Yardsticks on the road:

Regulatory contracts and cost efficiency in the Norwegian Bus Industry

by

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† Financial support from the Department of Economics of the University of Chile to cover travel expenses of one of the authors is gratefully acknowledged. We would like to thank comments by participants at the 7th European Workshop on Efficiency and Productivity Analysis, September 2001, Oviedo, Spain.

Abstract

In this paper a cost frontier model is estimated for an eleven-year panel of Norwegian bus companies (1136 company-year observations) using the methodology proposed by Battese and Coelli (1995). The main objective of the paper is to investigate to what extent different type of regulatory contracts affect company performance. The panel model proposed by Battese and Coelli (1995) allow for year/company specific efficiency measures to be estimated. Thus, unobservable network or other time invariant characteristic of the operating environment can be controlled for by analyzing the dynamics of measured productivity across time for firms regulated under different types of contracts, rather than relying solely on variations across companies during one time period. Therefore, the paper offers some methodological advantages over previous work on this subject. The main and robust result of the paper is that the adoption of a more high-powered scheme based on a yardstick type of regulation significantly reduces operating costs. The results contained in this paper thus confirms theoretical predictions regarding the incentive properties of high powered incentive schemes and in particular the dynamic benefits of yardstick competition.

Keywords: urban transport, yardstick regulation, frontier estimation methods

JEL Classification: L9, L5

1. Introduction

In this paper a cost frontier model is estimated for an eleven-year panel of Norwegian bus companies (1136 company-year observations) using the methodology proposed by Battese and Coelli (1995). The main objective of the paper is to investigate to what extent different type of regulatory contracts affect company performance. As explained in more detail further below, two main types of contracts have been used in Norway to regulate bus companies. One the one hand, regional authorities may bargain individually with transport companies on the subsidy levels to be granted during the forthcoming year—a regulatory contract assumed to be of low power in terms of its incentive properties. On the other hand, during the last decade a number of regional authorities have adopted a more high-powered contract based on a yardstick or benchmark model. More recently, regulatory contracts have evolved into a price-cap type scheme.

Jorgensen, Pedersen and Volden (1997) analyzed the performance of Norwegian bus companies in a similar vein to the present paper. They use a cross section for 1991 to estimate a cost frontier model. The inefficiency parameters are then regressed on contract and ownership variables to examine their correlation with cost efficiency. They find that the standard cost model improves cost efficiency over the individually negotiated contract between 1.7% and 3.5% depending on the distributional assumptions made for the inefficiency term. However, since it is only one year of data and all inferences are made using this cross section, there is the problem that unobservable network characteristics or other unobservable variables may be influencing the results.

Odeck and Alkadi (2001) apply DEA analysis to examine the performance of Norwegian bus companies using data from 1994. They do not study the effects of regulatory contracts on the performance of companies. However, they do note the limitations of not controlling for unobservable effects. As the authors point out "the major drawback [of the paper] concerns the geographical characteristics of the area in which bus companies operate. Such information would probably help explain some of the differences found in the performance between companies".

Controlling for network structure and spatial characteristics is always a problem when dealing with cross section data to measure performance of transport companies. Although attempts have been made to control for these effects using observable network characteristics, the problems of unobserved differences among observations remain. Unlike the previous studies mentioned above, the main advantage of the present paper is the use of a relatively long panel of observations with several transitions in the data. The panel model proposed by Battese and Coelli (1995) allow for year/company specific efficiency measures to be estimated. Thus, unobservable network or other time invariant characteristic of the operating environment can be controlled for by analyzing the dynamics of measured productivity across time for firms regulated under different types of contracts, rather than relying solely on variations across companies during one time period.

The present paper then contributes to the literature on three counts. First, substantially more data is used to study the effects of regulatory contracts than that used by previous studies. In addition, because we have information up to 1997 we are able to analyze the effects of a third type of contract—price cap—that was introduced in Norway in the mid nineties. Previous research has not documented the effects of this new regime. Second, we use a stochastic frontier model that simultaneously estimates the firms cost function and the cost inefficiency for each firm but taking into account variables that may explain the relative inefficiency across firms. Therefore, the two-stage method whereby a cost frontier model is first estimated and then firm's inefficiency estimate is regressed—in a second stage—on explanatory factors is avoided. As will be explained below, this two-stage method, besides being inefficient, is ad-hoc and inconsistent. Third, given the panel nature of our data we are able to control for unobservable firm specific network characteristics, overcoming one of the main problems in the empirical analysis of transit company performance.

The main and robust result of the paper is that the adoption of a more high-powered scheme based on a yardstick type of regulation significantly reduces operating costs. These results are important for several reasons. In a recent survey, De Borger and Kerstens (1999) argue that most studies on transit company performance show that there are substantial technical inefficiencies among urban transport operators. These authors also note that the evidence seems to suggest significant variability of measured efficiency among transit companies, both within as well as across countries. Furthermore, few studies have explicitly analyzed the impact of different regulatory contracts in explaining these differences. Thus, given the potential efficiency gains available, a better understanding of the effects of different regulatory contracts on company performance is important[1].

Finally, the present paper may be interest beyond the transport sector. Although the theory of incentives in regulation has become a well-developed theoretical field, empirical research has not been very extensive. To date few studies have empirically analyzed how firms actually respond to changes in regulatory incentives[2]. Rigorous empirical evidence on the benefits of yardstick competition is even more difficult to find. This is probably due to the fact that there are few formal experiences of this type of regulation around the world[3]. This lack of evidence may be somewhat troubling given the wide acceptance—following the publication by Shleifer (1985)—of the benefits of yardstick competition as an instrument to reduce the problems of asymmetric information faced by regulators. International development agencies, consultants and academics invariably recommend this type of regulation whenever possible[4]. However, these recommendations rest more on

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[1] Kerstens (1996) analyzes the impact of different regulatory contracts on French transit companies. See also Dalen and Gomez-Lobo (1996, 1997) and Gagnepain and Ivaldi (1999) also study the effects of regulation on cost performance by transit firms. However, they use a structural approach to recover the firm's underlying cost efficiency distribution in order to model the effects of the introduction of an optimal regulatory contract (including network auctions) a lá Laffont and Tirole (1993). These studies are quite restrictive owing to the structural nature of the estimation strategy and may thus introduce unnecessary biases that are avoided by the reduced form approach adopted here.

[2] One of the few exceptions is Mathios and Rogers (1989). They use a reduced form econometric model to study the impact on AT&T's long-distance telephone rates of the introduction of price-cap regulation in the United States. They find that rates are significantly lower in states that introduced price-cap and pricing flexibility than in states that continued to use rate-of-return regulation. However, since the analysis focuses on price effects, it is not possible to determine whether the reported impact of incentive regulation was due to an improvement in efficiency or to profit shifts. There are also numerous studies that analyse the effects of privatisation and liberalisation, especially of the United Kingdom utility sectors. However, these studies cannot separate the effects of changes in regulatory contracts (for example, the introduction of price caps) from the effects of a change in industry structure and ownership since these changes were introduced simultaneously.

[3] The UK water regulator has used benchmarking extensively during the last decade to determine company specific revenue requirements. The Chilean electricity regulator is also using a benchmarking model to set electricity distribution tariffs. However, in both of these cases there is no variation in the regulatory contracts offered to companies which could be used to isolate the effects of yardstick competition from other potential influences on efficiency.

[4] See for example Coelli, Estache, Perelman and Trujillo (2001), a manual for regulators prepared by the World Bank which stresses the importance of yardstick competition.

theoretical considerations than on hard evidence as to the effects of benchmarking in practice. This paper provides some rigorous empirical evidence on the effects of yardstick competition on company performance.

The paper is organized as follows. The next section describes the main aspects of regulatory practices in the Norwegian bus transport industry. Section 3 describes the data set and section 4 presents the model. The results are presented and discussed in section 5, and concluding remarks are offered in section 6.

2. Regulatory practice in Norwegian bus transport

In Norway, responsibility for local transport is decentralised to the regional governments (counties). They define the network route, schedules, fares and the subsidies given to companies. Each county is free to choose its own regulatory policy. As a consequence, regulatory practice has evolved differently across the various regions of Norway.

Two basic approaches have characterized regulatory practice in Norway. What both approaches have in common, though, is that they involve lump sum grants to companies[5]. Most counties originally bargained annually and individually with each company over both costs and transfers. This scheme exposed companies to a ratchet type effect. If costs are reduced, it becomes harder to argue that the next lump sum grant must be kept at the previous level. On the other hand, if costs rise it may not be too difficult to convince the authorities that subsidies must increase. Therefore, it is reasonable to assume that the individual-bargaining scheme is of low-power in terms of the cost reducing incentives that it provides.

In the late eighties some counties started adopting a standard-cost model to determine annual transfers. In such a system, the county and the companies agree upon a set of criteria for calculating costs of operating a bus-network. It is a linear model that links driver costs,

[5] In 1989 the share of government subsidies amounted to about 40% of the total revenues of Norwegian transport companies. The majority of these companies are privately owned.

fuel costs, and maintenance costs to the number of bus kilometers produced for different categories of routes (from inner-city, low speed to long distance, high speed routes). Given fares and route schedules, the standard-cost model determines the level of transfers that is granted by the regulator. A version of the standard-cost model is presented in more detail in the appendix.

The important aspect of the scheme is that the same standard cost model applies to all companies within a county. This makes the regulatory scheme more high powered: Once the criteria are set, realized costs by one company that happens to deviate from the standard-cost figures, will not affect the level of its next annual lump sum transfer. This gives the standard-cost model a flavor of yardstick competition (see Shleifer, 1985). The main characteristic of yardstick competition is that transfers be based on a benchmark estimated on the basis of cost performance of a larger set of companies.

More recently, both of the previous contracts are being replaced by a third type of contract, a subsidy cap. The companies and the county agree upon a reduction in the level of governmental transfers by X% per year, over a five years period. This last contract was introduced as a compromise after counties threatened to tender network services.

Table 1 shows how the use of the different types of contracts has evolved over the sample period 1987-1997. It shows the number of counties using each type of contract.

Table 1: Number of counties using each type of contracts

Contract type	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Individual negotiation	16	13	12	11	11	9	8	7	2	1	0
Standard Cost	4	6	7	8	8	9	9	9	10	7	3
Subsidy cap	0	0	0	0	0	1	2	3	7	11	16

During the first part of the sample period, most counties used the relatively low-powered individual negotiation type of contract. By 1992-1993, the yardstick model had become the most popular contract with 9 out of 19 counties using this type of regulation. From 1992 onwards, counties that previously used the low-powered contract switched to a subsidy cap. In the last two years of our sample period, many counties using yardstick contracts have also switched to the subsidy cap contract.

3 Data

The data used in this study was collected by the Central Bureau of Statistics in Norway. It is based on annual reports presented by bus companies. In certain parts of Norway there is a large number of very small bus companies, often with only one or two employees. As these companies produce a very narrow set of services and at very small scale, they are excluded from the dataset. Furthermore, companies with incomplete reports of either costs or output are excluded. In some cases, incomplete data was a consequence of the decision by the Bureau of Statistics to store only aggregated county summaries rather than company level information.

In all, information was available for 142 companies over the 11 year period from 1987 to 1997. Not all companies had complete information for all years. Therefore, an unbalanced panel with 1136 company/year observations was obtained[6].

The two outputs used in this study were the number of vehicle kilometers in the regulated transport sector (urban) and the unregulated transport sector (inter city services). Labor costs are reported separately for drivers and administrative personnel. Wages for these two inputs were derived from reported labor costs and hours. The fuel price was derived from reported fuel-costs and quantity used. Capital is measured by the total number of seats of the rolling stock. This variable is assumed to be an exogenous quality variable determined by the regulatory authorities.

A set of variables constructed by the Central Bureau of Statistics is used to control for network and demand characteristics between counties. These are the density, centrality, and the industry index. Their values are associated with the region in which the major part of

[6] The results are not sensitive to the unbalanced nature of the data. Estimation using a balanced sub-panel did not affect the general results presented below.

the companies' production takes place. The density variables measures different population densities (low values are associated with more scattered populated areas) and the centrality index measures the average distance to different types of city centers (a low value is associated with areas having longer travelling distances to city centers). Finally, the industry index shows the average type of industry in the region (low values are associated with more weight on agricultural production).

Another aspect of our data set are variations in company ownership. Most companies have been privately owned throughout the sample period. Since 1993, however, the state-owned Norwegian railway company (NSB) has been responsible for around 20-25 takeovers (Carlquist, 1998). Before 1993, the bus division of NSB was already one of the major companies in Norwegian bus transport.

4. The model

In order to determine the efficiency properties of the different regulatory contracts we estimated the following cost frontier model:

$$C_{it} = \alpha_0 + \alpha' w_{it} + \beta' q_{it} + \delta' z_{it} + \varepsilon_{it} + \mu_{it}$$

where *i* and *t* index the firm and the year, respectively, *C* are operating costs (driver wages, administrative wages and fuel costs), *w* is a vector of price variables, *q* a vector of output variables, *z* is a vector of variables that account for different operating environments or technology for each firm, and α, β, and δ are the corresponding parameter vectors. All continuos variables have been transformed to logarithm. In some specifications, such as the translog cost function specification, second-order and interaction terms are also included.

The error structure adopted follows the specification for panel data due to Battese and Coelli (1995), where ε are assumed to be i.i.d. $N(0, \sigma_\varepsilon^2)$ random noise terms and μ are non-negative random variables accounting for the cost inefficiency of each firm. These inefficiency effects are assumed to be independently distributed as truncated normal $N(\omega_{it}, \sigma_\omega^2)$, with mean,

$$\omega_{it} = \gamma' r_{it}$$

where r is a vector of firm specific variables that affect inefficiency across firms.

The advantage of the above specification is that cost inefficiency measures are estimated for each firm and each year, allowing for changes in firm's performance through time. Moreover, the inefficiency effects are estimated considering certain explanatory variables that may account for differences in performance across firms. These last variables do not affect the production technology or the cost minimising input ratios per se, but rather explain why some firms are closer or farther from the cost minimising frontier. Estimating the cost function parameters together with the parameters that explain efficiency variations across firms is statistically more efficient and less ad-hoc than the two stage methods employed by many authors since Pitt and Lee (1981)[7].

As with most frontier models, the drawback from the above specification is that certain distributional assumptions must be made on the error terms in order to separate random noise from the inefficiency term[8].

Since operating costs are the sum of administrative wage, driver wage and fuel expenses, the cost frontier is a function of the prices for these three inputs (w_a, w_d, p_f). We impose the homogeneity restriction on the cost function by deflating operating costs and the wage rate of administrative workers and drivers by the unit price of fuel.

[7] The two stage method consists of estimating a cost (production) frontier first, derive the inefficiency measures for each firm and, as a second stage, regress these measures on some other variables that may explain efficiency variations across firms. Apart from the loss of some estimating efficiency, the two stage method is somewhat inconsistent since the inefficiency error terms are assumed to be identically distributed for each firm in the first stage. This assumption is clearly contradicted in the second stage when these error terms are assumed to depend on some other variables.

[8] The approach proposed in Kumbhakar, et al. (1999) is less restrictive in this sense.

The variables in the vector *r* that influence cost efficiency are four. First, a dummy variable if the firm in a particular year was regulated using the yardstick contract (*contr1*). Second, a dummy variable if the firm in a particular year was regulated with the subsidy cap contract (*contr2*). Finally, two variables for the number of years elapsed since each of those contracts were introduced (*dumc1* and *dumc2*). These last two variables were included in order to capture any dynamic effects from the introduction of these contracts. For all of the above variables, the parameters should be interpreted relative to the omitted case, firms that were regulated under the individually negotiated contract.

5. Results

Before presenting the results for the cost frontier model, we discuss the results of conventional regression estimates. These are shown in Table 2. All variables have the expected sign and the parameters are very stable across different model specifications.

The first model shows the results of an OLS model with dummy variables for each of the two new regulatory contracts (yardstick and subsidy cap). The coefficient on the driver wage rate is highly significant and close to the average share of this input on costs (0.74). The administrative wage coefficient is also significant but low compared to the average share of this variable on costs (0.14). Regulated output and unregulated output are both significant but there are important economies of scale in unregulated output. This is consistent with the observation that long distance transport exhibits strong economies of scale compared to urban or commuter transport services (at least when measured by kilometres travelled) because of lower congestion and more intensive use of driver time.

The coefficient on capital is negative, which is to be expected since we are estimating a short run operating cost function. Higher capital investments reduce operating costs. The density of the operating environment significantly affects operating costs, raising these costs by about 3%. This is reasonable since average speeds are lower in more congested municipalities. Conditional on the density of the operating environment, municipalities where communities are closer together (*central* variable) have somewhat lower costs. The industry variable is positive, implying that more industrialised areas are costlier to serve, although the effect is quite small. This is probably related to the fact that this variable is most probably proxying for urban municipalities as compared to rural areas.

Firms owned by the public railway company (*Nsb*) also exhibit lower costs. There are several possible interpretations for this result. First, since *Nsb* operates a substantial number of services, the lower costs of these firms could be an indication of strong economies of scale or scope in the industry. These economies may explain the increasing numbers of mergers and takeovers observed among private operators. Another interpretation is that there are economies of scope between road transport and the provision of railway services. Third, the results may be showing that this public firm is intrinsically more efficient than private operators[9].

[9] Another possibility is that there is some accounting cross subsidy between the railway company and its affiliated bus companies. However, this is unlikely. First, we are estimating operating costs and it would be difficult to directly subsidise the fuel or wage bill as compared, for example, to maintenance expenditure where it may be possible for the bus companies to use some of the staff and infrastructure of the railway company. Second, the bus company is operated autonomously as a daughter-company, owned by *Nsb*. Therefore, there is an arms length relationship between both types of actives in the railway company.

Table 2: Regression Results

	Model 1		Model 2		Model 3		Model 4	
Variables	Coeficient	t test	Coeficient	t test	Coeficient	t test	Coeficient	t test
Constant	-1.5322	-10.98	-1.5477	-11.13	-1.3140	-9.21	-1.0321	-1.35
Adm. Wage	0.0252	2.00	0.0252	2.01	0.0287	2.31	0.0329	3.68
Driver wage	0.7381	34.25	0.7345	34.10	0.6975	30.62	0.6140	37.17
Q unregulated	0.1121	4.57	0.1207	4.89	0.1099	4.50	0.2263	6.38
Q regulated	0.8102	39.55	0.8134	39.64	0.8056	39.53	0.7138	18.02
Qunreg*Qreg	0.0035	0.96	0.0026	0.71	0.0047	1.30	-0.0102	-2.03
Capital	-0.0863	-6.58	-0.0852	-6.50	-0.0841	-6.46	-0.0680	-6.91
Central	-0.0045	-1.81	-0.0042	-1.66	-0.0034	-1.36	0.1708	1.08
Density	0.0282	12.06	0.0285	12.20	0.0278	12.07	0.1573	0.92
Industry	0.0032	2.76	0.0029	2.54	0.0027	2.33	-0.0488	-0.95
Nsb	-0.0650	-3.09	-0.0589	-2.81	-0.0579	-2.80	0.0122	0.50
Time dummies	No		No		Yes		Yes	
Firm specific effects	No		No		No		Yes	
Contract 1	-0.0874	-7.82	-0.0444	-2.61	-0.0836	-4.53	-0.0330	-2.20
Contract 2	-0.0444	-2.74	-0.0594	-2.09	-0.0100	-0.34	-0.0274	-1.27
Duration 1	----	----	-0.0103	-3.35	0.0012	0.33	-0.0005	-0.18
Duration 2	----	----	0.0071	0.64	0.0094	0.85	0.0208	2.69
Observations	1136		1136		1136		1136	
Adj-R2	0.98		0.98		0.98		0.86	(within group)

The main results of this paper relate to the contract variables. From Model 1 in Table 2 we see that the introduction of the yardstick contract lowers costs by close to 9% on average compared to the traditional negotiated contract. What is more interesting is that the change from the yardstick contract to the subsidy cap contract seems to increase costs[10]. This implies that this later type of regulation is not as powerful as the yardstick contract in providing cost saving incentives to firms.

Model 2 is identical to Model 1 except that two additional variables were included. These variables measure the number of years since each type of contract was introduced and are expected to capture any dynamic effects that such contracts may provide. The results show that the yardstick contract has on average lower costs (by about 4,4%) but in addition each year the contract is in place costs are lowered by about 1%. This is to be expected from a yardstick type regulation that provides incentives for firms to continually lower costs in order to 'beat' the benchmark. In this regression the subsidy cap contract does not seem to provide these dynamic incentives. However, this is probably due to the fact that these contracts were only introduced during the last few years of our data set. Therefore, there is not enough information to capture any dynamic effects.

Model 3 introduces yearly dummies in order to control for shocks that affected all companies during the period, for example due to technological change. This may be important if—along with the tendency towards the introduction of the new type of contracts during the decade— there was technological change that lowered costs during this period. Not controlling for this factor will wrongly attribute cost improvements to the introduction of these contracts. However, it can be seen from the results that the introduction of the yardstick contract is still significant and of a similar magnitude as in Model 1. Therefore, the apparent incentive effects of these contracts do not seem to be the results of unaccounted for technological change[11]. However, the coefficient on contract 2 becomes

[10] The coefficient on contract 2 is lower than contract 1 implying that costs compared to the omitted case (negotiated contracts) are lower with this type of contract but not as much as they would be with the yardstick regime.

[11] The dynamic impacts of the contracts become insignificant. However, in order to capture these effects in this regression it would be better to interact the yearly dummy variables with the contract dummies.

insignificant, implying perhaps that these contracts did not have any effect above and beyond those that affected all companies during each year.

Finally, Model 4 includes firm specific fixed effects as well as time dummies. The firm specific effects are intended to control for unobserved heterogeneity across firms that are not captured by the observed variables. The fixed effects will also help to control for some types of endogeneity in the contract variable. For example, assume that the yardstick contracts were introduced by innovative and strongly willed regulators, or in regions where there was a political preference for the efficient provision of transport services. In this case, it would be reasonable to assume that prior to the introduction of the new contracts these regulators were also successful in regulating companies efficiently through the traditional types of contracts. If this were the case, then the new contracts would have been introduced in counties where companies already exhibited lower than average costs. Another type of endogeneity would occur if those counties where companies were particularly inefficient introduced the new type of contracts. In both cases, the contract variables would be endogenous, biasing the estimation results[12]. By introducing firm specific effects this endogeneity problem is controlled for.

The results for model 4 show that, even controlling for firm specific effects and yearly effects, there are still significant impacts from the introduction of the yardstick contract, albeit smaller than in the other models. These contracts would lower costs by about 3,3%. The subsidy cap contract also has a negative coefficient but is not statistically significant at conventional confidence levels.

In summary, the models presented above seem to confirm that there are significant effects related to the regulatory contracts adopted in Norway and in particular to the yardstick type contract introduced by some counties. In addition, these effects seem to be robust to several specifications. With these results in mind we proceeded to estimate the cost frontier model

[12] Notice that the endogeneity arguments apply to the contract variables. It would be much harder to argue that the duration of the contract variables are also endogenous.

in order to gain more precise results regarding the efficiency properties of each type of contract.

Table 3 presents these results[13]. All models report a *sigma squared* and a *tau* coefficient. These are defined as:

$$\sigma^2 = \sigma_\varepsilon^2 + \sigma_\omega^2$$

$$\tau = \frac{\sigma_\omega^2}{\sigma_\varepsilon^2 + \sigma_\omega^2}.$$

Tau measures the importance of the variance of cost inefficiency relative to total variance. A value close to one, as reported for all models in Table 3, indicates that cost inefficiency is important relative to the random noise term affecting costs.

Most of the cost function variables have the same sign and magnitude as the regression results. However, the output variables have a lower coefficient, but this is compensated by a positive and significant output interaction effect. *Density* and the *industrial* characteristics of the route environment have a positive effect on the cost frontier, while *Nsb* and *Central* have a negative impact on costs.

Regarding the contract types, Model 5 includes a dummy for each of the new contracts as explanatory variables for the one-sided error term. The results show that firms with contracts 1 or 2 are closer to the cost frontier than firms with the traditional negotiated contract. Including the duration since the introduction of each contract (Model 6) changes the parameters somewhat but the results are similar to the regression case. Those firms that had a yardstick type contract exhibited actual costs that were closer to the cost frontier. Moreover, the cost inefficiency for these types of firms was reduced as more years elapsed with this type of regulation. There was no such dynamic effect with the subsidy cap contract, although, as explained earlier, there is probably not enough information in the data to capture such an effect in this last case.

Table 3: Cost frontier estimation results

	Model 5		Model 6		Model 7	
Variables	Coefficient	z value	Coefficient	z value	Coefficient	z value
Constant	-1.2984	-9.06	-1.3594	-9.30	-0.9961	-6.93
Adm. Wage	0.0201	1.68	0.0194	1.63	0.0231	2.10
Driver wage	0.7335	34.19	0.7221	34.20	0.6859	30.41
Q unregulated	0.0496	2.00	0.0686	2.72	0.0386	1.57
Q regulated	0.7650	36.92	0.7779	37.26	0.7532	36.68
Qunreg*Qreg	0.0127	3.43	0.0100	2.71	0.0156	4.26
Capital	-0.0796	-7.18	-0.0795	-7.03	-0.0784	-7.17
Central	-0.0069	-2.90	-0.0066	-2.88	-0.0065	-2.85
Density	0.0276	12.31	0.0283	12.19	0.0256	11.40
Industry	0.0029	2.98	0.0031	3.12	0.0029	2.89
Nsb	-0.0634	-3.26	-0.0495	-2.76	-0.0542	-2.86
Time dummies	no		no		yes	
Constant	-1.2148	-2.79	-0.2969	-2.31	-1.0247	-4.41
Contract 1	-2.0814	-3.83	-0.2080	-3.35	-2.5701	-4.27
Contract 2	-0.4798	-4.50	-0.2979	-3.08	0.0590	0.74
Duration 1	----	----	-0.1720	-2.80	0.2217	3.59
Duration 2	----	----	0.0188	0.59	0.0230	0.79
σ^2	0.2272	4.1444	0.1058	6.06	0.1824	6.62
τ	0.9284	53.4314	0.8507	29.48	0.9229	67.03
Log likelihood function		458.81		459.94		504.32
LR test of one sided errors		143.11		145.38		171.91
Number of restrictions		4		6		6
(this statistic has a mixed chi-square distribution)						

[13] All models were estimated using the FRONTIER41 software written by Tim Coelli.

Finally, the last model includes yearly time dummies. In this case, the subsidy cap contract does not seem to have any measurable effect on cost efficiency, but the yardstick contract does[14].

Using the results from Model 6 and 7, cost inefficiency measures were obtained for each company and each year[15]. The average cost inefficiency measures are presented in Table 4. It can be seen that using the results from Model 6 (without yearly time dummies), firms regulated with a negotiated type contract had on average throughout the sample period a cost inefficiency of 17.9%. That is, these firms had costs almost 18% above the cost frontier. The same figure for companies regulated with the yardstick type contract was 7.6%, less than half of the previous group. Those regulated with the subsidy cap regime had on average a cost inefficiency of 13.2%.

Very similar results are obtained if yearly time dummies are included (Model 7). Companies regulated with the negotiated contract had on average a cost inefficiency of 15.2% compared to 6.8% for those firms regulated through yardstick competition. The results for the subsidy cap contract show that these firms are even more inefficient than those regulated by the negotiated contract.

Looking at the evolution of these figures, firms regulated through the negotiated contract started out having an average inefficiency of 20.2% (according to model 6) in 1987. They reduced this parameter to around 15% by the middle of the last decade, and rose towards the last few years of the sample. In contrast, firms regulated under the yardstick contract started out with an average inefficiency of 13.8%, lowering this to under 6% by the middle of the decade and rising somewhat thereafter. The yearly average change in cost

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[14] It was not possible to include firm specific effects in these estimations. However, since the model estimates individual firm inefficiency effects, these will include some of the unobservable firm specific heterogeneity. If these last effects are important but are not correlated with right hand side variables the estimated results should not be biased. However, care should then be taken when interpreting the inefficiency coefficients. It should also be noted that this problem is less likely to affect the change of the inefficiency parameters through time.

[15] The efficiency measures from each of the frontier models were highly correlated. This correlation was never lower than 0.90 for any particular year between the any two model results and on average they were above 0.95. Also the Spearman rank correlation coefficient was on average above 0.90 if efficiency results were used to rank firms each year.

inefficiency was -0.06% of potential costs for the firms regulated through the negotiated contract and -0.77% for those under the yardstick regulation. Therefore, these last companies were able to close the gap between actual and potential costs much faster than the first group of firms.

Model 6 also implies that companies regulated under the subsidy cap system started out being very inefficient, which is reasonable considering that the counties that applied this type of regulation first were the ones that had not switched to a yardstick type contract earlier. The results also suggest that that these firms are catching up fast (at around 0.82% of potential costs a year). However, this last effect is probably due to a composition effect since most counties operating under the yardstick system (and thus more efficient) switched to the subsidy cap system during the last few years of the sample.

The results for Model 7 are broadly similar, except that inefficiency rises during the period for those firms regulated with a negotiated contract. Yardstick regulated firms also exhibit some rising inefficiency, although on average they have remained as efficient as they were initially. Only subsidy cap regulated firms show strong efficiency gains, but again this is probably due to the composition effect discussed above.

Table 4: Average cost inefficiency estimates

	Contract type	1987	1988	1989	1990	1991	1992	1993
					Year			
Model 6	Negotiated	1.202	1.194	1.198	1.184	1.171	1.152	1.144
	Yardstick	1.138	1.115	1.088	1.071	1.060	1.064	1.054
	Subsidy cap						1.197	1.137
	Average	1.180	1.162	1.140	1.125	1.114	1.106	1.099
Model 7	Negotiated	1.133	1.135	1.154	1.166	1.160	1.143	1.148
	Yardstick	1.058	1.058	1.053	1.056	1.058	1.074	1.077
	subsidy cap						1.237	1.172
	Average	1.107	1.104	1.101	1.109	1.108	1.112	1.116

Table 4 (continuation): Average cost inefficiency estimates

	Contract type	1994	1995	1996	1997	Average	Average yearly reduction
				Year			
Model 6	Negotiated	1.155	1.156	1.164	1.197	1.179	-0.06%
	Yardstick	1.046	1.057	1.065	1.061	1.076	-0.77%
	subsidy cap	1.223	1.132	1.124	1.104	1.132	-0.82%
	Average	1.115	1.105	1.118	1.124	1.129	-0.56%
Model 7	Negotiated	1.155	1.160	1.165	1.212	1.152	0.79%
	Yardstick	1.076	1.088	1.120	1.053	1.068	-0.05%
	subsidy cap	1.279	1.164	1.154	1.135	1.166	-0.92%
	Average	1.137	1.128	1.147	1.149	1.117	0.42%

6. Conclusions

Overall the results suggest that firms regulated under the yardstick type contract exhibit less than half the cost inefficiency compared to those firms regulated under the traditional contract. In addition, consistent with the estimation results shown in Table 2, the firms regulated with the yardstick type contract reduce cost inefficiency faster. This contract type provides more dynamic incentives for cost reduction by firms. As regards the subsidy cap system, the recent introduction of these contracts and the general switch of counties to this new system do not allow us to make strong conclusions regarding their incentive properties.

The results contained in this paper thus confirms theoretical predictions regarding the incentive properties of high powered incentive schemes and in particular the dynamic benefits of yardstick competition.

Further research should explore the precise origin of the cost efficiency gains made by Norwegian bus companies regulated with the standard cost model. These gains could have been the result of higher technical efficiency, changes in relative input mix or a better procurement of inputs (lower price of inputs). The welfare evaluation of the regulatory changes introduced in the Norwegian bus industry differ depending on the origin of the cost savings. Whereas the first two sources of cost savings unambiguously increase welfare, this is not the case if cost savings were achieved exclusively by lowering wages. In this last case, cost savings are mainly the result of a distribution of resources among agents.

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Appendix: The yardstick subsidy-cap model

The standard-cost model is developed and maintained by a consultancy firm (ASPLAN VIAK) and is used by regional regulators to determine the level of subsidy granted to the companies. The main input to the model is a 4x5 output-vector Q that consists of the number of kilometers produced in four different types of routes by five different types of buses. q_i^j denotes the number of kilometers in route type *i* with bus type *j*. Route types differ according to average speed of traffic and bus types differ according to size. The regulator controls this output-vector.

The benchmark costs of producing the output-vector is derived from a linear model that determines the drivers, fuel, maintenance and bus capital inputs:

$$c_k = p_k \sum_i \sum_j a_i^j q_i^j ,$$

where p_k is the market price for input *k* and a_i^j is the input coefficient for output q_i^j. a_i^j is derived from observed cost figures from companies within several regions and applies to all companies controlled by the regulator. The number of bus companies in each region is large enough to make a_i^j almost insensitive to efficiency improvements by the individual company.

Administration costs, c_{adm}, are set proportional to $\sum_k c_k$ (excluding fuel costs, however, that tend to vary considerably over time).

The level of subsidy, *S*, is now determined by the difference between expected traffic revenue, given fares and kilometer produced, and standard-costs:

$$S = P \cdot y^e \cdot \sum_i \sum_j q_i^j - \sum_k c_k - c_{adm} ,$$

where y^e is the expected number of passengers per kilometer produced and P is the average fare level set by the regulator. It is important to note that S is not adjusted to the actual number of passengers per kilometer effectively transported.