The Costs of Bus Operations in Norway

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1. Introduction

The objective of this paper is to reveal the cost structure of the bus industry in Norway by discussing, theoretically and empirically, how total costs per vehicle-kms of a bus company are influenced by: (1) company size; (2) bus size; (3) the number of passengers; (4) the company's working conditions (that is, exogenous characteristics of the company's licence area); (5) the company's ownership structure; and (6) the subsidy procedure with which the company has to work. Our empirical analysis is based on data from all of the 174 bus operators in Norway in 1991.

The topics of cost structure and efficiency in public transport have attracted considerable research effort in recent years (see, for example, Diaz, 1982; Berechman and Giuliano, 1985; Winston, 1985; and Oum *et. al.*, 1992, for reviews). Much of the work has been concerned with the properties of economies of scale in bus transit. According to Berechman and Giuliano (1985) and Button (1993), the empirical results regarding economies of scale in the bus industry provide a rather confusing picture, but the majority of the latest works, which use flexible cost models, indicate a U-shaped long-run average cost curve (LRAC-curve); that is, economies exist up to a certain point, then diseconomies occur.

Empirical studies which compare the efficiency of privately owned bus companies to public ones, show some conflicting results: Pucher (1982), Pucher *et al.* (1983), Perry and Babitsky (1986), who all used data from the US, reported higher costs in publicly-owned than in privately owned bus companies. The same conclusion was made by Oelert (1976) and Hensher (1987) on the basis of West German and US data, respectively. Other US studies, for example Barnum and Gleason (1979) and Anderson (1983), did not, however, find any significant differences in cost profiles between these two groups of bus operators.The Norwegian bus industry is quite suitable for such a study because the ownership structure varies considerably among the companies.

There also exists a wide range of empirical studies which evaluate the welfare effects of deregulation of bus markets (see, for instance, the works connected to the UK done by

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Heseltine and Silcock, 1990; Evans, 1990; Tyson, 1990; Beesley, 1990; and White, 1990). However, as pointed out by Andersen (1992) the regulatory changes in Norway (and in other Scandinavian countries) in the bus industry are different from those implemented in the US and the UK. In Norway, new procedures have been introduced to distribute subsidies in order to reduce the bus operators' revenue support, while the licence systems and the public control of fares and supply in the bus markets have been continued. Today, county councils in Norway are using two main procedures to distribute subsidies among the bus operators. In one case, the size of the subsidy to an operator for the coming year is based on negotiations between the company and the county council; in the other case the county council uses standardised cost norms to estimate the size of the subsidy to an operator and no negotiations take place. In the latter case the size of the subsidy is exogenous to the bus operator, in the former case it is not.

The paper proceeds as follows. Based on a principal-agent relationship between the local authorities and the companies and a modified Cobb-Douglas specification of the cost structure, we outline the theoretical and methodological cost model in Section 2. Section 3 briefly describes the data collection procedure and presents and discusses our empirical findings. Finally, in Section 4 we present three possible political implications which follow from our analysis, and evaluate some aspects of the quality of our study.

2. The model

Theoretical framework

In accordance with a traditional principal-agent model (see, for instance, Rees, 1985; or Rasmusen, 1989), we assume that the bus companies have the ability to adjust an unobservable cost-reducing effort level, E. Futhermore, we assume that the total costs, C, in a company can be given by the function:

$$C = C(E;A), \quad C_E < 0, \; C_{EE} \geq 0, \tag{1}$$

where A symbolises a vector of exogenous and observable variables which may affect costs, and $F_H = \partial F/\partial H$. Moreover, the size of the subsidy, S, transferred to one company is supposed to be dependent on some exogenous and observable variables, such as the size of production and other characteristics of the operator and the operator's licence area, symbolised by the vector B, the company's reported costs, C, the authority's stipulated market revenue R^*, and the operator's reported market revenue, R. Generally, we assume that different subsidy policies practised in Norway can be described by:

$$S = (1 - \alpha)[\tau(B) - R^*] + \alpha(C - R), \; \tau(B) > 0, \; 0 \leq \alpha < 1 \tag{1}$$

where α can be interpreted as the public authority's marginal reimbursed ratio which the company faces. Only in the case of $\alpha = 0$ does the company receive a lump-sum subsidy equal to $\tau(B) - R^*$, where $\tau(B)$ can be interpreted as the stipulated costs following from a cost norm model practised by the authority. In this case the size of the subsidy will be exogenous for the operator. However, if the authority negotiates with the company, the size of the operator's cost and revenue reports may influence the size of the subsidy. Therefore, when negotiations take place, we assume that the subsidy is partly based on the difference between the cost norm and stipulated market revenue, the calculated required

subsidy $\tau(B) - R^*$, and partly based on the difference between the company's cost and revenue reports, the announced required transfer, $C-R$, that is, $0 < \alpha < 1$. A subsidy policy which balances the company's account can be described by (2) by assuming that $\alpha = 1$. From equations (1) and (2) it follows that the company's profit, π, can be expressed as

$$\pi = R + S - C = (1 - \alpha)\{[\tau(B) - C(E;A)] + (R - R^*)\}. \quad (3)$$

In our further discussions, we will consider R as an exogenous variable.[1] The company is supposed to have preferences over profits and effort given by the utility function

$$U = U(\pi,E) = \pi - \beta G(E),\ \beta > 0,\ G_E > 0,\ G_{EE} > 0, \quad (4)$$

where $\beta G(E)$ can be interpreted as the company's disutility of yielding effort in cost-reducing activities, measured in monetary terms. It follows from (4) that the utility is assumed to be constantly increasing in profit ($U_\pi = 1$) and strictly decreasing and concave in effort ($U_E = -\beta G_E < 0$ and $U_{EE} = -\beta G_{EE} < 0$). The company is assumed to maximise U with regard to E, given A, B, R^* and R. It then follows from (1), (2), (3) and (4) that the operator's optimal effort level, E^*, will satisfy the condition

$$-(1 - \alpha)C_E = \beta G_E, \quad (5)$$

which implies that the bus operator adjusts effort so that the company's share of marginal cost savings, $-(1 - \alpha)C_E$, is equal to the marginal disutility in the company by yielding effort, βG_E. The chosen effort will be dependent of the values on α, β and A, generally written as $E^* = E^*(\alpha,\beta;A)$. Furthermore, it follows from (1), (4) and (5) that

$$E^*_\alpha = C_E/[\beta G_{EE} + (1 - \alpha)C_{EE}] < 0,\ E^*_\beta = -G_E/[\beta G_{EE} + (1 - \alpha)C_{EE}] < 0. \quad (6a)$$

The reduced cost function, C^*, can then be expressed by

$$C = C[E^*(\alpha,\beta;A),A] = C^*(\alpha,\beta,A) \Rightarrow C^*_\alpha = C_E E^*_\alpha > 0,\ C^*_\beta = C_E E^*_\beta > 0. \quad (6b)$$

If we believe that this theoretical model describes the behaviour of a company in an adequate way, and if it is possible to identify the conditions which affect the values of α and β, any specifications of the reduced form in (6b), as distinct from (1), can be used to derive consistent and unbiased estimators of the cost structure in bus operations.

Model specification

In the following model, we adopt a modified Cobb-Douglas function. Adjusted to the reduced form of (6), we specify the conditions given in vector A by the exogenous variables X, Z_1, Z_2, Z_3, D_1 and D_2, the exogenous ownership structure and the subsidy policy affecting the values of α and β by the variables D_3, D_4, D_5 and D_6, and formulate the model by the equation

$$\ln Y = a_0 + a_1 \ln X + a_2(\ln X)^2 + b_1 \ln Z_1 + b_2 \ln Z_2 + b_3 \ln Z_3 + d_1 D_1 + d_2 D_2 + d_3 D_3 + d_4 D_4 + d_5 D_5 + d_6 D_6 \quad (7)$$

where

[1] This assumption can be justified by referring to the fact that the Norwegian transport authorities regulate the fares and the number of vehicle-kms supplied, which are the most important factors in determining R. If the authorities also know the demand conditions, the market revenue will be observable. It should also be noticed that in the case where the authority has perfect information about the demand conditions *ex ante*, the stipulated market revenue will be equal to the actual value of sales, that is, $R = R^*$.

Y is total costs per vehicle-kms in the company;
X is the number of vehicle-kms produced by the operator;
Z_1 is the average bus size in the company, measured by the sum of seating capacity and standing places;
Z_2 is the number of passengers boarding the buses of the company per vehicle km;
Z_3 is the number of local counties in the licence area of the company;
D_1 describes whether the company operates in a coastal area ($D_1 = 0$) or not ($D_1 = 1$);
D_2 describes whether the bus operator is also engaged in sea transport ($D_2 = 1$), or not ($D_2 = 0$);
D_3 describes whether the majority of shares are held by owners located in the licence area of the company ($D_3 = 1$) or not ($D_3 = 0$);
D_4 describes whether the company is publicly owned and faces a subsidy policy based on cost norms ($D_4 = 1$) or not ($D_4 = 0$);
D_5 describes whether the company is privately owned and has the ability to negotiate with the county councils over the size of the subsidy ($D_5 = 1$) or not ($D_5 = 0$); and
D_6 describes whether the company is privately owned and faces a subsidy policy based on cost norms ($D_6 = 1$) or not ($D_6 = 0$).

Equation (7) entails flexibility regarding scale economies. In the case of $a_1 < 0$ and $a_2 > 0$, the cost per vehicle-km as a function of X will be U-shaped, where the optimal size of production, X^*, is given by $X^* = e^{-a_1/2a_2}$. It is also seen that the values of the Z's and D's do not influence X^* and that the b's and the d's can be interpreted as constant cost elasticities.

Some hypotheses concerning parameter values

Jørgensen (1986) analysed the cost structure in the local bus industry in Norway based on a cross-section data set from 1982 and concluded that the average cost function was U-shaped. As far as we know, no considerable changes have taken place in technology or in relative factor prices during the 1980s in the bus industry. Therefore, our presumptions are that $a_1 < 0$ and $a_2 > 0$.

It is reasonable to expect that the costs will increase less than proportionally with the average bus size. The major reason is that variable costs, such as labour costs, will barely increase with bus size, while energy costs will increase slightly with bus size, that is, $0 < b_1 < 1$. Furthermore, it can be argued that an expansion in the number of passengers per vehicle-km will partly increase the number of stops per vehicle-km, and partly the number of passengers boarding the bus at each stop. Since the costs of stopping and starting the bus are mainly independent of the number of passengers boarding, it seems reasonable to assume that the costs will increase less than proportionally with passengers per vehicle-km, that is, $0 < b_2 < 1$.

As the number of local counties in the licence area increases, the number of densely built-up areas which need to be served by the bus operator increases. The local counties in the licence area will often have conflicting interests regarding the transport supply, which, for the bus company, leads to the need for more resources in planning and operating the scheduled bus transport in the region. Our hypothesis is, therefore, that $b_3 > 0$.

Operating bus routes in areas with many fjords and islands is assumed to involve more resources than operating the same routes in interior parts of Norway. A major reason for this is that scheduled bus transport in such coastal regions will be dependent on corresponding sea transport, which often leads to waiting time for the buses and, thereby, higher costs per vehicle-km. It is also likely that the standard of roads is lower in coastal areas than elsewhere. Hence, our *a priori* assumption is that $d_1 < 0$.

If the bus service efficiency benefits from the company's involvement in scheduled sea transport, then d_2 is negative. One reason which supports this hypothesis is that the company, by operating both scheduled bus and sea transport, is able to improve coordination between bus and boat routes and to utilise inputs such as management resources and engineering workshops more efficiently. However, one can also find reasons for assuming that d_2 will be positive. For example, bus companies also engaged in sea transport can be less capable of organising efficient bus operations than companies which specialise in bus transport. *A priori*, we do not know the relative magnitudes of these effects. Therefore, we do not have any specified hypothesis about the sign of d_2.[2]

Regarding the sign of d_3, again we do not have any strong presumptions. Suppose first that owners located inside the licence area, for geographical reasons, have better control of their managers and workers than externally-located owners. If the workers employed are those who have disutility of yielding effort, and the owners are concerned about profit, we would expect locally owned companies to have a lower value of β, which leads to a higher effort level and lower costs (see equation (6)). Another aspect which might influence cost in the same way (but does not affect β) is that local owners are likely to be more competent to run the bus company more efficiently because of local geographical knowledge. However, β can also be higher for locally owned companies. A possible reason for this could be that internal owners, public or private, may benefit from the lower cost effort of the bus company. For instance, lower cost effort in the bus company may increase the factor demand and thereby increase the activity in the actual region. If the first two effects are the strongest ones, we would expect $d_3 < 0$, while $d_3 > 0$ will indicate that the third effect is dominating.

A priori we believe that public owners put less stress on management to improve profits than is the case with private owners. In other words one may say that privately owned bus companies have a stronger profit motive than publicly owned bus companies. This hypothesis is strengthened by the general theories of public enterprises (see Hay and Morris,1991), and by the majority of the empirical works mentioned in Section 1. In accordance with our model this hypothesis can be expressed by assuming that the value of β is higher in publicly owned bus companies than in private ones.

If a cost norm procedure is used, where the operators do not have any influence on the standard norms in the cost model, the size of the subsidy will be totally independent of the *ex post* reported costs. According to our theoretical model, this is true when α is zero (see

[2] It should be remarked that the sign of d_2 does not give a clear answer concerning scope economies between bus transport and sea transport. To be able to test whether economies of scope exist or not, we must also consider how costs of sea transport are influenced by the size of bus operations; see, for instance, Baumol *et al.* (1982).

equation (2)). However, when the subsidy transfers to different bus operators are based on negotiations with the county councils and not only on standardised cost norms, we believe that both publicly and privately owned companies have the ability to influence the size of the subsidy by referring to the costs of bus operations in their particular licence area. This means that the subsidy procedure under negotiations can be characterised by a positive α. It then follows from our model that companies facing cost norms will insert more cost-reducing effort, which implies that they will have lower costs than negotiating operators (see equation (6)).

If we connect the above prior assumptions regarding α and β, we would expect that a public company facing cost norms has lower costs than a publicly owned company which negotiates, that is, $d_4 < 0$. Furthermore, it follows from our discussion that a private company will have lower costs than a public company in the situation where both negotiate, that is, $d_5 < 0$. Obviously, a private company facing cost norms is assumed to have lower costs than a public company which is negotiating, that is, d_6 is negative and $d_6 < d_4$, $d_6 < d_5$.

3. Data and Estimation Results

The data set consists of data from 174 bus operators in Norway in 1991. All subsidised companies providing local bus services are contained in the data base. The size of the companies' production levels varies from bus operators with a yearly output of 12,000 vehicle-kms to bus companies producing almost 9 million vehicle-kms. The information used in the analysis is obtained from the local transport authorities located in the 19 regional counties in Norway. Each year the bus companies are obliged to report, on a standard scheme to the county councils, annual production levels, revenue, costs and capital equipment. In the cases where information was incomplete, we asked the operators directly.

Adding a standard disturbance term to the right hand side of equation (7) and running OLS regression where we use our data set, gives us the estimates and sample statistics which are presented in Table 1. In addition, it should be mentioned that a plot of the residuals shows no systematic traits or derivations from normality.

First, we notice from the results in Table 1 that the model is significant at the 1 per cent level. Secondly, the estimated values of the a's are significantly different from 0 at the 5 per cent level, and, as expected, we find that the average cost function is slightly U-shaped. Using the point estimates of a_1 and a_2, it is seen that Y reaches its minimum for about 1.5 million vehicle-kms, which, according to our data, corresponds to a bus operator with nearly 40 vehicles, the average size of Norwegian bus companies. However, the average cost curve is rather flat when output exceeds approximately 0.5 million bus-kms. Another indication of the constant scale elasticity in the bus industry is that a transformation of all operators to the optimal size gives only 2.8 per cent reduction in costs. Taking into account the transaction costs which probably follow from such a change, the net effect will be quite small, if not negative.

Table 1
Estimation Results

	Coefficient	*t-value*		*Coefficient*	*t-value*
a_0	5.052**	4.38	d_1	–0.094*	–2.47
a_1	–0.483*	–2.52	d_2	0.161*	2.50
a_2	0.017*	2.35	d_3	–0.010	–0.20
b_1	0.290**	3.71	d_4	–0.201**	–2.74
b_2	0.130**	4.11	d_5	–0.091	–1.47
b_3	–0.043	–1.30	d_6	–0.211**	–3.37

N = 174
R^2 = 0.67**
F = 11.79**

** Significant at the 1 per cent level
* Significant at the 5 per cent level

The estimate of b_1 is evidently higher than 0 and less than 1, and states that an increase in the bus size with 1 per cent will give a 0.29 per cent growth in the total costs of bus operations. Furthermore, it is seen that b_2 is significantly higher than 0 and less than 1 at the 1 per cent level. The estimate shows that when the number of passengers per vehicle-km increases by 1 per cent, the costs increase by 0.13 per cent. Rather surprisingly, we find that the estimated value of b_3 has the opposite sign to that expected, but it is not significantly different from 0. This indicates that the size of the licence area, measured by the number of local counties, does not raise costs in scheduled bus planning and operations.

It is also seen that d_1 is significantly higher than 0 at the 5 per cent level, which means that we can conclude that operators located in coastal areas, as expected, have higher costs than companies operating in the interior parts of Norway. The point estimate of d_1 indicates that the disadvantage of operating in a coastal area will be reflected by 10 per cent higher costs than elsewhere. By looking at d_2, it is seen that this coefficient is significantly higher than 0 at the 5 per cent level. The point estimate indicates that bus companies also engaged in sea transport have 16 per cent higher costs in bus operations than companies which do not operate scheduled sea transport. One reasonable explanation for this remarkably high positive estimate of d_2 could be that operators who are also involved in sea transport are located in the coastal areas of Norway which are the most difficult regions technically to operate. In any case, however, this result shows that the transport companies operating both scheduled bus and sea transport do not have any cost advantages in bus operations compared to the other bus operators.

Furthermore, we see that the point estimate of d_3 is negative, but not significantly different from 0 at the 5 per cent level. Hence, we find no evidence in our data that locally owned companies are more or less cost-efficient than externally owned companies.

As expected, we find that d_4 is significantly lower than 0 at the 1 per cent level. The point estimate tells us that publicly-owned bus companies, facing a subsidy policy based on cost norms, have 20 per cent lower costs than companies in public ownership which negotiate with the authorities over the size of the subsidy. Furthermore, based on the definitions of the dummy variables d_4, d_5 and d_6, it can be shown that privately owned companies facing cost norms have 12 per cent lower costs than privately owned companies which negotiate, that is, $(d_6 - d_5) = -0.12$, which is significantly below zero at the 1 per cent level (the t-value is –2.80).

The point estimate of d_5 is negative, but not significantly below 0 at the 5 per cent level. The difference $(d_6 - d_4)$ can be interpreted according to the definitions of d_4, d_5 and d_6 as the percentage difference in costs between private companies and public ones which are both facing cost norms. The estimated value of $(d_6 - d_4)$ is –0.01, and not significantly below 0. Hence, we find no evidence in our data that privately owned companies exhibit superior efficiency to companies in public ownership. This holds true when we compare companies facing a subsidy policy based on either negotiations or cost norms.

Thus, irrespective of ownership structure, the estimation results show that a subsidy policy based on cost norms leads to higher efficiency. It is, however, worth noting that the estimation results indicate that the introduction of cost norms will improve efficiency more in public bus companies than in private ones, that is, $[(d_4 - (d_6 - d_5)] = -0.08$, which is significantly below 0 at the 5 per cent level (the t-value is –2.00). One possible explanation is that publicly owned companies have better contact with the county councils than the private ones and, therefore, can have greater influence on the subsidy amount when negotiations take place; that is, the value of α which a publicly owned company faces is higher than for a private one.

4. Concluding Remarks

Based on the conclusions drawn in our analysis, it is tempting to present the following three political implications:

(1) A strategy which aims to change the size distribution of the bus companies will have only minor influence on the efficiency of the Norwegian bus industry.

(2) A strategy of privatisation of the publicly owned companies will not give any significant cost reductions.

(3) To change the subsidy policy from negotiations to cost norms will give better incentives for the bus operators to improve internal efficiency and, hence, result in significant cost reduction in the bus industry; the cost reduction is estimated to be 20 per cent and 12 per cent for publicly owned and privately owned firms, respectively.

As in all other empirical works, the reliability of the results obtained is dependent on the quality of the data and how suitable the theoretical and econometric models are in describing the cost structure and the behaviour of the companies. In this context it should be noted that we have accounted for the traditional criticism concerning comparisons of different companies' costs when there are variations in product characteristics and differences in technological conditions among the operators (the Z's, D_1 and D_2).

However, to exemplify how critical assumptions might be, suppose that the bus operators' observed costs may differ from the actual costs. One reason for this can be that the county councils, which collect the information from the companies, are unable to control the accuracy of the costs reported. If the size of the subsidy increases with the size of the reported cost, the operators will gain by reporting higher costs than the actual ones. If we add this assumption of unobservability of realised costs to our model, it then follows that companies facing a cost norm system as the basis for calculating subsidies do not have any incentives to over-report costs (because α in equation (2) is zero), while negotiating companies will gain subsidies by reporting higher costs than they actually have (because α is positive). Furthermore, under cost unobservability, both groups of companies have the same incentives to be internally efficient with regard to (unobservable) efforts in cost-reducing activities because the subsidies will be independent of *the actual costs*. Changing policy from negotiations to cost norms then only leads to identical reductions in the public subsidies and in the companies' profits, which is a pure distributional effect. Unlike the reasoning in the original model, the actual costs of bus operations will be unchanged. Therefore, the political implication in (3) above might be misleading, and an alternative implication can be presented:

(4) Although the gain for the authorities is the same as the loss for the bus operators when policy is changed from negotiations to cost norms, reducing public budgets will be welfare-improving because the public sector has to finance all transfers through taxation which involves efficient losses in other markets.

On the basis of the data available, it is impossible to test whether it is better to use our prior hypothesis or this alternative model assumption to explain that the *reported and observed* costs are significantly lower in companies which face cost norms, compared with those which only negotiate.

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