equal – will tend to increase the costs for the PTA.

There are both theoretical underpinnings and empirical calculations suggesting that it may be welfare improving to increase supply beyond a level which would arise in an unregulated market. A classical theoretical result from public transport analysis (Mohring 1972) is that when taking users' waiting time into account economies of scale in public transport become significant. The reason is that an increase in frequency increases user benefits in the form of reduced waiting time. The main implication is that profit maximizing operators produce less frequent, less comprehensive and more highly priced services than would welfare maximizing social planners. Welfare maximizing supply and pricing would therefore require subsidization. These results have been developed further by for example, Turvey and Mohring (1975), Jansson (1979), Larsen (1983) and Jansson (1993).

In a recent paper (Jansson, Lang and Mattsson 2008) these results are developed further and extended to the question of a theoretically optimal subsidy paid to the operator per journey. The main results are the following. A profit maximising monopoly will have a too low frequency and too few passengers from a welfare point of view. Given the right level of subsidy the monopolist will however supply the welfare maximising price, frequency and transport unit size as a profit maximum. The paper also presents results for profit maximising operators in competition. These are shown to supply frequencies in excess of what is socially optimal. Therefore the authors argue it may be welfare improving to tax departures in this setting.

One recent contribution by Parry and Small (2009) develops a computational model to calculate optimal fares for public transport, applying the model to Washington DC, Los Angeles and London. Their result support the notion that substantial fare subsidies are welfare improving in the monopoly context. In the model subsidies above 50 percent of the operating costs may be justified from efficiency considerations alone. A calculation with a similar model for Stockholm county commuter trains Eliasson et.al. (2008) indicate that subsidy levels in Stockholm are justified and even that larger subsidies may be justified in peak-hours. We have found no such calculations for smaller cities and counties.

Given a clear picture of the welfare optimal level of supply of public transport, the question arises of how public transport should be organised to yield optimal incentives for efficiency both in provision of public transport and in its production. There is both theoretical and empirical support for the fact that procured services may be more cost efficient than services produced by an in house public sector producer. A recent survey of studies into the longer term experiences from tendering (Hensher and Wallis 2005) suggests that after substantial savings in the initial rounds of tendering of bus services the subsequent tenders delivers smaller cost reductions and in some cases even larger subsidies to public transport. In developed countries part of the explanation to this is that the number of bidders in a re-tender tends to decrease. Alexandersson and Pyddoke (2003) also show that the savings in Sweden were reduced after the first rounds of tendering. Despite these doubts concerning long term efficiency, competitive tendering remains the preferred strategy for delivering public transport in many countries.

Given that competitive tendering is the chosen mode to provide public transport the question arises what is the optimal contract forms. Hensher and Wallis (2005) argue that there is reason to reconsider the forms of tendering and to consider other regimes and especially negotiated performance based contracts. Introducing incentives for patronage creates a budget uncertainty for government. This may be mitigated by introducing a cap on the subsidy.

In Sweden and other European countries there has been a long standing debate on the relative merits of gross and net contracts. At the same time good empirical evidence on the relative merits of gross and net contracts is scarce. Nash and Nilsson (2010) argue that it is hard to see any dramatic differences in the performance of gross and net contracts. In an empirical study of medium sized Swedish towns with one local public transport (bus) operator (Pyddoke et.al. 2007) operators in towns with gross contracts were compared to towns with net cost contracts. The Swedish towns with net cost contractors tend to have higher prices, less service but on the other hand less costly services and more satisfied customers. These results therefore support the main theoretical predictions. Pyddoke et.al. (2007) caution that the results may be a result due to short time period and few observations. It may be the case that some of the observed differences are due to different history and differing geographical conditions.

The ways in which gross and net contracts may be modified to adjust the incentives are infinite. Therefore PTAs have tended to experiment with different degrees of intensity of the incentives and some researchers have sought to shed light on the outcomes of such experiments. A study by Longva et.al. (2003) examines a case where a PTA amended a net contract with incentives to provide more services by supplementing the ticket revenues with subsidies per revenue and per bus kilometre. The results suggest that this contract form caused increased patronage.

We have found no studies that simulate different designs of net cost contracts and how they perform welfare wise. We therefore wanted to examine if it was at all possible to generate outcomes with net cost contracts that could improve on the welfare properties of gross contracts.

2 Modelling approach

Theoretical background

The central question in this paper is if a net contract amended with a per passenger subsidy can give incentives to increase patronage. For this purpose we consider three theoretical maxima. The first is a franchised monopoly operator choosing price and frequency to maximise profit. The second is benevolent PTA choosing price and frequency to maximise welfare. The third is a franchised monopoly operator in this case again choosing price and frequency to maximise profit but in this case receiving a subsidy per passenger in turn chosen to yield a certain level of patronage.

The franchised monopoly is charged with running a network of bus lines. In the monopoly case the monopolist is allowed to choose price p and frequency f freely. The monopolist therefore to maximise profits with respect to p and f.

$$\pi^n = p * q(p, f) + B - C(f)$$

where

π	profit
p	price
q	travel demand
f	frequency of departures
B	the winning bidders fixed price (negative or positive) for the contract
C	operator costs

In the second case a public transport authority is assumed to maximize welfare W with respect to p and f and thereby choosing the level of patronage. In the formula below we have suppressed the calculation of the total willingness to pay WP for the service.

$$W = WP(p,q) - B - C(f)$$

In the third case finally a monopoly operator is again assumed to maximise with respect to p and frequency f although this time given a per passenger subsidy s. In this model the PTA chooses the subsidy level and awaits the response from the monopolist who in turn operates a net cost contract with full freedom to choose a profit maximising combination of p and f.

$$\pi^n = (p + s) * q(p, f) + B - C(f)$$

Given well-behaved functional forms these theoretical maxima exist and are unique.

The demand modelling approach

The modelling of public transport has taken different paths depending of the objectives at hand. For the analysis of economic principles small analytic models may in many cases be the preferred path. For the analysis of the potential demand with different price levels or differentiation principles a public transport authority will in many cases turn to extensive demand modelling.

Such extensive demand models may represent the demand for each separate line and in different periods of the day and if necessary with individual frequencies and prices. In principle it is possible to model menus of different prices, like single journey tickets and discount schemes as well as travel passes of different validities. As an extension to the demand model a supplementary cost benefit calculation model may be added.

With demand and cost benefit calculation models come several advantages. The principal advantage is the models may give municipalities and public transport authorities indications on the welfare consequences of simultaneous changes in several different policy instruments. Furthermore the models may use quantitative data as a base, and hence lend themselves to validation and calibration. Therefore they may in many cases give precise directions concerning price level and demand. Such simulations and cost benefit models are also indeed used by public transport authorities to guide planning and decision making. The main disadvantage with this approach are however, that such models are seldom tractable for analytic or computational optimisation. Therefore what appears as attractive combinations of prices and transport supply may not even be local optima. Furthermore there are presently no computational models that model public transport to the same degree of resolution for passenger behaviour as demand models or that represent the behaviour of operators or PTA:s. For these reasons we have restricted the analysis of the demand model to a limited number (13) of changes in action space with the primary purpose to investigate the potential for improvements in profits or welfare in the sense given in the theoretical section above.

For the analysis we have used a simplified version of the Swedish national transport model (Sampers) called Lutrans. Sampers is an extensive demand model for all personal transport in Sweden (Beser and Algers 2001). The model covers walking, cycling, car and all the modes of public transport. The model also represents car ownership and the access to a car. It is implemented for highly resolved representation of road network and public transport opportunities. The demand system is used to model responses in demand for the available modes to different kinds of supply changes. Sampers consists of 5 regional models (short trips), one national model and one international model. All models are multinominal nested logit models, estimated on costs and availability for all modes and on the national travel survey. Furthermore all modes are associated with average valuations of time, accidents and externalities.

Sampers is also developed to be able to represent all demand, consumer surpluses and costs for different subpopulations and infrastructure links. Therefore it is possible to calculate the consumer surplus changes on account of a change in the price or supply of public transport.

The calculations in Sampers are quite time consuming. Sampers was therefore simplified to shorten the computation times by reducing the separation of results for the many subpopulations, the simplified version is called Lutrans. Lutrans uses data from the extensive descriptions of road nets and public transport produced for used with Sampers for the Swedish national infrastructure planning. The model was then further modified and calibrated for the county of Örebro. The main modification in the Lutrans version used by us is that the share of the population having a travel pass was endogenised (Sampers/Lutrans normally assumes that the travel pass share is exogenous). Sampers/Lutrans uses two matrixes for travel costs with public transports – one for travel passes and one for single tickets. Work trips is assumed to be frequent enough for a travel pass (for a month) card to be profitable. For other trips the marginal costs is equal to the single trip cost or, for those who have a travel pass, zero. In the Örebro application of Lutrans the travel pass share is decided by the decision to use public transport for work trips. The model has been calibrated for all of Sweden and checked in particularly against passenger counts, price and ticket revenue data which we have received from the Örebro PTA.

Örebro county is the eighth largest county by population in Sweden with a population of 278 thousand inhabitants. Örebro city is the sixth largest city with more than 90 thousand inhabitants. The county public transport service includes 87 bus lines and 16 commuter train lines. According to the annual report for the Örebro county PTA the total amount of public transport trips in 2008 where 12,6 million of which 12,1 million where bus transport trips. In 2000 the prices for a single ticket ranged from 9 SEK within Örebro city to 49 SEK for a trip across the county border. The travel passes ranged from 175 to 500 SEK for county wide validity.

Table 1 The number of boardings, ticket revenue, average passenger revenue in Örebro county

	Boardings	Ticket revenue	Average per passenger revenue
2000	6,30	43	6,83
2006	7,07	52	7,36

Boardings millons per year, ticket revenues millon SEK per year and average revenue SEK.

A separate calculation step for CBA evaluation of the changes in travel patterns forecasted by Lutrans was developed in this project. The consumer surplus is calculated at O/D-level with rule of the half for changes in the number of trips. The producer surplus is calculated as the difference between ticket revenues and costs for vehicles (including overhead costs). The calculated vehicle costs are based on recommended cost for the national Swedish transport Benefit-Cost manual (SIKA 2008), adjusted to data from the Örebro PTA. External effects for road traffic is calculated with the Swedish national road administrations relations.

As mentioned above it is time consuming and costly to do many model runs even with the simplified model Lutrans. We therefore opted for calculating demand for 13 combinations of price and service frequency. The results from these calculations are all compared to the results from a reference case modelled on the prices and frequencies in year 2000. The reasoning being that Örebro county has changed the prices and frequencies between 2000 and 2008 very little. In the model of Örebro we have therefore varied ticket prices and service frequencies uniformly according to Table 2

Table 2 Combinations of Price and Frequency variations modelled in Lutrans

		Frequency					
*		-30%	-20%	-10%	0	10%	20%
Price	50%			X			
	25%		x	X	X		
	0	x	x	X	0	X	x
	-25%		x	X	X		
	-50%			X			

The modelling involves three steps. In the first step we calculate the changes in net revenue for a hypothetical franchised monopoly operator servicing the county of Örebro for thirteen combinations of price and frequency. The assumption is that the operator chooses the combination of price and frequency that maximises the net revenue. We therefore assume that this monopolist may choose price and frequency freely. This implies that if we find that a combination at the limits of the set of combinations is optimal, it may very well be the case that a combination outside the set would imply even higher net revenue.

In the second step we examine the thirteen combinations for the welfare outcome. Welfare is defined as the sum of consumer and producer surplus.

In a third step we examine how the net revenue of the thirteen combinations are affected if a subsidy per passenger is introduced. In this way we may infer if the optimal responses from the operator to different levels of subsidies per passenger given by the PTA may induce welfare improvements or not.

3 Results

3.1 The monopolists profitability

In Table 3 we show the results of the calculations of the net revenues for a monopolist operator in million SEK per year, the number of boardings per day and the price and frequency changes from the reference year 2000. The demand program generates exact numbers, so do not mind this apparent precision.

Table 3 Combinations of price and frequency ranked by net revenue, Örebro county

Net revenue	Boardings	Price	Frequency
112	51727	+50%	-10%
93	52483	+25%	-20%
79	56551	+25%	-10%
69	59900	+25%	0
67	54015	0	-30%
Reference	66013	0	0

Net revenue in million SEK per year, Boardings per weekday

This table indicates that the most profitable direction to move in the available price frequency space is to increase price and reduce frequency. The most profitable change of price by 50 percent and to reduce frequency by 10 percent. This is the maximum price increase. The frequency reduction is the sole alternative for this choice of price increase. This implies a significant decrease in patronage compared to the reference year. The fact that the most profitable price frequency combination of the examined combinations lies on the limit of the set indicates that larger price increases and frequency reductions may be even more profitable.

3.2 Welfare consequences

We turn now to the welfare consequences of the studied price and frequency combinations. In Table 4 we have summarized the results.

Table 4 Combinations of price and frequency ranked by net welfare, Örebro county

Net welfare	Boardings	Price	Frequency
98	77091	-50%	-10%
58	69096	-25%	-10%
53	73388	-25%	0
52	64013	-25%	-20%
24	62257	0	-10%
Reference	66013	0	0

Net revenue in million SEK per year, Boardings per weekday

This table indicates that the most welfare improving move in the price frequency space is to reduce both price and frequency. Compared to the reference case the most welfare improving price and frequency among the available combinations is a decrease in price by 50 percent and a reduction in frequency by 10 percent. This is the maximum price decrease and the frequency reduction is the sole alternative for this choice of price increase.

A striking feature of the results for welfare maximising price and frequency combination for Örebro county is that it implies a considerable increase in patronage compared to the reference year 2000. In fact the three most welfare improving combinations imply increases in patronage.

The fact that the welfare maximising price frequency combination of the examined combinations lies on the limit of the set indicates that larger price decreases may be even more welfare improving. Concerning frequency adjustments the indications are less clear. The next most welfare improving combination implies no frequency changes. This may indicate that price decreases is a less costly policy, in Örebro county, to improve welfare than is increases in frequency.

3.2 What are the optimal responses for the monopolist to subsidies per passenger?

Now we turn to the results of the main policy experiment in this paper: how would a monopolist respond to a subsidy per passenger? A main result from the analysis above is that it is welfare improving to decrease price. A goal for the Örebro PTA (and for most PTA:s) is to increase patronage. Our first experiment is therefore to successively increase the subsidy per boarding until the monopolist operators' net revenue is maximized by choosing a combination of price and frequency where the price is not increased. In the general case where a monopolist is given a subsidy per unit sold, the monopolist will choose a lower price and sell more units. In the present case this happens when the subsidy is 14,5 SEK per boarding. In Table 5 we present the results from the net revenue calculations for a subsidy level of 14,5 SEK.

Table 5 Combinations of price and frequency ranked by net revenue, Örebro county

Net revenue	Boardings	Price	Frequency
184	76893	0	+20%
181	51721	+50%	-10%
180	59900	+25%	0
173	56551	+25%	-10%
173	71073	0	+10%
Reference	66013	0	0

Net revenue in million SEK per year, Boardings per weekday

These results show that the subsidy shifts the profit maximising combination in price-frequency space from the case without a subsidy (where the operator increases price with 50 percent and reduces frequency) to a combination where prices are not changed and frequency is increased by 20 percent. Note that the net revenues for the different combinations of price and frequency are quite close to each other indicating that a subsidy at this low level may not be decisive in driving the operator to choose a price and frequency combination yielding a patronage increase.

The fact that the most profitable price frequency combination lies on the limit of the set also indicates that larger frequency increases may be even more profitable, for the subsidy 14,5 SEK. The total cost for the 14,5 SEK-subsidy is 358 million SEK per year. The calculated profit for the operator is 184 million. Assuming that the operator bids the full 184 million for the contract (which is not likely due to risk and profit margin), the total cost of the subsidy is 358 minus 184 equals 174 million SEK per year. This is roughly 50 percent more than the total net cost for the PTA today which is 118 million SEK.

If the same experiment is done only for the traffic in Örebro city, the subsidy necessary would only be 6 SEK per boarding. This makes the total cost of the subsidy 86 million SEK per year and the operators profit 64 million SEK. Making the (strong) assumption that the operator is willing to bid away the full profit this implies a net cost of (86 minus 64) 22 million SEK. The current net cost with the gross contract is not shown specifically for the city traffic in the Örebro PTA annual reports. But 22 million is about the same as the by us calculated subsidy with today's frequency and price level (but with higher patronage)! This implies that a subsidized net contract would not necessarily be more costly than the gross contract.

An analysis of the profit per line in the county gives two main conclusions. The first is that some lines become very profitable with subsidy per boarding (the profit margin goes up to several hundred percent). The profitable lines are mainly city lines. The second that there are a few lines that are not profitable with any subsidy (within reasonable limits). These lines are likely to be motivated by distributional objectives.

4 Qualifications to models and results

The perhaps most important drawback of this kind of modelling is that it does not represent the process of developing public transport. There are no explicit and endogenous mechanisms for the adjustments that an operator may make in the relative frequencies of different bus lines, frequencies and prices. Neither are there any adjustments in the bus fleet. Therefore there may be substantial further adjustments that are likely to be possible. Neither have we modelled the possibility to introduce a more differentiated price scheme to increase revenue. This would have effects on demand and hence on the optimal supply.

One of the central hypotheses for the net contract approach is that it induces a stronger incentive to economize on production costs and that it may induce stronger incentives to increase travel with public transport if this is profitable. This hypothesis is only examined insofar that we have studied the profitability for the operator with a net cost contract to change price and frequency.

In the current formulation the welfare function lacks explicit consideration of distributional objectives, accessibility objectives as well as particular geographic preconditions requiring particular public transport objectives. The calculated welfare maximisation may therefore only be considered as a rough check on the level of supply of public transport. It may give an indication of that more or less services may be advisable but unless we consider distributional, accessibility and particular objectives separately it is not a complete tool for evaluation.

Considering possible franchising contracts it does not appear to be probable that PTA's would let prices and supply completely free. A more likely scenario is some kind of partial freedom to adjust price level in a given price and supply structure. For regulatory purposes different kinds of price-caps involving caps on price indexes (electricity or telecom) have been chosen to allow for flexibility within bounds. Such measures would make it possible for PTA's to delegate more of pricing decisions to operators.

5 Summary and discussion on policy implications

The most important conclusion of our study is that a subsidy per passenger may indeed shift the incentives for an operator to choose price and frequency. If the subsidy is sufficiently high it will make the operator choose a price and frequency combination that will yield a desired higher level of patronage. Our partial calculations also indicate that the contract induces operators to refrain from increasing prices as they would do in a monopoly context. We also identify a lowest possible subsidy inducing the operator to choose a combination of no price increase and no frequency reduction.

This suggests the misgiving that such a contract could turn out to be very costly for the PTA. This must, however, not necessarily be the case. If operators bid all their potential profits from a subsidised contract, we show that PTA are likely to retrieve a significant part of the rents that profits that operators would otherwise earn. We also show that for the city of Örebro the net costs for the city in that case would be about the same. We are however not able to calculate the possible adaptions so we cannot indicate what the real costs and therefore risks for the PTA would be. For the *county* of Örebro the subsidies that are calculated to be necessary to induce a net contract operator to choose no price increase and no frequency decrease is 358 million SEK or 14,50 SEK per boarding wich implies a net subsidy of 174 million SEK compared to the current subsidy which is 118 million SEK or 3,80 SEK per boarding.

The results of our calculations concerning the welfare maximising combinations of price and frequency indicate that a welfare optimal policy imply an increased patronage. Not surprisingly our results also confirm the well known propositions that a profit maximising monopoly would supply less frequency and higher prices than motivated from a welfare maximising perspective and what current policy does. They also suggest that lower ticket prices (that is increased subsidisation) is part of a welfare improving policy. Our results therefore support the political notion that increased patronage in public transport in Örebro county is desirable.

Finally, two reservations must be given for our calculations. Firstly, we are not able to decide if the analysed contract device is flexible enough to enable the PTA to make the operator choose a welfare optimizing combination of price and frequency. Secondly, we have not modelled the possibilities for operators to adapt their supply, and hence their cost structure. We therefore not able to estimate what operators would be prepared to pay for a franchise to a monopoly.

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