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WELFARE ASPECTS ON ORGANIZATION OF PASSENGER TRANSPORT

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Abstract

The paper deals with various reasons for authority intervention in public transport. A simple economic model is employed in order to analyse the economic outcome of profit maximisation and welfare maximisation respectively. Special attention is given to the implications, of the "network effect", ie that public transport consists of a network.

INTRODUCTION

Since the middle of this century the responsibility for local and regional public transport in most industrialized countries have been taken over by public authorities. Competitive tendering for the operation has during the last decade been introduced in a few countries. Free competition as adopted in Britain outside London has ever since it was introduced in 1986 been widely debated. The opponents to the reform argue that is preferable that planning is in the hands of a public authority, while the operation is put out for competitive tendering.

With respect to long-distance airline and coach transport one reason for the lack of interest in public planning and competitive tendering is probably that these services in general are profitable—although many airline companies face severe financial problems. Train services in Europe are mostly still government owned and subsidized. In the U.S. rail services are private but partly financed by federal funds. In Sweden the state-owned Swedish Rail was in 1989 split into a Railway Administration (Banverket) responsible for infrastructure investments (financed by the government) and a "commercial" operator (SJ). A similar separation was made in Great Britain and Germany in 1994. In Sweden there have also appeared Government thoughts on permitting "competition on the track". In Sweden, coaches are since July 1994 allowed to compete with the intercity trains in certain corridors.

As far as I understand, not all decisions on organization of public transport have been foregone by economic analyses of economic consequences. This paper aims in brief to highlight some of the aspects which should be considered in such analyses.

This paper deals with various reasons for authority intervention in public transport. We employ a simple economic model in order to analyze the economic outcome of profit maximization and welfare maximization respectively. Special attention is given to the implications of the "network effect", ie that public transport consists of a network and not of a bunch of independent routes.

The next section specifies the basic model and assumptions. The following section employs the model for comparison of welfare and profit maximization for the one route case, followed by three arguments for public intervention. In the fourth section we analyze the consequences of welfare versus profit maximization for the network case, where shortcomings of profit maximization are demonstrated for the smallest possible network. The final section includes discussion and conclusions.

BASIC MODEL AND ASSUMPTIONS

The basic model employed here is a simplified version of that in K. Jansson (1991). For the production of the service we assume the following: The round-trip time of the service is $h=bX/F+\gamma$ hours, where b is fixed boarding time per passenger, X is the number of passengers, F is the number of departures per time period (frequency), X/F is the number of passengers per departure and γ is the remaining (passenger independent) run time per round trip. Arguments of functions are delimited by [], while polynoms are delimited by (). The number of units needed in each period is $F(bX/F+\gamma)$. If C[] denotes the cost per departure, total operating costs per hour are:

$$FC[\Sigma X, F, N,\sigma] \equiv F((c_C[N, \sigma])(b\Sigma X/F+\gamma) + c_S) \qquad (1)$$

In (1) N is the number of carriages used in a train (N=1 for all modes except train) and σ is the number of seats per vehicle or carriage. c_C is the capital and personnel costs related to the transport unit. c_S is the distance (kilometre) cost and a fixed terminal cost per departure.

Aggregate consumers' surplus is expressed as a function of "generalized cost", G:

$$G[p,T, F, N, \sigma] \equiv p + T[X[F, N, \sigma], F] + D[F] \equiv p + T[X[F, N, \sigma], F] + \phi/F \qquad (2)$$

In (2) p is price per journey. T is the cost of travel time as a function of demand, X, frequency, F, number of carriages, N, and number of seats per unit, σ. $D \equiv \phi/F$ is the cost of frequency delay ($\partial D/\partial F<0$), where ϕ is the value of time. The frequency delay is thus the time interval between ideal and actual departure time.

Passenger demand, X, is taken to be specified for a certain period of time and is a function of generalized cost: $X=X[G]$. Aggregate consumers' surplus is a function $S[G[p, F, N, \sigma]]$.

We ignore here the operator and passenger costs associated with boarding and in-vehicle congestion (crowding), as well as the number of carriages and the number of seats per vehicle. This simplification will substantially decrease the complexity of the calculations without affecting the basic analysis and results. The generalized cost is then expressed as:

$$G = p + D[F] \tag{3}$$

For differentials, eg both $\partial G/\partial F$ and G_F will be used as identical notations. Since $X[p,F] = X[G[p, F]]$, we will make use of the following relationships:

$$X_p = X_G G_p = X_G \tag{4}$$

$$X_F = X_G G_F = X_p X_F \tag{5}$$

We use a welfare objective function, transformed into a Lagrangian, L, by use of a budget constraint (where μ is the multiplier and Π the minimum profit), and profit objective function, π:

$$L = S[G[p, F]] + pX[p, F] - FC + \mu(pX[p, F] - FC - \Pi) \tag{6}$$

$$\pi = pX[p, F] - FC \tag{7}$$

WELFARE AND PROFIT MAXIMIZATION FOR ONE ROUTE

The first two sub-sections include a modelling approach to the welfare versus profit maximization of a public transport service. The final three sub-sections include three aspects on the theme.

Welfare versus profit maximization

For the welfare maximization case, the first-order condition with respect to price is:

$$\frac{\partial L}{\partial p} = \frac{\partial S}{\partial G}\frac{\partial G}{\partial p} + (1+\mu)X + (1+\mu)\, p\frac{\partial X}{\partial p} = 0 \tag{8}$$

where

$$\frac{\partial G}{\partial p} \equiv 1 \text{ and } \frac{\partial S}{\partial G} \equiv - X$$

(8) can then be written as:

$$\frac{\partial L}{\partial p} = \mu X + (1+\mu)p\frac{\partial X}{\partial p} = 0 \tag{9}$$

Rearrangement and use of the definition of price elasticity, $\varepsilon_p = (\partial X/\partial p)p/X$, yields:

$$p^* = -\frac{X}{(\partial X/\partial p)}\frac{\mu}{1+\mu} \equiv -\frac{p}{\varepsilon_p}\frac{\mu}{1+\mu} \tag{10}$$

$$\varepsilon_p = \frac{-\mu}{1+\mu} \tag{11}$$

Note that if the budget constraint does not bind, $\mu=0$, then $p^*= 0$, since marginal cost with respect to number of passengers is assumed to be zero.

For the welfare maximizing case, the first-order condition with respect to frequency is:

$$\frac{\partial L}{\partial F} = \frac{\partial S}{\partial G}\frac{\partial G}{\partial F} + (1+\mu)(p\frac{\partial X}{\partial F} - C) \equiv - X\frac{\partial G}{\partial F} + (1+\mu)(p\frac{\partial X}{\partial F} - C) = 0 \tag{12}$$

Use of (5) yields:

$$- X\frac{\partial G}{\partial F} + (1+\mu)(p\frac{\partial X}{\partial F} - C) \equiv -X\frac{X_F}{X_p} + (1+\mu)pX_F - (1+\mu)C \equiv -XX_F(\frac{1}{X_p} - (1+\mu)p\frac{1}{X}) - (1+\mu)C \equiv$$

$$\equiv -XX_F(\frac{-p}{X\varepsilon_p} - (1+\mu)p\frac{1}{X}) - (1+\mu)C \equiv -XX_F\frac{p}{X}(\frac{-(1+\mu)}{\mu} - (1+\mu)) - (1+\mu)C \equiv$$

$$\equiv -XX_F\frac{p}{X}(\frac{-(1+\mu)}{\mu} - (1+\mu)) - (1+\mu)C \equiv -XX_F\frac{p}{X}(1+\mu)(\frac{-(1+\mu)}{\mu} - C) \equiv -(1+\mu)(X\frac{X_F}{X_p} + C)$$

So, irrespective of whether the budget constraint is binding or not:

$$X\frac{\partial G}{\partial F} + C = 0 \tag{13}$$

For the profit maximization case, the first-order condition with respect to price is:

$$X + p\frac{\partial X}{\partial p} = 0 \tag{14}$$

$$p^* = -\frac{X}{\partial X/\partial p} \tag{15}$$

By use of the price elasticity concept, optimal price can also be written as:

$$p^* = -\frac{p}{\varepsilon_p} \tag{16}$$

Note thus that since marginal cost is assumed to be zero (equal to marginal revenue), the first-order condition is fulfilled for

$$\varepsilon_p = - 1 \tag{17}$$

Observe also that for all situations the optimal price is lower for the welfare maximizing policy than for the profit maximizing one. If the budget constraint is not binding, the welfare optimal price is zero, while if the budget constraint is binding, the welfare maximizing price is lower than the profit maximizing one, since $\mu/(1+\mu)<1$.

For the profit maximization case, the first-order condition with respect to frequency is:

$$\frac{\partial L}{\partial F} = p\frac{\partial X \partial G}{\partial G \partial F} - C \equiv p\frac{\partial X \partial G}{\partial p \partial F} - C \equiv X\varepsilon_p\frac{\partial G}{\partial F} - C \equiv -X\frac{\partial G}{\partial F} - C = 0$$

That is:

$$X\frac{\partial G}{\partial F} + C = 0 \tag{18}$$

Table 1 summarizes the results.

Table 1 Optimal frequency and price for three schemes

	Welfare maximization		Profit maximization
	Budget constraint binding	Budget constraint not binding	
Frequency	$X\frac{\partial G}{\partial F} + C = 0$	$X\frac{\partial G}{\partial F} + C = 0$	$X\frac{\partial G}{\partial F} + C = 0$
Price	$p^* = \frac{-p}{\varepsilon_p}\frac{\mu}{1+\mu}$	$p^* = 0$	$p^* = \frac{-p^*}{\varepsilon_p}$

Use of a functional form

The results in the previous section did not make it possible to say whether the welfare maximizing policy or profit maximizing policy yields the higher optimal frequency. We then use a functional form to see if we can draw some further conclusions, for this particular form at least.

For the numerical example we assume for computational simplicity an exponential demand function:

$$X = \exp(a\text{-}bG) \equiv \exp(a\text{-}b(p + T + \phi/F))$$

Differentiating this function yields:

$$\frac{\partial X}{\partial p} = -bX$$

$$\varepsilon_p = -bp$$

$$\frac{\partial X}{\partial F} = bX\phi/F^2$$

$$\frac{\partial G}{\partial F} = -\phi/F^2$$

$$\varepsilon_F = b\phi/F$$

It is easily seen that the solution is as shown in Table 2.

Table 2 Optimal frequency and price for three schemes, using a functional form

	Welfare maximization		Profit maximization
	Budget constraint binding	Budget constraint not binding	
Frequency	$F^* = \frac{X\phi}{F^*C}$	$F^* = \frac{X\phi}{F^*C}$	$F^* = \frac{X\phi}{F^*C}$
Price	$p^* = \frac{1}{b}\frac{\mu}{1+\mu}$	$p^* = 0$	$p^* = \frac{1}{b}$

We know that the optimal price is growing in the order:

- Welfare maximization, budget constraint not binding
- Welfare maximization, budget constraint binding
- Profit maximization

We then ask how optimal frequency is related to the various policies

$$F^* = (\phi/C)^{0,5}\,(X[p, F])^{0,5} = K(X[p, F])^{0,5} \tag{19}$$

Implicit differentiation yields:

$$dF = K0{,}5X^{-0,5}X_p dp + K0{,}5X^{-0,5}X_F dF$$

$$\frac{dp}{dF} = \frac{1}{X_p}\left(\frac{1}{K0{,}5X^{-0,5}} - X_F\right) \equiv \frac{1}{X_p}\left(\frac{1}{K0{,}5X^{-0,5}} - \frac{X_F}{X}\right)$$

Using (19) yields:

$$\frac{dp}{dF} = \frac{1}{X_p}\left(\frac{1}{K0{,}5X^{-0,5}} - X_F\right) \equiv \frac{1}{X_p}\left(\frac{1}{0{,}5} - \varepsilon_F\right)$$

That is, as long as $\varepsilon_F<2$, then $\frac{dp}{dF}<0$. Since demand elasticity with respect to frequency most reasonably is below unity, we can conclude that a higher optimal price corresponds to a lower optimal frequency. (Harald Lang, Department of Economics, Stockholm University, has shown for this functional form, using Topkis' theorem, that this conclusion is true irrespective of the frequency elasticity.)

The second-best argument for public intervention

The most common argument for public intervention, and probably the most commonly understood argument among politicians, is the "second-best argument". By making use of a model of the type presented earlier, complemented with a substitute mode (private car), the following result can be shown, for the simple case with cross-elasticities between mode A (public transport) and mode B (private car) but with no cross-elasticities between time periods (see eg Glaister [1974] and K. Jansson [1991] for comprehensive analyses):

$$p_A - m_A = -(p_B - m_B)\frac{X^B}{X^A}\frac{\varepsilon_A^B}{\varepsilon_A^A} \tag{20}$$

where m_A and m_B are marginal social costs, X^A and X^B are the demands, ε_A^B is the price cross-elasticity between the modes and ε_A^A is the own-price elasticity for mode A.

This argument thus concerns public intervention in terms of financial support, but not necessarily in terms of public planning and operation. The government could simply pay the firm A part of the cost per passenger. The alternative solution would be, if possible, to force mode B to charge a price equal to marginal cost. Public intervention is, however, needed in one way or another for an efficient solution.

The economics of scale argument for public intervention

Mohring (1974) observed economics of scale in consumption of public transport which gives rise to a positive external effect. Each additional passengers will benefit the already existing passengers through a higher optimal service frequency or a more dense network. We will here briefly demonstrate this effect where in price, frequency, vehicle size and number of train carriages are simultaneously optimized. For the purpose in this context it suffices to show the optimal price which results from the first-order condition with respect to frequency (using the definition of frequency delay, D):

$$p^* = \frac{FC}{X} + \frac{1}{F}\frac{\partial D}{\partial F} \equiv \frac{FC}{X} - \frac{\phi}{F} \tag{21}$$

According to (21) the optimal price equals the increase in operators' cost minus the passenger benefit in terms of less frequency delay due to a one unit increase in frequency, $X\partial D/\partial F$. This is thus an argument for public intervention through part government financing. Since empirical studies (see for example Algers, Colliander, Widlert [1985], Fowkes and Preston [1989], Fowkes and Wardman [1987]) indicate that the value of frequency delay is higher for local and regional transport than for long-distance transport, the argument for intervention is smaller for long-distance than for short-distance transport.

The intra-marginal demand argument

We know already from the objective functions for the welfare maximizing and the profit maximizing firms, that the profit maximizing firm ignores the consumers' surplus. The additional argument under this heading follows from the assumption made here that there are several sub-markets (for example two services in a simple case) with different demand levels and different elasticities with respect to generalized cost. The figure below illustrates this case.

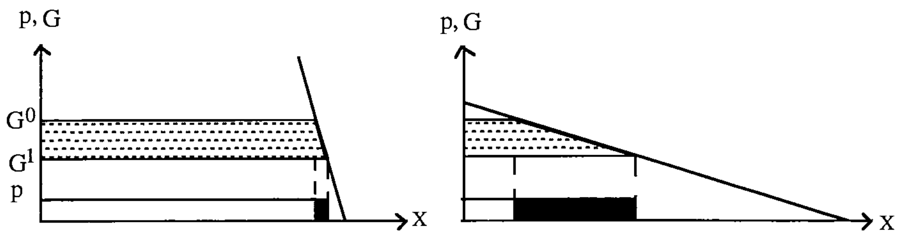

Figure 1 Illustration of gains for a welfare maximizing and a profit maximizing firm

Figure 1 shows two sub-markets (routes) where demand is a function of generalized cost, G. Assume for simplicity that G originally is G^0 on both routes. Assume that a welfare maximizing and a profit maximizing body, both have the opportunity to reduce generalized cost to G^1, at a fixed cost on both routes. The welfare maximizing body would choose to improve the route to the left, where consumers' surplus (horizontally lined area) plus producer's surplus (black area) is the largest. The profit maximizing body would choose to improve the route to the right, where producer's surplus is the largest, ie the profit maximizing firm invests on the route which would yield the lower social net benefit.

Unlike the earlier two arguments for intervention, this intra-marginal demand argument favours public authority intervention in terms of planning of routes and investments.

A NETWORK

Assumptions

Some persons argue that profit maximizing operators would create a better functioning route network than would any authority. The reason claimed is that the profit maximizing firm has an economic incentive to listen to their passengers and find new ones. This is an argument which we will discuss at the end of this section, contrasting this with the network argument which is the main theme of this section. Nash (1978) analyses this issue and compares a welfare maximizing and a profit maximizing operator, considering one service. Here we have the intention to analyze the issue taking into account a network, where the interaction between demand for various services becomes a crucial matter.

We could either think of a network as an entity of routes planned by one single monopolized body, welfare maximizing or profit maximizing, or as the bunch of routes which appear if several bodies each plan a limited number of these routes. The first case applies to most urban transport systems in Europe and United States. The latter case applies for example where several private operators each run a number of services in a city, or where several airline companies each operate a few lines in a country, or even where there are separate owners of airlines, train services and long-distance coach services, since this variety of services may also to some extent function as a network where passengers change between modes. The analysis made here is valid for both cases even though our example applies to the latter case.

Our network is a very simple one. We assume that there is originally an existing route, E, (which may be thought of as part of a network). Another firm introduces a new route, N. This route is partly "parallel" with route E, thereby attracting some passengers to switch from route E to route N. We may think of routes E and N as two bus routes or airline routes belonging separate companies. We may also think of route E being an airline route and N a new competing railway line, or that E is a rail line and N is a new coach route. Route E operates between points a and c, via point b. Route N operates on the section between points b and c. Passenger group e1, who travels on the section between point a and b on route E is unaffected by the new route. However, part of the passengers e2, who travels on the section between point b and c are attracted by the new route. Figure 2 below may help to explain the basic idea.

```
          / -----       group e1          group e2          ----/
Route E   o-------------------------------  o---------------------------o
          a                                 b                           c
                                            / ---- group n        ------/
Route N                                     o---------------------------o
```

Figure 2 An existing and a new route

The cost per departure for each section is assumed to be constant C, the same for both operators. The cost is thus assumed to be independent of road/air/track congestion and number of boarding passengers, something which does not influence the result of this analysis. The cost per round trip of the two routes are thus assumed to be 2C for route E and C for route N. If F denotes the number of departures per a specific period of time (eg. an hour or a day), the total costs are then 2CF and CF respectively.

We will analyze the following four policies:

I Welfare maximization of route E with no budget constraint

II Welfare maximization of route E with a budget constraint

III Profit maximization of route E

IV Profit maximization of route E and of the competing route N

Chris Nash (Institute for Transport Studies, Leeds University), has commented on an earlier version of this paper that the assumption on profit maximization made here is not constrained by actual or potential competition. This comment is partly correct and important, implying that it would be wise to complement the analysis with a game-theoretic approach. However, it is not assumed here that the profit maximizers are monopolists, they are in fact facing a demand which depends on price and frequency of service

We will here employ the model outlined earlier, and use a specific functional form and parameter values for the objective functions, in order to be able to illustrate the outcomes of each of the four policies. For the numerical calculations we assume the following parameter values:

$a = 7.3$; $b = 0.1$; $T = 10$; $\phi = 20$; $C = 200$

so that the demand function is

$$X_{e1} = X_{e2} = \exp(7.3 - 0.1(p + 10 + 20/F_e))$$

Case I: Welfare maximization of route E with no budget constraint

The solution is arrived at by solving the following equation system:

$$p_{e1}^* = p_{e2}^* = 0$$

$$F_e^* = \frac{2X\phi}{2F_eC} = \frac{2\exp(7.3 - 0.1(p+10+\phi/F_e))\phi}{2 \cdot 200F_e}$$

Computation yields the following solution:

$$p_{e1}^* = p_{e2}^* = 0 \text{ ; } F_e^* = 6.3 \text{ ; } X_{e1} = X_{e2} = 396$$

Generalized cost, $G_{e1} = G_{e2} = 0 + 10 + 20/6.3 = 13.17$

Profit, $\pi = 0 - 6.3 \cdot 400 = - 2\,520$

Consumers' surplus: $2 \cdot 396/0.1 = 7\,920$

Case II: Welfare maximization of route E with a budget constraint

The solution is arrived at by solving the following equation system:

$$p_{e1}^* = p_{e2}^* = p^* = \frac{1}{b}\frac{\mu}{1+\mu}$$

$$F_e^* = \frac{2X\phi}{2F_eC} = \frac{2\exp(7.3 - 0.1(p+10+\phi/F_e))\phi}{2 \cdot 200F_e}$$

$$p_{e1}X_{e1}[p_{e1}, F_e] + p_{e2}X_{e2}[p_{e2}, F_e] - 2F_eC = 0$$

Computation yields:

$$p_{e1}^* = p_{e2}^* = 4.05 \text{ ; } F_a^* = 4.9 \text{ ; } X_{e1} = X_{e12} = 243$$

Generalized cost, $G_{e1} = G_{e2} = 4.05 + 10 + 20/4.9 = 18.13$

Profit, $\pi = 4.05 \cdot 2 \cdot 243 - 4.9 \cdot 400 = 0$

Consumers' surplus: $2 \cdot 243/0.1 = 4\,860$

Case III: Profit maximization of route E

In the initial situation, where only service E exists (denoted e as index), the profit objective function is:

$$\pi_0 = p_1X[p_1, F_e] + p_2X[p_2, F_e] - 2CF_e$$

The solution is arrived at by solving the following equation system:

$$pe1^* = pe2^* = \frac{1}{b}$$

$$Fe^* = \frac{2X\phi}{2F_eC} = \frac{2\exp(7.3 - 0.1(p+10+\phi/F_n))\phi}{2 \cdot 200F_n}$$

Computation yields:

$$pe1^* = pe2^* = 10 \,;\, Fe^* = 3.3 \,;\, X_{e1} = X_{e2} = 109$$

Generalized cost, $G_{e1} = G_{e2} = 10 + 10 + 20/3.3 = 26.01$

Profit, $\pi = 2 \cdot 109 \cdot 10 - 3.3 \cdot 400 = 2180 - 1\,320 = 860$

Case IV: Profit maximization of route E and of the competing route N

In the new situation (denoted n as index) we assume that the new service N attracts around half of the group 1 passengers. This is obtained by offering these passengers a somewhat shorter riding time or access time, ie the parameter T is assumed to be lower for service N than for service E. The reason why all group E2 passengers are not attracted is that not all are gaining by choosing the new service N, due to varying access times to the two routes for example. This is taken into account in the model by picking a new parameter a, such that just a fraction of the passengers constitute the demand for service N. The demand function for service N is assumed to be:

$$X_n = \exp(6.5 - 0.1(p + 7 + 20/F_n))$$

Passengers who are still using the original, existing service, in situation N, denoted e1n and e2n respectively, have the demand functions:

$$X_{e1n} = \exp(7.3 - 0.1(p + 10 + 20/F_{en}))$$

$$X_{e2n} = \exp(6.8 - 0.1(p + 10 + 20/F_{en}))$$

The parameter a for group E2 passengers has been chosen so that all of those who have not chosen service N, will continue to use service E. The parameter a for group E1 passengers is the original one, so that a change in generalized cost will affect the demand in this group.

The solution for the new situation, N, is arrived at by solving the following equation system:

$$pn^* = \frac{1}{b}$$

$$F_n^* = \frac{X\phi}{F_nC} = \frac{\exp(6.5 - 0.1(p+7+\phi/F_e))\phi}{200F_e}$$

Computation yields the following solution for the passengers who switch to service N, denoted n, in situation N:

$$p_n^* = 10 \,;\, F_n^* = 2.25 \,;\, X_n = 50$$

Generalized cost, $G_n = 10 + 7 + 20/2.25 = 25.89$

Profit, $\pi_n = 50 \cdot 10 - 2.25 \cdot 200 = 500 - 450 = 50$

The solution for the existing route in situation N is arrived at by solving the following equation system:

$$pe1n^* = pe2n^* = \frac{1}{b}$$

$$F_{en}^* = \frac{X\phi}{F_{en}C} = \frac{\exp(7.3 - 0.1(10+10)) + \exp(6.8-0.1(10+10))\exp(-0.1\phi/F_e)\phi}{2 \cdot 200F}$$

Computation yields the following solution for service E in situation N:

$$p_{e1n}^* = p_{e2n}^* = 10 \; ; F_{en}^* = 2.8 \; ; X_{e1n} = 59 \; ; X_{e2n} = 99$$

Generalized cost, $G_{e1n} = G_{e2n} = 10 + 10 + 20/2.8 = 27.14$

Profit, $\pi_{en} = 59 \cdot 10 + 99 \cdot 10 - 2.8 \cdot 400 = 1\,580 - 1\,120 = 460$

We are now able to calculate changes in consumers' surplus and producers' surplus, due to the introduction of the new service, N.

Changes in consumers' surplus for various groups when introducing service N (where the demand function between the two points for generalized cost is approximately linear and where losses are given a negative sign):

Group N2: (26.01 - 25.89)50 =	+6
Group E1: (26.01 - 27.14)59 =	-67
Group E2: (26.01 - 27.14)99 + 0.5(26.01 - 27.14)10=	-117
Sum	-178

Changes in producers' surplus for the two services

Service E: 460 - 860 =	-400
Service N:	+50
Sum	-350

Change in consumers' and producers' surplus	-528

We have thus seen that interactions between various commercial operations can cause welfare losses. In this example both the producers and the consumers, in the aggregate, become worse off with the introduction of a competing route. Other examples could of course result in gains for the producers and losses for the producers, but the net outcome may still be negative. But could a welfare maximizing authority have introduced this new service? The answer is no, given the specified functional form, because what causes the welfare loss is the fact that commercial operators ignore the external effects on competing services in terms of loss of frequency. That is, if the introduction cause a welfare loss when commercially operated, there is still a loss when operated on welfare grounds. There may of course be welfare gains if in a commercial environment a new service is introduced, but introduction of the same service in a welfare oriented environment would lead to even greater net benefits. Let us demonstrate this fact by calculating the social surplus for the existing service, given that the operator were welfare maximizing. We look at both the case where there is no budget constraint and that there is a full cost recovery constraint.

Summary of the four policies

We are now able to summarize the outcome of the four policies (Table 3):

I Welfare maximization of route E with no budget constraint
II Welfare maximization of route E with a budget constraint
III Profit maximization of route E
IV Profit maximization of route E and of the competing route N

Table 3 Outcome of four policies in terms of price (p), frequency (F), demand (X), consumers' surplus (CS), profit (π), net social benefit (NSB)

	p	F	X	CS	π	NSB
Policy I	0	6.3	792	7920	-2520	5400
Policy II	4.05	4.9	486	4860	0	4860
Policy III	10	3.3	218	2180	860	3040
Policy IV, service E	10	2.6	158		460	
Policy IV, service N	10	2.3	50		50	
Policy IV, aggregate	10		208	2002	510	2512

There is clearly a descending order from policy I to policy IV, in terms of net social benefit and frequency, while the order is the opposite in terms of price. Note, however, that one cannot draw any conclusions from the magnitudes of differences in various respects, since these strongly depend on the specific demand function and the parameter values which were chosen.

The differences in outcome between policies I and II reflect the social cost of the budget constraint. The constraint imposes a tax on the consumers, and the difference in net social benefit shows the social cost of the tax. One should though be aware that alternative financing through some kind of tax will also cause social losses. One cannot therefore easily tell whether policy I or II is socially preferable.

The differences in outcome between policies II and III reflect the social cost of a commercial policy as compared to a welfare oriented policy. The reason for the differences is that the commercial operator does not take into account the value to the passengers of frequency delay. This social cost is nothing but the positive external effect due to economics of scale in production which was dealt with previously.

The differences in outcome between policies III and IV reflect the social cost of commercial competition. The difference in net social benefit may be said to be due to a combined externality stemming from both consumption and production; the operator decides to operate the service and the passengers who get attracted by this service in turn cause a lower ridership and a higher frequency on the existing service, to the disbenefit of the passengers remaining on that service.

Note that the same kind of welfare loss from policy IV may appear even if we had one profit maximizing monopoly operating both services. Had we chosen the parameter values in a somewhat different manner, one could very well have found that the aggregate profit had increased when the new route was introduced, but that the passengers' disbenefits would have outweighed the profits, so that the change in net social benefit would have been negative.

Note also that the analysis of network here applies to a number of situations: a) An urban transport network, b) An airline network, c) A long-distance transport network, comprising of airlines, train services and coach services. Note here for example that deregulation of long-distance coach services may disbenefit the rail services to such an extent that the net social benefit declines. Observe that the analysis also applies to the situation where a ringroad around a city is built, or a motorway is built, something which may decrease the demand for public transport and reduce the supply of public transport to the disbenefit of the passengers. As a matter of fact this is exactly what has happened in most developed countries over the last half century.

DISCUSSION AND CONCLUSIONS

The conclusions that can be made so far are that there are four arguments for a welfare policy as compared to a commercial policy with respect to decisions on output and prices:

i) The second-best argument when competing private transport is not priced at social marginal cost.

ii) The economics-of-scale argument, which applies for each single service.

iii) The intra-marginal demand argument.

iv) The external effect related to the consideration of the network; each service may affect other services and their passengers.

These arguments seem to make a strong case for the policy that a public welfare maximizing authority should be in charge of public transport.

Are there no relevant counter arguments, in favour of free competition? Yes there are. We have actually assumed an ideal situation where the public sector really decides according to a welfare maximizing principle. There are a few reasons why this may not be the case.

It may be that the politicians, who are the prime agents to the principal voters, do not decide in accordance with the wishes of the voters. Such action may depend on biased information from voters; the "loudspeakers" get more political attention than the silent citizens. Such action may also depend on prejudices held by politicians - who have not studied transport systems' cost and quality in any detail. This possibility may be referred to as the "public choice" argument against public intervention. Virtually anyone who has worked within a transport authority can tell stories about "stupid" political decisions where projects with very low benefit/cost ratios have been given high priority rankings. Nilsson (1991) shows that the rankings made by the Swedish Road Administration in actual project decisions differ substantially from the benefit/cost ratio rankings made originally by the planners. There may of course be distributional or other aspects that the politicians rightly consider, but nevertheless, the problem may very well exist.

Another reason may be that the planners in the authority are quite happy with having a job, without an exaggerated interest in making tedious investigations of passengers′ needs and valuations. This possibility may be called the "lazy-in-lack-of-competition argument". According to the experience of the author of this paper, this argument is not very strong, however. Planners within transport authorities in general seem to be dedicated persons with a great feeling for the customers' welfare. However, even if the planners are dedicated, they may be so in love with their own methods that they are not able to accept alternative methods. This risk applies not only to public authorities, but to any, private of public, monopoly. In Sweden it seems as if the Swedish Rail (SJ) has become more alert in finding cost reducing measures since they experienced competition from the private rail company BK-tåg.

Another problem with regard to public authorities is that each authority may "argue in favour of its own child". For example, the road administration may find reasons to favour road building, while the rail administration argues for new railway lines. Even if they do so "correctly", in the sense that the projects are socially beneficial, each authority may not fully take into account the external effects on the other transport modes. This problem is partly analogue to the one observed concerning profit maximizing operators, in the sense that network effects are disregarded, even though the welfare maximizing authorities within their own field act in an optimal way. This problem also points out that it may be worthwhile to establish a national authority which deals with all modes within one network frame, thereby considering priorities and coordination between modes. This problem is, however, not directly related to the welfare versus profit maximization issue, but is rather a matter of how to achieve the welfare maximizing policy.

Given that the various authorities are welfare maximizing and that the laziness argument is not strong, the authority may have a greater interest than a profit maximizer in investigating the passengers' travel pattern and in using sophisticated computer software for analysis of the network. The reason is again that the profit maximizer ignores the welfare of the existing passengers. The methods needed by the profit maximizer in order to try and find new passengers are typically much less complex than the methods needed by the welfare maximizer in order to calculate the effects of various actions in terms of riding time, waiting time, transfers etc. for *all* passengers.

Our conclusion is basically that the only really strong argument against public authority intervention, that may counterweight the four arguments for intervention, is the "public choice" argument. If now this argument is considered strong enough to set the market free in for example the road or the rail industry, what do the long run perspectives look like?

Assume that a private consortium shows some interest in investing in and maintaining a new road or rail link, thereby setting their fares and cashing in the revenues. One problem which has been observed is that private investors in practice have little interest in long-run risky investments, unless they can get some government insurance against losses. One reason for the risk is of course that politicians may change the rules of the game. Another reason is that shareholders often do not have the 40-50 years perspective which is relevant for heavy transport structure investments. According to Stopher (1992) yet no contract has been signed in the U.S. where a private enterprise constructs, maintains and charges a new road. Another risk pointed out by for example Rothengatter (1992) is that private investors do not consider the network aspect, but "skims the cream" and leave the less profitable parts to the public sector. Still another problem, also pointed out by Rothengatter, is that once a profit maximizing enterprise has been given the right to construct, maintain and earn money on a project, it may be difficult for the government to change "the rules of the game". New public measures such as fuel taxes, a new rail-road line etc. may severely influence the revenues of a road enterprise. Future political decisions which for example are meant to improve the environment may be blocked or delayed, or the government may be judged to pay some liability, which means that the tax payers get involved anyway.

Our conclusion of this discussion is that four arguments suggest that a free market solution in the public transport sector will not imply optimal solutions. The arguments against free competition are, however, stronger for local and regional transport than for long-distance transport:

	Strength of arguments against free competition in:	
	Local and regional transport	Long-distance transport
i) The second-best argument.	strong	weak
ii) The economics-of-scale argument.	strong	weak
iii) The intra-marginal demand argument.	strong	strong
iv) The network argument.	strong	strong/weak

We have thus seen that the optimal deviation between price and social marginal cost probably are smaller in long-distance than in urban transport. We have also seen that the optimal (tax financed) deficit is much smaller in long-distance transport than in urban transport. It may be that the interactive external network effects are stronger in urban than in long-distance transport, since the latter networks normally are less inter-dependent than complex urban networks where passengers often are forced to use several modes or routes to reach their destinations. On the other hand, in long-distance transport, even if most passengers stick to one mode for each journey, any new air route or any new coach line may hurt all passengers on an existing railway line and vice versa. So, the network effects may be strong both for urban and long-distance transport, the magnitudes of which, to our knowledge, have never been really studied.

On the other hand, even if free market solutions are not always optimal, empirical evidence suggests a) that "public choice" effects may not always imply efficiency in consumption (external efficiency) and b) that public planning and operation may not always imply efficiency in production (internal efficiency).

Given the short-comings of both total public and total commercial responsibility for public transport, what are the alternatives? To this question the solution may be public planning, in order to achieve efficiency in consumption, and free competition for the actual operation, in order to achieve efficiency in production. At least this solution, which we can call competitive tendering, may be beneficial for some sectors of the public transport industry. The solution is probably less brilliant for sectors where "public choice effects" are strong and where at the same time the four mentioned market failures are relatively weak.

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