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EFFICIENT PUBLIC TRANSIT SUBSIDIES

ODD I. LARSEN
Institute of Transport Economics, Oslo and
Molde College, Molde, NORWAY

Abstract

A model of the public transit system in Oslo is used to investigate the implications for fares and level of service assuming an objective that is maximisation of social surplus. Consequences of different constraints are tested and "second best" solutions are investigated. Results are given for fares, level of service, demand, costs, revenue and the shadow price of financial constraints.

INTRODUCTION

Public transport, and especially urban transit, receives considerable subsidies in industrialised countries. From an economic point of view there are two prominent arguments for subsidies that may be applied to transit:

1. There are increasing returns to scale in the provision of public transit services. This means that fares set at marginal cost will not recover total cost
2. If the main competing mode of transport, which is the private car, is priced below marginal cost, the theory of second best tells us that this should be counteracted by also pricing public transit below marginal cost.

The economies of scale argument has a long standing in transport economics, but mainly related to railways and the fixed cost involved in railway operations. In the last two decades it has also been demonstrated that considerable economies of scale is present even in bus services when costs are properly interpreted to include users' costs (ie the value of travel time and efforts related to the use of public transport). This issue has been thoroughly explored after the appearance of the seminal paper by Turvey and Mohring (1975), see for example Jansson (1979, 1984) and Nash (1988).

The "second best" argument is clearly valid when we are dealing with a congested road system without proper congestion pricing, but may also be valid if excise taxes on petrol are too low to adequately cover the external costs of environmental pollution and accidents caused by motorists.

However, while there is—in theory—a strong rationale for public subsidies it is also well known that subsidies tend to carry its own burden in terms of reduced efficiency and inflated cost in the transit industry, see for example Pucher and Markstedt (1983). Usually the argument for subsidies is also put forth as if the opportunity cost of public funds is 1, but public revenue raised by high and distorting taxes may easily involve an opportunity cost in the range 1.2–1.5 for public funds. Thus the case for subsidies may not be as strong as it initially appears and the amount of subsidy should at least be decided with these counteracting forces in mind.

Finally I will point to the issue of provision of transit services. Roughly stated the services, in terms of revenue kilometres, should be extended to the point where marginal benefits equals the marginal cost of further extension. This condition is also modified if the opportunity cost of public funds or the second best issue related to car traffic is taken into consideration.

The rest of this paper deals with the implications of different types of constraints on public transit services that, in an economic sense, leads to different "second best" solutions with respect to fares, the level of service in public transit and the level of subsidies. Throughout I will assume that the objective used to determine these magnitudes should be maximisation of social surplus.

The numeric results are based on a model of the Oslo Public Transit Company.

A MODEL OF COST AND DEMAND FOR THE OSLO PUBLIC TRANSIT COMPANY

The present situation

The Oslo Public Transit Company (OPTC) is a limited company owned by the municipality of Oslo and the company has virtually a monopoly on public transport within the City of Oslo. The company operates bus services, tram services and an urban rail service on own account and also hire private bus companies to serve some of the bus routes. In 1992 the company had a deficit of 481 Mill NOK (1 NOK ≈ 0.15 US$) that was covered by transfer of public funds, mainly from the municipality. The deficit amounted to approximately 39 per cent of total cost in 1992, but has shown a declining trend in recent years.

At present, the transit system has a flat fare system and offers discounts on seasonal tickets and prepaid tickets. Elderly people and children are granted a 50 per cent discount on regular fares. The fares are decided by the City Council of Oslo.

The project that forms the basis for this paper was initiated due to a discussion on the Board of Directors of OPTC. The discussion raised the issue of the profitability of the company. This posed a difficult question for the administration to respond to, given the amount of subsidies.

Profit in the commercial sense is obviously not a proper measure of performance for a transit company like OPTC. On being consulted on the issue we pointed out that OPTC, being a monopoly, certainly could be operated at a profit. The relevant question to ask was really about the benefits of the subsidies which allowed the company to follow a non-monopolistic policy with respect to fares and the level of service.

In order to shed some light on the issues involved, we developed a model that as closely as possible could be a representation of OPTC. The model was intended to handle certain crucial facts with respect to the transit system:

- Demand, measured in trips per hour, varies considerably between peak and off peak and, within the peaks, also by direction.
- The total capacity needed in the transit system is determined by the inbound traffic in the morning peak and the outbound traffic in the afternoon peak and enough capacity must be provided.
- Corresponding to the fluctuations in demand there are corresponding fluctuations in the marginal cost per trip.
- In meeting the demand for capacity there is a trade-off between the number of revenue kilometres and the capacity per revenue-kilometre.
- At present OPTC is constrained by decisions in the City Council with respect to fares and the amount of subsidies is also decided by the City Council. There may also be some technical constraints that may be important to the company.

We also wanted the model to reproduce, as closely as possible, demand, costs and revenues for the benchmark situation which was 1992. 1992 was the last year with a full set of figures available for cost, revenues and ridership.

From OPTC accounts of 1992 we derived the figures in Table 1 which may be taken as the costs and revenues of the transit services proper when costs and revenues from some auxiliary activities are deducted. Thus 481 Mill NOK (425 + 20 + 36) was not paid by fares.

Table 1 Cost and revenues of transit services

Total cost:	1233 Mill NOK
Covered by:	
Fare revenues	752 Mill NOK
Municipal subsidies	425 Mill NOK
Government subsidies	20 Mill NOK
Deficit in accounts	36 Mill NOK

Demand

From various sources we were able to compile the following (Table 2) consistent figures for the demand in the benchmark situation. This gave us 100 Mill trips per year. The official figure was 130 Mill trips, but this also included transfers which are free within an hour. We wanted to use the number of trips actually paid for and there is an average of 0.3 transfers per paid trip.

Initially we thought that the average fare varied by category of demand as defined in Table 2, but OPTC's on board surveys showed that no significant difference could be detected in average fare.

Table 2 Demand for OPTC services in the benchmark situation

Category:	Million trips per year	Hours per year	1000 trips per hour
Peak (demand on capacity)	22.5	690	32.6
Peak (other)	7.5	690	10.9
Off - peak	70.0	5880	11.9

Thus with 100 Mill trips and fare revenues of 752 Mill NOK per year, the average fare per trip for each category in the benchmark situation could be set at 7.52 NOK. This was less than 60 per cent of the single ticket adult fare. Seasonal tickets and discounts for children and elderly people thus have a great impact on average fare.

As an indicator of the level of service we used revenue kilometres per hour. An increase in the number of revenue kilometres will correspond to an increase in the frequency of the services and/or an increase in the geographical density of routes. Revenue kilometres will consequently have a direct impact on average waiting time and walking distance for transit trips. For the model we thus needed a demand function for each category of demand that depended on the number of revenue kilometres and on the fare and that also would reproduce the benchmark situation. For this purpose we assumed demand functions of the form:

$$Y = K e^{\lambda G} \quad (1)$$

with

$G = p + AX^{-0.3}$

Y = trips per hour

p = fare

X = revenue kilometres per hour

G can be interpreted as the generalised cost of a public transit trip.

λ, K and A are parameters that had to be assumed/calibrated for each demand category. Table 3 shows the values that were used. Based on prior knowledge we considered the implied demand elasticities to be realistic, and on the conservative side. Sensitivity test showed that the conclusion were not very sensitive to minor changes in assumptions in Table 3.

The demand function (1) has the convenient property that it allows us to write the "social revenue" (SR) for OPTC as:

$$SR = \sum_i T_i (p_i Y_i - 1/\lambda_i Y_i) \quad (2)$$

T_i = number of hours per year with demand Y_i i=1,2,3

SR is comprised of operating revenue (pY) and consumers' surplus ($-Y/\lambda$).

Table 3 Parameters for demand functions and implied demand elasticities in benchmark situation

Category:	K	λ	A	Implied elasticity with respect to fare	Implied elasticity with respect to revenue kms
1. Peak (demand on capacity)	94.0184	-0.03	49.5204	-0.226	0.25
2. Peak (other)	31.3674	-0.03	49.5204	-0.226	0.25
3. Off - peak	65.7784	-0.05	35.9234	-0.376	0.40

The services operated

As in any urban transit system we can roughly divide the services operated by OPTC in a basic service that is operated throughout the day and an additional service operated only in the peak periods. When we looked at revenue kilometres irrespective of the mode of operation we could describe the service as in Table 4.

Table 4 The benchmark supply of services

Category:	Revenue kms per hour - 1000	Capacity per rev. km, seated + standing	Hours operated per year	Revenue kms per year - 1000	Capacity per year - Mill passenger kms
Basic service	2.7	145	690+5880	17739	2572
Additional peak supply	3.9	185	690	2691	498
Total				20430	3070
Peak supply	6.87		690	4740	794

From Table 4 it is apparent that an additional 150 per cent is added to capacity in the peak periods. Peak supply per hour in Table 4 is slightly higher than the sum of *Basic service* and *Additional peak supply*. The reason is that *Basic service* is slightly higher on workdays than for the weekends.

Costs

In the model we identify five cost components:

1. A fixed cost per passenger trip associated with boarding, ticket handling etc.
2. A cost per revenue kilometre that depends on the capacity provided per kilometre. Given the same capacity, the additional services that are run in peak periods have a higher cost per revenue kilometre than the basic service.
3. A "capacity cost" dependant on the size and capacity of the vehicle fleet.
4. A fixed cost per hour the transit system is operated. As the period of operation is not an issue here, this can be considered as a fixed annual cost.
5. A minimum annual cost that is necessary in order to keep the (rail based) services operational.

The variable costs thus consist of 1-3. The fixed costs (4 and 5) amounts to 3-4 per cent of total cost in the model.

In order to simplify we assumed the same cost structure with respect to variable costs for all three modes of operation and worked with an average revenue kilometre for all modes. Comparisons of costs for bus, urban rail and tram services showed that this was not as farfetched as it may seem.

The following table that shows the cost structure is partly based on information from OPTC and partly data calibrated in order to reproduce the benchmark situation. However all data were accepted by OPTC as approximately correct.

Table 5 Unit costs

Component	Cost
1. Fixed cost per passenger -NOK	1.00
2. Operating cost per revenue kilometre	
Basic service -NOK	$12.50 + k \times 0.20$
Additional peak service -NOK	$20.00 + k \times 0.25$
3. Capital per "wagon" -Mill NOK	$0.25 + 0.025k + 0.0000075 \times k^2$
4. Cost per hour - Mill NOK	0.005
5. Fixed cost - Mill NOK per year	7.5

In the assessment of capital cost, the unit is an artificial "wagon". For a given capacity (wagons · k) the minimum capital cost is found for k = 183, ie very close to the average capacity offered per revenue kilometre of additional peak services.

From this cost structure we constructed a cost function for annual cost. This cost function has 5 arguments and can in general be written as:

$$C = C[(Y_1 + Y_2 + Y_3), X_1, X_2, k_1, k_2] \tag{3}$$

Y_1, Y_2, Y_3 = demand as defined in Table 2.

X_1 = revenue kilometres per hour in basic services

X_2 = revenue kilometres per hour in additional peak services

k_1 = capacity per revenue kilometre in basic services

k_2 = capacity per revenue kilometre in additional peak services

However, before we can have a proper determination of costs we have to introduce constraints that determine the relationships between demand, the number of revenue kilometres, capacity per revenue kilometre (k) and the number of wagons needed for basic services and additional peak services, respectively.

Constraints

It is a prerequisite that enough capacity should be provided both in the peak and in the off-peak. We assumed that OPTC did not pursue a wasteful practice with respect to provision of capacity. Based on this assumption we applied the following constraints that could be derived from current practice:

$$Y_1 \leq \frac{X_1 \cdot k_1 + X_2 \cdot k_2}{av_1 \cdot 1.8} \tag{4}$$

$$Y_3 \leq \frac{X_1 \cdot k_1}{av_2 \cdot 1.6} \tag{5}$$

av_1 and av_2 are average speed of operation in peak and off peak respectively.

An additional constraint to be investigated is the consequences of a fixed annual subsidy (S). This constraint can be written as:

$$S + \sum_i T_i \cdot p_i \cdot Y_i \geq C((Y_1+Y_2+Y_3), X_1, X_2, k_1, k_2) \tag{6}$$

It is also possible to introduce constraints directly on variables as we will do later on.

Finally "social surplus" (SS) for the transit services can be defined as:

$$SS = SR - C \tag{7}$$

In a "first best world" we can determine the three fares (p_1, p_2, p_3), the level of service (X_1 and X_2) and capacity per revenue kilometre (k_1 and k_2) by maximising social surplus (SS) subject to the constraints (4) and (5). This will give us fares equal to marginal cost and the optimum level of service. Formally we solve a problem of non-linear optimisation with non-linear constraints.

MAXIMISING SOCIAL SURPLUS WITHOUT CONCERN FOR CAR TRAFFIC

Table 6 shows the "benchmark situation", the social optimum with only (4) and (5) as constraints, social optimum with an added constraint on subsidies equal to the present level (481 Mill NOK), social optimum with present constraint on subsidies and fares and the solution with subsidies constrained to zero.

We can regard the results as representative for a either a situation with no congestion in the road system or a situation with proper road pricing applied. In these two cases it is sufficient to focus only on the transit system.

Firstly, the "benchmark situation" (case A) which reproduce all vital data for OPTC in 1992 shows there is no reason for concern over the *social* profitability of OPTC even with a financial deficit of 481 Mill NOK. This should come as no surprise to anyone familiar with the issues involved.

The "first best" solution (case B1) which is usually treated in the literature implies an increase of 74 per cent in the subsidies. The increase in subsidies is nearly equal to the increase in social surplus and amounts to 42.8 per cent of total cost. The solution also shows that the present fare in peak periods is far below marginal cost. For other peak traffic the present fare is above marginal cost, and off-peak the fare is approximately correct. The obvious conclusion is that OPTC loses money on any additional passenger that creates demand for more capacity in the peak. This was contrary to what the company believed.

Table 6 Maximising social surplus: no concern for car traffic

	Bench-mark situation	"First best" solution	Subsidies at present level	Fares and subsidies fixed at present level	No subsidies
Public transit trips-Mill/year:	A	B1	C1	D1	E1
Peak - demand on capacity	22.5	19.6	17.4	21.3	13.8
Peak - other	7.5	10.7	9.4	7.1	7.5
Off - peak	70.0	105.7	92.7	74.2	72.0
Total number of trips	100.0	136.0	119.5	102.6	93.3
Fares - NOK per trip:					
Peak - demand on capacity	7.52	17.30	20.70	7.52	27.20
Peak - other	7.52	1.00	4.40	7.52	7.90
Off - peak	7.52	7.30	9.30	7.52	13.20
Level of services-1000 rev.km per hour/capacity:					
Basic services	2.7/145	8.8/67	8.0/65	3.1/132	6.6/61
Additional peak services	3.9/185	4.1/87	3.7/85	2.1/300	3.2/81
Peak total	6.9	13.8	12.5	5.6	10.5
Costs - Mill NOK per year:					
Operating costs (dep. on revenue km)	914.4	1617.0	1441.9	939.7	1158.1
Capital costs	178.2	162.0	143.9	169.9	114.7
Fixed cost per trip	100.0	136.0	119.5	102.6	93.3
Dependant on operating hours	32.9	32.9	32.9	32.9	32.9
Fixed annual cost	7.5	7.5	7.5	7.5	7.5
Total cost	1233.0	1955.6	1745.6	1231.2	1406.5
Average cost per trip - NOK	12.33	14.40	14.60	12.20	15.10
Operating revenue - Mill NOK/year:					
Peak - demand on capacity	169.2	339.8	360.0	160.2	374.3
Peak - other	56.4	10.7	41.7	53.4	81.5
Off - peak	526.4	767.3	862.9	557.9	950.7
Total revenue	752.0	1117.7	1264.6	771.6	1406.5
Economic results:					
Profit - exc. subsidies - Mill NOK/year	-481.0	-837.7	-481.0	-481.0	0.0
Social surplus - Mill NOK /year	1919	2286	2267	1950	2149
Shadow price of subsidies	?	0.00	0.114	0.584	0.422

We also see that the "first best" solution implies an overall increase in demand of 36 per cent, but the fare increase reduces the costly peak demand even though the level of service is considerably improved in peak periods. The most important change is in the level of the basic services and capacity per revenue kilometre. This reflects the adaptation of the level of service to an optimum trade-off between transit system cost and users' cost (the value of time and inconvenience associated with public transit trips).

If fares are allowed to be optimally adapted, constraining subsidies to the present level (case C1) does not have any great impact on social surplus. Fares are increased and the level of service somewhat reduced compared to the optimum, but the shadow price on the financial constraint (0.114) shows that the level of subsidies even may be too high if the opportunity cost of public funds is in the range of 1.2 - 1.4 as the case seems to be in Norway (Vennemo 1992).

The actual situation for OPTC is that there are constraints both on subsidies and fares (case D1). We see that the social optimum in this case closely resembles the benchmark situation and that the combination of these two constraints is very costly in terms of reduced social surplus. The shadow price of the financial constraint shows that if the City Council regulate fares at the present level they should probably also increase the subsidies to make the shadow price come closer to the opportunity cost of public funds. The straight conclusion is that transit users in this case will benefit from an improvement in the level in service financed by a corresponding increase in fares.

With no subsidies (case E1) fares are increased and the costly peak demand is greatly reduced. However, the level of service is greatly improved compared to the benchmark situation and social surplus is also higher than in the benchmark situation. In a sense the present policy is worse than nothing. The social result could be improved if fare regulation is dropped and subsidies abandoned, provided that OPTC pursue a goal of maximising social surplus.

One lesson to be learned from these examples is that a policy that involves regulated fares combined with too low subsidies may be very costly in terms of reduced social surplus for a transit system. The losers are mainly travellers in off-peak periods.

Another lesson is that if the opportunity cost of public funds for example is in the range of 0.2 - 0.4, the amount of subsidy may be reduced to 30-50 per cent of the "first best" solution if an optimum mix of fares and level of services is attained.

A figure to notice is also average cost per trip. The best alternatives have higher average cost per trip than the benchmark situation. Thus, by itself, *low average cost per trip is no measure of performance*. It may only indicate a sub optimum trade-off between system cost and users' cost.

CAR TRAFFIC ENTERS THE PICTURE

When we entered a discussion with OPTC they expected that we should focus on the environmental issues and the role of public transit as an alternative to the private car. However we convinced them that a strong case could be made for high subsidies and high social profitability without cars being considered at all as shown in the previous section.

Given the high rates of taxation on petrol and cars it also seems that motorist in Norway actually face a private cost of driving that closely matches the social cost except in congested situations.

This is also true in Oslo even though the city has a toll cordon. The average toll rate for cars is about 9 NOK, but only inbound traffic is tolled. The marginal congestion cost for trips crossing the cordon in the peaks is of the order of 20 - 25 NOK for the average trip. The "second best" argument for subsidising public transit in Oslo is thus valid.

The social benefit of moving a motorist crossing the cordon in the peak from the private car to public transit is the difference between the toll rate and marginal congestion cost. Based on this assumption we constructed a function that took the value zero in the benchmark situation. The argument of the function is Y_1, ie peak traffic with demand on capacity. If Y_1 increases from the benchmark situation (22.5 Mill trips per year) the function adds to social surplus, but levels off and reaches a maximum of 20 Mill NOK per year for Y_1 27 Mill trips per year. At this point the marginal congestion cost will equal the toll rate (NOK 4.50 assuming that the toll is divided between the two legs of a round trip with one leg in the morning peak and one leg in the afternoon peak).

On the other hand, if public transit in peak periods loses traffic to the private car, the marginal congestion cost will increase steeply. Correspondingly the function deducts progressively higher values from social surplus of the transit system when Y_1 decreases and reaches a value of -120 Mill NOK per year when $Y_1 \approx 17$ Mill trips per year. The function also includes the assumption that one public transit trip corresponds to 0.85 car trips. This function adequately summarises our knowledge of congestion cost in Oslo from previous studies (Larsen 1991).

We could then proceed by maximising an amended expression for social surplus in order to study the implications of the second best argument concerning "underpriced" car traffic in peak periods.

Table 7 shows the results of this exercise. The "first best" of the "second best" cases (B2) with no constraint on subsidies or fares shows that the subsidies increase by approximately 200 Mill NOK or 1/4 compared to B1 and reach 50 per cent of total cost. The consequence is that the fare for peak traffic with demand on capacity decreases. This reduces slightly the social surplus of the transit system seen in isolation, but the reduction is compensated by the benefits from reduced car traffic. We can notice that the fare for peak traffic with demand on capacity even in this case is higher than in the benchmark situation, but it is now slightly lower then the present single fare ticket for adults.

Table 7 Maximising social surplus: accounting for impacts on car traffic

	Bench-mark situation	"First best" solution	Subsidies at present level	Fares and subsidies fixed at present level	No subsidies
Public transit trips-Mill/year:	A	B2	C2	D2	E2
Peak - demand on capacity	22.5	24.3	22.3	21.6	19.1
Peak - other	7.5	10.9	9.0	7.2	6.8
Off - peak	70.0	105.7	83.9	73.4	61.2
Total number of trips	100.0	141.0	115.1	102.2	87.2
Fares - NOK per trip:					
Peak - demand on capacity	7.52	10.90	13.30	7.52	17.40
Peak - other	7.52	1.00	7.00	7.52	15.00
Off - peak	7.52	7.30	10.80	7.52	15.70
Level of services-1000 rev.km per hr/capacity:					
Basic services	2.7/145	8.8/67	7.4/63	3.0/134	5.8/59
Additional peak services	3.9/185	5.9/101	6.1/103	2.5/263	6.1/103
Peak total	6.9	15.6	14.2	5.8	12.3
Costs - Mill NOK per year:					
Operating costs (dep. on revenue km)	914.4	1682.8	1412.2	935.5	1109.8
Capital costs	178.2	199.5	182.3	171.5	156.8
Fixed cost per trip	100.0	141.0	115.1	102.2	87.2
Dependant on operating hours	32.9	32.9	32.9	32.9	32.9
Fixed annual cost	7.5	7.5	7.5	7.5	7.5
Total cost	1233.0	2063.6	1750.0	1249.5	1394.1
Average cost per trip - NOK	12.33	14.60	15.20	12.20	16.00
Operating revenue - Mill NOK/year:					
Peak - demand on capacity	169.2	266.3	296.5	162.3	332.8
Peak - other	56.4	10.9	62.7	54.1	102.8
Off - peak	526.4	766.5	909.8	552.2	958.5
Total revenue	752.0	1043.8	1269.0	768.5	1394.1
Economic results:					
Profit - excl. subsidies - Mill NOK/year	-481.0	-1019.8	-481.0	-481.0	0.0
Social surplus - Mill NOK /year	1919	2270	2237	1961	2089
Shadow price of subsidies	?	0.000	0.219	1.797	0.726
Benefits due to transferred car traffic	0.0	16.8	-3.0	-11.9	-58.8

With subsidies constrained at the present level (case C2), the shadow price of the financial constraint becomes 0.219 and may still be below the opportunity cost of public funds. However, as a percentage of total cost the subsidies decreases to 27.5 from 39.0 in the benchmark. Compared to the benchmark situation fares are increased and the level of service greatly improved. The present situation thus puts too must emphasis on low fares compared to the level of service. This becomes even more evident in case D2 that includes both the present political constraints, ie on fares and subsidies. The extremely high shadow price for the financial constraint in this case indicates that the level of service is very low compared to the attainable optimum. Finally, constraining subsidies to zero (E2) we get a shadow price of 0.726 which indicate that subsidies have a very high social return on the margin. A more extensive analysis of the difference between first best and second best reveals that accounting for underpriced car traffic, in general, will warrant additional subsidies of the order of 200 Mill NOK as results for the financially unconstrained cases (B1 and B) also show. In general Table 7 points to the same problem as Table 6, present practice tends to put too much emphasis on low fares as compared to the level of service, especially when it comes to the basic services. When we consider the consequences of adapting public transport supply and fares to underpriced car traffic we should also keep in mind that Oslo is not a very congested city. The presence of the toll cordon also reduces the optimum amount of subsidy to public transit. In many large urban areas the social return on subsidies may be much higher (1+shadow price equals the benefit /cost- ratio of an additional unit of subsidy).

OBJECTIVES AND INCENTIVES

The analysis so far has not considered the impact of subsidies on operational efficiency. This has been a major concern in the drive towards privatisation and deregulation of public transit. OPTC has actually reduced costs and maintained the level of service in recent years when faced by a squeeze on subsidies. This by itself indicates that efficiency is affected by subsidies and—in the case of OPTC—probably also by public ownership.

A point made by OPTC in our discussions, was that any effort made by the company to improve efficiency and reduce cost, resulted in a further reduction in subsidies granted by the City Council. The incentives implied by such a policy are mixed. The issue of costs and subsidies could also be illuminated with the model.

We assumed that the opportunity cost of public funds were 1.25. This allowed optimisation without a financial constraint, but with an added cost that amounted to 25 per cent of the financial deficit. For the "second best" case with no constraint on fares the optimum amount of subsidies turned out to be 431.2 Mill NOK. We then assumed that OPTC managed to cut all unit costs by 10 per cent. What will be the impact on the optimum amount of subsidies? For the new optimum it turns out that subsidies should be 571.3 Mill NOK. Thus, contrary to current political practice, improved efficiency should lead to more subsidies. The more intuitive explanation for this fact is that lower (unit) costs for public transit increases the social return on subsidies.

Thus cutting subsidies in order to force public transit companies to improve efficiency is a strange, but understandable policy. If efficiency is improved and unit costs reduced, the situation may actually improve. But at the same time subsidies shall be increased if the return on subsidies—on the margin—is to be maintained at the level of the opportunity cost of public funds!

This problem of incentives with respect to productive efficiency can be overcome by tendering out public transit services. Tendering has become the trend in many countries in recent years. More or less clever schemes have been devised and tried out for this process. However, while tendering may solve the problem of inefficiency in transit services with respect to costs, it still leaves a heavy burden on public administration when it comes to market efficiency, ie setting the "correct" level of fares and service and designing the details of the route network. The political system also has to come up with the "correct" amount of subsidies.

An interesting question is whether it is possible to design a system of subsidies and possibly also a regulatory system for public transit that would allow a competitive transit industry to provide the "right" level of service with an "appropriate" level of fares. This remains an open question.

Simulations with the model at least showed that fixing the fares close to an optimum level and providing an appropriate subsidy per revenue kilometre may lead a profit maximising transit company to a solution that can characterised as quite good in terms of social surplus.

Some of the results from these simulations are presented in Table 8. One interpretation of this scheme is that OPTC and the municipality enter an agreement where the municipality automatically pays a fixed price for the revenue kilometres that OPTC offers. The fares are regulated by the municipality, but OPTC can maximise profits under these conditions. The advantage is that the company will have a clear and operational objective and if the company can keep the profits it will also have a proper incentive to cut costs.

One disadvantage is that the revenue from kilometres is not an adequate incentive in a second best situation with underpriced car traffic. Also, we still have the problem of a regulated monopoly that may not have strong enough incentives for cost efficiency. However, a similar scheme may also work in a competitive environment.

Table 8 Profit maximisation with regulated fares and a subsidy per revenue kilometre

	Alternative 1	Alternative 2	Alternative 3
Fares - NOK per trip:			
Peak - demand on capacity	14.00	14.00	15.00
Peak - other	8.00	8.00	5.00
Off - peak	11.00	11.00	10.00
"Subsidy"-NOK per revenue kilometre:			
Basic services	10.50	10.50	11.00
Additional peak services	21.00	21.50	20.00
Level of service-1000 rev.km per hour/capacity:			
Basic services	6.3/71	6.3/70	6.2/75
Additional peak services	3.5/160	4.8/121	2.1/214
Trips - Mill /year:			
Peak - demand on capacity	20.4	21.0	19.2
Peak - other	8.1	8.4	8.6
Off - peak	79.2	79.3	83.0
Trips total	107.7	108.6	110.8
Economic results -Mill NOK/year:			
Total cost	1552.1	1583.4	1534.7
Fare revenue	1220.0	1232.3	1160.6
"Revenue from kilometres"	482.5	504.9	477.9
Profits	152.4	153.8	103.9
Social surplus	2204	2202	2213
Benefits from car traffic	-31.2	-21.4	-57.1

SOME CONCLUDING REMARKS

The analysis presented here was initiated because the administration of OPTC needed some arguments to present to the Board of Directors and ultimately to the political system. Rather than coming up only with the standard theoretical arguments that give an economic rationale for subsidies and for the irrelevance of profits as a measure of performance, we tried to give the arguments some empirical underpinning and relate them to a benchmark situation that was known to OPTC.

All the same it is possible to ask whether the results have any relationship to reality. In our opinion they clearly do. The most critical issue when it comes to realism is probably related to the fact that OPTC operates three services. For the urban rail service they are faced with a constraint on frequency in the peaks, and to some extent this may also apply to parts of the tram service. On the other hand, the minimum capacity of a revenue kilometre by urban rail or tram is quite high compared with some of the results presented here for optimum capacity per revenue kilometre. This puts most of the burden on the bus system if the company is to offer a higher level of service.

The optimum average capacity per revenue kilometre in most alternatives we have looked at is close to the capacity of a standard bus. With urban rail and trams to pull up the average, the implicit conclusion is that any major increase in the level of service must rely on the employment of a large fleet of minibuses if excessive capacity is to be avoided. This may be a "correct" policy despite the fact that only one small bus route uses minibus at present. It may also be "correct" to introduce new bus routes that takes some of the traffic away from the urban rail system and the tram system.

A final observation related to present policy issues in the Oslo-area , but not directly to the results above, is that there is a strong willingness in the political system to finance major investment projects in rail based systems with dubious benefits, while subsidies that will allow a higher level service in the existing systems are difficult to get. Similar observations were made by Vickrey (1980).

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