ASYMMETRIC INCENTIVES OF PRIVATE AND PUBLIC FIRMS TO LABOUR-SAVING TECHNICAL PROGRESS: EVIDENCE FROM THE ITALIAN MOTORWAY INDUSTRY

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Asymmetric Incentives of Private and Public Firms to Labour-Saving Technical Progress: Evidence from the Italian Motorway Industry*

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Abstract. This paper provides a novel justification for the superior productivity performance of private vs. state-owned firms, widely documented in the literature. We argue that technical progress, when of labour-saving type, is adopted to a greater extent by private firms compared to state-owned ones. This finding emerges from the analysis of a longitudinal dataset containing information on all 21 Italian motorway concessionaires over the 1992-2007 period, mostly of which have been privatized within the years covered by our data. By estimating a total cost function model with fixed effects, we confirm the previous evidence of Benfratello *et al.* (2009) that a significant technological progress of about 0.3% per year and a cost advantage for private firms of 2% exist. We then ascertain the non-neutral (labour-saving) nature of technical progress, mainly due to the introduction of new technologies for toll payments. More importantly, we find that private firms enjoy a higher technical progress than public ones, thereby showing that a private ownership is associated to a higher growth rate over time, and that private firms introduce the new labour-saving technology whereas public ones do not.

JEL codes: D24; H11; K23 ; L33; L92.

Keywords: State-owned firms; Privatisation; Labour-saving technical progress; Motorway industry.

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1. Introduction

The performance of state-owned enterprises relatively to private firms has been investigated for a long time, both at theoretical and empirical level.[1]

The first empirical investigations date back to late '60s, when some studies directly compared cross sections of public and private firms in terms of their productivity. This early literature found only a slightly positive advantage for private firms, although more than a passing doubt can be cast on the reliability of these results due to the possibility that some omitted factors could be at work (see Boardman and Vining, 1989, for a review). To overcome such a criticism, more recent literature has exploited the large privatisation processes occurred in different contexts – i.e., developed, developing and transition economies – and has clearly shown that private firms enjoy a productivity advantage over public ones (see Megginson and Netter, 2001; Megginson, 2005; Estrin *et al.*, 2009).

Different theoretical arguments have been provided to support these results. The traditional view in *public finance and welfare economics* (e.g., Musgrave, 1954; Atkinson and Stiglitz, 1980; Pestieau, 2009) stresses that public firms generally are assigned a "social role" and pursue multidimensional objectives, not always completely compatible with the efficient allocation of resources and, more in general, with one another. For example, maintaining labour in large quantities that are allocatively inefficient could be legitimated by macroeconomic considerations of employment policy. Other scholars (Hart *et al.*, 1997; Shleifer, 1998) rely on the theory of *incomplete contracts* to show that public managers have relatively weaker incentives to make innovation and cost-reducing investments, as they will only get a part of the associated return, while private regulated contractors have much stronger incentives because, as owners, they will get more of the returns on the investment. The monitoring and disciplining of managers may be more problematic in public rather than private firms due to the very dispersed nature of ultimate owners (citizens) (e.g. , and to the lack of discipline enforced by capital markets, often replaced by a soft budget constraint (e.g., Sheshinsky and Lopez-Cava, 1999) . Finally, a strand of *political economy* literature (e.g., Shleifer and Vishny, 1994; Besley, 2006) recognizes that state-owned enterprises may have assigned distorted objective functions, involving the pursuit of politicians' individual goals by transferring value to voters. In this view, the lower productivity in public firms is viewed as the outcome of the government's deliberate policy to channel resources – for instance, in the form of excess employment or jobs at above-market wages – towards their supporters, in order to remain in power and enjoy the benefits of their office.[2]

Despite the clear empirical evidence and these theoretical justifications, the exact mechanisms by which public firms underperform private ones are still unexplored. Most of the empirical

[1] Albeit somehow incorrectly, we use the terms "public" and "state-owned" as synonims.

[2] For these theoretical arguments see Megginson (2005), ch. 2.

literature (see the reviews in Megginson and Netter, 2001; Megginson, 2005 and Estrin *et al.*, 2009) has simply compared productivity levels of public and private firms without further investigating their differential characteristics. Notable exceptions are the few studies focusing on the employment levels before and after privatisation and those analysing the dynamics over time of the productivity, besides its levels, which we briefly review in what follows.

The effect of privatisation on labour has received less attention than the effect on firms' performance measures. The evidence is rather inconclusive so that Megginson (2005, p. 395) lists the effect on labour one of the unsolved issue about privatisation. If public firms tend to be overstaffed, especially in those industries not exposed to intense competition the evidence from privatisation is mixed (see the review of Kikeri and Nellis, 2004).[3] Lopez-de-Silanes and Chong (2003) found that, in Latin America, privatisation has led to a striking decrease in the labour force (of the order of 20-30%), although an increase in wages has been recorded. A somehow different result is shown by Chong and Lopez-de-Silanes (2002), who exploit data on more than 400 privatised firm all around the world and find that, in 70% of cases, the number of employees increased after privatisation, mainly due to the rehiring of workers previously laid-off in the period before privatisation. Studies on transition countries tend to contradict the alleged negative effect of privatisation on labour (see the survey of Estrin *et al.*, 2009). For instance, Brown *et al.* (2010) use data on four transition countries and find no effect on labour of domestic privatisation (i.e. when the acquirer is a domestic company) and an increase in both in wages and employment for foreign privatisations.

The comparisons of productivity dynamics between public and private firms is another issue which has almost been neglected by the literature. The pioneering work on the issue is Ehrlich *et al.* (1994) who find higher productivity growth rates for private firms in their cross country analysis of airlines companies. They explain this results in the light of their theoretical model where managers in private owned firms, being more tightly monitored than public ones, can devote more time to the accumulation of firm-specific knowledge. Some subsequent papers have estimated private vs. public productivity growth rates (Liu 2001, Bartel and Harrison 2005); not only results on the effect of private ownership on the dynamics of productivity are less clear cut but the sources of the (potentially) higher productivity growth rates for private firms are not discussed in depth.

Overall, this literature tends to suggest that employment levels and productivity growth rates are candidate channels, possibly intertwined, through which the different types of ownership may affect firms' performance. In particular, a possible explanation of different performances that emerges from this literature is related to the possibility that *technical progress* – when of labour-saving type – is adopted to a greater extent by private firms compared to state-owned ones. Our study contributes to the ongoing debate about the effects of ownership testing this specific hypothesis on a proprietary dataset concerning the motorway industry in Italy. Several of its features make this sector a very good candidate for comparing the performance of public

[3] See also Borghi *et al.* (2010) for a recent analysis in the electricity generation industry in EU24 countries and Azmat *et al.* (2011) for a industry-level data analysis for some network industries in OECD countries.

and private firms and analysing the reasons underlying the observed differences (if any). Over the time period covered by our data (1992-2007), approximately half of the 21 Italian motorway concessionaires have been privatized, thereby providing enough "within" variation to recover reliable estimates of the ownership effect. Furthermore, as documented in a previous paper using a slightly shorter version of the dataset (Benfratello *et al.*, 2009), the industry has experienced a noteworthy technological progress. This allows us to analyse whether public and public firms tend to differently adopt the new technology and whether these choices affect labour force.

We find that private firms enjoy a higher productivity with respect to state-owned ones. This advantage can be explained by the different technical progress experienced by the two types of firms: neutral for public ones and labour-saving for private ones. This finding highlights the favour of public firms towards labour input and illustrates a new mechanism that motivates the superior performance of private firms.

The remainder of the paper is organized as follows. The next section briefly describes the structure of the Italian motorway industry. Section 3 presents our empirical test, discussing the data, model specification, and the results. Section 4 provides some final remarks. A data appendix concludes the paper.

2. The Italian motorway industry

The motorways network in Italy extends (at end of 2007) to 5,694 km of tolled and 894 km of not tolled roads. The network is currently operated by Anas, the State Department for road and motorways, and by 24 concessionaires. The main object of the current concession contracts is the maintenance of the network and the provision of motorway services. Most of the building activity, largely financed by the state, has indeed been carried out in the '60s and '70s, with the most notable exceptions of the new stretch of motorways crossing the Appennines between Florence and Bologna (still under construction) and outer ring of Mestre (in the outskirt of Venice).[4] In the '90s, the industry underwent two important changes, regarding both the *ownership* of the concessionaries and the *regulation* of tolls. As for the latter, a new regulatory framework was defined in 1996 (and later modified in 2004 and 2007), in order to replace traditional cost-plus regulation with a form of incentive regulation: the initial toll level has to be set to ensure that (expected) revenues cover the (expected) concessionaire's costs over the entire concession period, but limiting the subsequent toll dynamics through a rather standard Laspeyers-type price-cap constraint. The price-cap formula includes a productivity offset, X, and a quality adjustment term.

As for the privatisation process, at the beginning of the '90s most concessionaires were under public ownership, either under the control of IRI, the largest public holding, or in the hand of local public authorities or publicly-owned banks. The only exceptions were SATAP (Torino-Piacenza) and Torino-Milano, both privately owned. During the '90s, many concessionaires were privatised. The most relevant transaction occurred in 1999 with the privatisation of

[4] For a full account of the history of the industry, see Manzi (2001) and Benfratello *et al.* (2006) and (2007).

"Autostrade per l'Italia", the largest concessionaire (at the time simply named "Autostrade"), which currently controls – either directly or through participation into other concessionaires – more than half of the whole Italian motorway network. The change of ownership, however, was not restricted to Autostrade, since the group in control of SATAP (Torino-Piacenza) and of Torino-Milano gained also the control of further 6 concessionaires. Overall, the privatisation process lead to an increase in the number of privately owned concessionaires from 3 to 13 (see Table A3).

3. Empirical test

3.1. Data

We use a unique dataset containing information over the 1992-2007 period for 21 Italian motorway concessionaires.[5] Data were retrieved via inspection of several sources, such as official reports, publications from AISCAT (the concessionaires' association), and other sources (mainly press articles). The database contains firms' financial indicators (e.g., costs, revenues, inputs), characteristics of the sections served (e.g., length and total number of kilometres travelled), and concessionaires' institutional characteristics (notably ownership, private vs. state-owned).

Some industry characteristics are particularly important for the purposes of this study.[6] The structure of the three cost categories (labour, maintenance, and other costs) seem to have changed over time (Figure 1). Notably, a fairly constant increase in both maintenance and other costs is recorded; however, whereas labour costs accounted for roughly one half of total cost at the beginning of our sample period, this proportion has fallen to approximately one third in 2007. The decrease of labour share over total cost can be also assessed looking at the change of the number of workers over time (Table 1), whose mean value decreases from 968 in 1994 to 773 in 2007, with a reduction of about 20%.

Figure 1. Trend of maintenance, labour, and other costs (1994-2007)

[5] Our sample almost represents the whole industry. Our sample excludes 2 concessionaires which operate only tunnels and 1 concessionaire with a very special ownership structure and hence accounting rules. For further details on our dataset, see the Data Appendix.

[6] Other interesting features of the industry are the following. First, the Italian motorway industry is composed of one very large concessionaire ("Autostrade per l'Italia"), controlling almost half of the whole network, and a host of relatively small concessionaires. Second, a constant upward trend in total kilometres travelled is recorded in the years covered by our sample, the average yearly growth rate being approximately 3.2%. Finally, the introduction of price-cap regulation seems to have led to a sharp increase in maintenance costs, probably due to a distortion in the input mix induced by the quality adjustment term. For more details on these issues, see Benfratello *et al.* (2009).

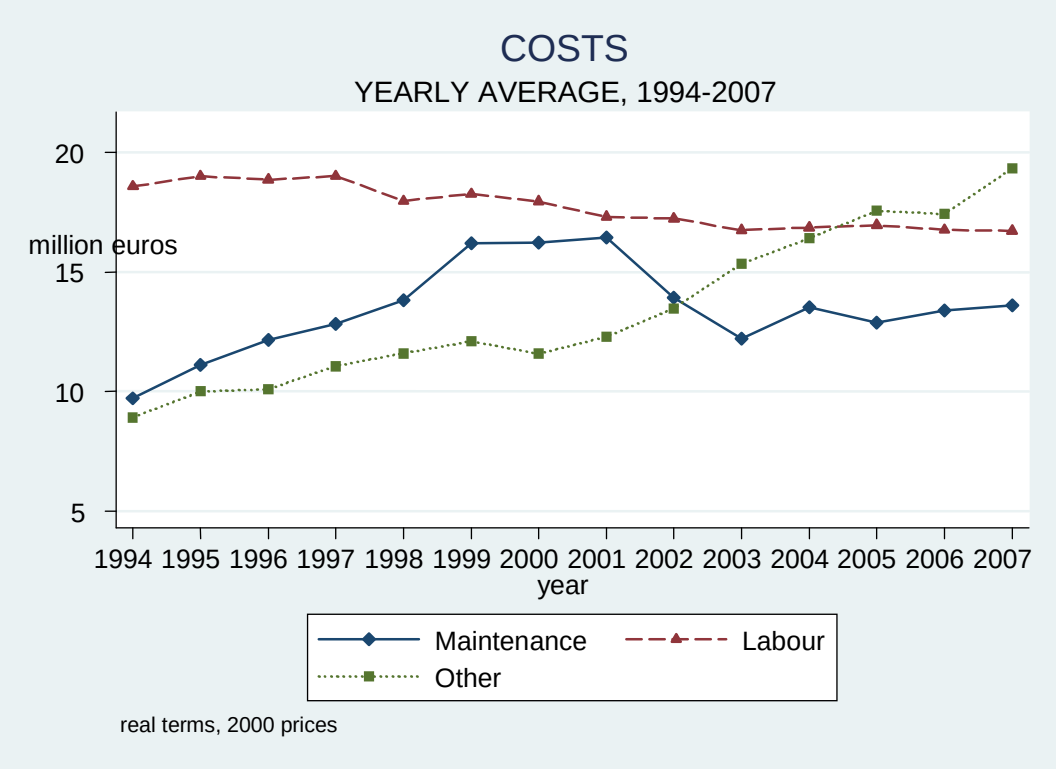

Table 1. Evolution of the number of workers and of means of payment

		1992	1996	1999	2003	2007
Number of workers*	Mean	968	930	918	825	773
	Median	458	438	421	389	387
Toll collectors**		4,735	4,169	3,568	2,930	2,652
Other workers**		3,698	3,568	3,518	3,452	3,419
Automatic payments (%)**		33.70	44.80	53.30	65.29	74.11
Electronic Toll Collection (ETC) users (thousands)		57.8	466.8	1,517.7	3,872.8	5,895.0

Note: * refers to mean/median values for all the concessionaires; ** refers to the "Autostrade per l'Italia" concessionaire only.

The reduction in labour force has been uneven across categories of workers. Although limited to the larges concessionaires ("Autostrade per l'Italia") figures in Table 1 show that the number of toll collectors has very sharply decreased (of the order of 40% from 1992 to 2007), whereas the number of other workers has recorded a decrease below 10%. This trend must be read in conjunction with the increase of the share automatic payments, which more than doubled over our sample period[7], and with the impressive increase of Electronic Toll Collection users

[7] Unfortunately, we were able to retrieve homogenous data on type of workers and on the share of automatic payments only for few concessionaires thereby preventing us to include this information in our regressions.

(Telepass) which increased from 58 thousands to almost 6 million over the sample period. All these features clearly suggest that the industry has experienced a remarkable labour-saving technical progress. To investigate whether this is the case and the role played, if any, by the different ownership we move to our econometric test.

3.2. Model specification

We estimate a long-run total cost function for the operation of the motorway. We include three inputs (labour, maintenance and other factors), one output (the number of travelled km), and one output characteristic (network length). In the baseline specification we also add a time trend accounting for the presence of neutral technical progress and an ownership dummy. We generalised the baseline specifications by interacting these two variables, to allow a different technical progress for private and public-owned firms, and by interacting technical progress and input prices, to allow the former to be non-neutral across factors. The most general model we estimate is the following *translog* specification:

$$\begin{aligned}\ln TC = {} & \beta_0 + \beta_o \ln p_o + \beta_l \ln p_l + \beta_m \ln p_m + \frac{1}{2}\beta_{oo}\left(\ln p_o\right)^2 + \\ & + \frac{1}{2}\beta_{ll}\left(\ln p_l\right)^2 + \frac{1}{2}\beta_{mm}\left(\ln p_m\right)^2 + \beta_{ol}\left(\ln p_o \ln p_l\right) + \beta_{ml}\left(\ln p_m \ln p_l\right) + \beta_{mo}\left(\ln p_m \ln p_o\right) + \\ & + \beta_y \ln y + \beta_{yy} \ln y^2 + \beta_{oy} \ln p_o \ln y + \beta_{ly} \ln p_l \ln y + \beta_{my} \ln p_m \ln y + \\ & + \beta_n \ln n + \beta_{nn} \ln n^2 + \beta_{on} \ln n \ln p_o + \beta_{\ln} \ln p_l \ln n + \beta_{m\mathrm{n}} \ln p_m \ln n + \\ & + \beta_{yn} \ln y \ln n + \beta_t t + \beta_{own} own + \beta_{to} t \ln p_o + \beta_{tl} t \ln p_l + \beta_{tm} t \ln p_m + \\ & + \beta_{town} t \times own + \beta_{townl} t \times own \times \ln p_l + \beta_{townm} t \times own \times \ln p_m + \beta_{towno} t \times own \times \ln p_o + \upsilon + \varepsilon\end{aligned} \tag{1}$$

where TC is total cost – the sum of maintenance, labour and other costs (mainly pertaining to capital) – and p_m, p_l, and p_o are the prices for maintenance, labour and other inputs respectively. The latter are constructed by dividing each cost category (maintenance, labour and other costs) by the main determinant of these expenditures: travelled km (p_m), average number of employees (p_l) and network length (p_o). y is the total number of travelled km, n is the network length. t is a time trend (i.e., t = 1 when the observation year is 1992 and t = 16 when the observation year is 2007), *own* is a time-variant dummy indicating whether the concessionaire is under private or public ownership (1 if the majority of shares belong to private firms or individuals, 0 otherwise). All variables are indexed i, t with i = 1, …, 21 and t = 1992, …, 2007. υ is a firm-specific (time-invariant) effect, whereas ε is the standard random shock. Individual (concessionaires) dummies are added to the total cost function equation (1) in order to capture time-invariant unobserved heterogeneity which, if correlated with some of the included regressors, and notably ownership, would cause estimates to be inconsistent.

We estimate a system of equations composed by (1) and the corresponding cost shares (derived via the Shephard's lemma) by using the SUR technique. As usual, to avoid singularity of the variance matrix of the errors, we drop one cost share (specifically, the one for other inputs). Moreover, we impose the usual restrictions stemming from the symmetry of the Hessian matrix of price elasticities, from the homogeneity of degree 1 in input prices and from cross-equations

symmetry.[8] Finally, in order to ease the computation of cost elasticities, we standardize prices and output variables (y and n) by their sample median value, so that first order coefficients can be directly read as elasticities evaluated at the median.

3.3. Estimation results

Table 2 contains the results of 4 models, which differ in the way technical progress is treated: neutral (MODEL 1); non-neutral (MODEL 2); neutral but different for state-owned and private firms (MODEL 3); non-neutral and different for state-owned and private firms (MODEL 4).

Result for MODEL 1 replicate – but using a longer period – one of the equations in Benfratello *et al.* (2009): we confirm the previous evidence that a significant technical progress around 0.3% per year and cost savings for private firms of about 2% exist.[9] The likely reason underlying this substantial technical progress is the introduction of automatic toll payments, which enabled concessionaires to reduce labour force remarkably, as pointed out above. Thus, we expect technical progress to be labour-saving. To test this hypothesis, in MODEL 2 we allow technical progress to be non-neutral, i.e., price-time interactions are now introduced in the cost function specification so that input cost shares depend on time trend t. To our knowledge, this simple strategy has been very rarely used in the literature (notable exceptions are XXX). The estimates confirm our a priori intuition: the coefficient for the interaction between labour price and the trend ($t \times \ln p_l$) is negative, thus labour cost share reduces – holding the price constant – by 0.1% a year.

Interestingly, when we also allow state-owned firms to have a technical progress different than the one of private firms (MODEL 3), we find that the latter enjoy a much higher technological progress. The difference in the productivity pattern between the two types of firm is not a one-off event, observed in the years of or around privatisation. Rather, it seems a phenomenon permanently linked to the nature of the ownership. Indeed, private firms enjoy privatisationa higher growth rate of productivity over time, as pointed out by the coefficient of the interaction $t \times own$: whereas public firms enjoy a technical progress of about 0.2%, this measure is about twice as large for private firms.

Finally, when we fully interact the ownership dummy with non-neutral technological progress (MODEL 4), we find the striking result that only private firms enjoy a labour-saving technical progress, whereas technological improvements in public firms appear to have a neutral nature (the interactions of t with input prices when *own* is 0 are all not statistically different from zero). This seems to suggest that, faced with the new technological opportunities, private firms do introduce the labour-saving technology, while state-owned enterprises do not. It also worth pointing out that the reduction of labour cost share of 0.2% per year implemented by private firms (see the coefficient of $t \times own \times \ln p_l$) is compensated by an equal increase of the incidence of

[8] For further details about the SUR estimation technique and these restrictions, see Berndt (1991, chapter 9). We performed all estimations using Stata (version 10.1).

[9] Also input price elasticities, as well as network density economies and global scale economies, are very close to the estimates obtained in Benfratello *et al.* (2009). Since in this paper we focus on the relationship between technical progress and ownership, we will not discuss here these other features of production technology.

both maintenance costs and other inputs expenses ($t \times own \times \ln p_m = t \times own \times \ln p_o = 0.1\%$): while the latter can be viewed as the result of the introduction of more efficient technologies (i.e., automatic toll systems, whose depreciation costs are included in other inputs expenses), the former is likely to be a consequence of the distortion toward maintenance services caused by the new price-cap regulation through the quality adjustment term (Benfratello *et al.*, 2009).

4. Final remarks

In this paper we aim at shedding new light on the mechanisms that allow private firms to perform better than state-owned ones in terms of productivity, an issue rarely explored by the existing literature on the effects of privatisation processes. In particular, we investigate the role played by technical progress and the possible presence of asymmetric incentives of private and public firms towards the adoption of new labour-saving technologies. To this end, we estimate a total cost function model using an original dataset containing information on virtually all 21 Italian motorway concessionaires observed from 1992 to 2007, mostly of which have been privatized within this period.

The results point to the non-neutral (labour-saving) nature of technical progress in the industry, mainly related to the introduction of automatic systems for toll payments. More interestingly, we find that private firms enjoy larger cost savings from technical progress than state-owned ones, showing that private ownership leads to a higher growth rate of productivity over time through the adoption of labour-saving technologies. This evidence confirms the favour of public producers towards labour input highlighted by some recent studies and provides a new channel for interpreting the superior performance observed for private firms. Possible justifications for our results may be found looking at the multidimensional objectives pursued by state-owned producers (among which employment policies), the relatively weaker incentives of managers in public firms to make innovation and cost-reducing investments, and the issue that state-owned enterprises may involve the pursuit of politicians' individual goals through the transfer of value to voters.

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Table 2. SURE estimates of Translog cost model (1) [a]

Regressor	MODEL 1		MODEL 2		MODEL 3		MODEL 4	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Constant	-0.045	0.064	-0.038	0.065	0.001	0.066	0.005	0.067
ln *y*	**0.534*** **	**0.019**	**0.539*** **	**0.021**	**0.508*** **	**0.020**	**0.514*** **	**0.022**
ln *n*	**0.517*** **	**0.056**	**0.508*** **	**0.057**	**0.500*** **	**0.056**	**0.485*** **	**0.565**
ln p_l	**0.400*** **	**0.004**	**0.411*** **	**0.006**	**0.400*** **	**0.004**	**0.409*** **	**0.006**
ln p_o	**0.323*** **	**0.002**	**0.320*** **	**0.004**	**0.323*** **	**0.002**	**0.322*** **	**0.004**
ln p_m	**0.277*** **	**0.002**	**0.269*** **	**0.003**	**0.277*** **	**0.002**	**0.269*** **	**0.003**
ln n^2	0.191***	0.035	0.204***	0.035	0.168***	0.035	0.180***	0.036
ln y^2	0.110***	0.009	0.115***	0.009	0.104***	0.009	0.107***	0.010
ln $y \times$ ln p_l	0.046***	0.004	0.048***	0.005	0.046***	0.004	0.047***	0.005
ln $y \times$ ln p_o	-0.157***	0.003	-0.158***	0.003	-0.156***	0.003	-0.157***	0.003
ln $y \times$ ln p_m	0.110***	0.003	0.110***	0.003	0.110***	0.003	0.110***	0.003
ln $n \times$ ln p_l	-0.110***	0.006	-0.112***	0.006	-0.110***	0.006	-0.112***	0.006
ln $n \times$ ln p_o	0.198***	0.004	0.200***	0.004	0.198***	0.004	0.199***	0.004
ln $n \times$ ln p_m	-0.088***	0.004	-0.087***	0.004	-0.088***	0.004	-0.087***	0.004
ln $n \times$ ln y	-0.274***	0.024	-0.286***	0.026	-0.257***	0.025	-0.266***	0.027
ln $p_l \times$ ln p_o	-0.118***	0.003	-0.118***	0.003	-0.118***	0.003	-0.118***	0.003
ln $p_l \times$ ln p_m	-0.087***	0.003	-0.086***	0.003	-0.086***	0.003	-0.086***	0.003
ln $p_o \times$ ln p_m	-0.081***	0.002	-0.082***	0.002	-0.081***	0.002	-0.082***	0.002
ln p_l^2	0.102***	0.002	0.102***	0.002	0.102***	0.002	0.102***	0.002
ln p_o^2	0.100***	0.001	0.100***	0.001	0.099***	0.001	0.100***	0.001
ln p_m^2	0.084***	0.001	0.084***	0.001	0.084***	0.001	0.084***	0.001
T	**-0.003*** **	**0.001**	**-0.005*** **	**0.001**	**-0.002** **	**0.001**	**-0.002**	**0.001**
t $\times$ **ln p_l**	-	-	**-0.001** **	**0.001**	-	-	**0.000**	**0.001**
t $\times$ **ln p_o**	-	-	**0.000**	**0.000**	-	-	**0.000**	**0.000**
t $\times$ **ln p_m**	-	-	**0.001*** **	**0.000**	-	-	**0.000**	**0.000**
Own	**-0.020*** **	**0.005**	**-0.020*** **	**0.005**	**-0.005**	**0.007**	**-0.001**	**0.007**
t $\times$ ***own***	-		-	-	**-0.002*** **	**0.001**	**-0.004*** **	**0.001**
t $\times$ ***own*** $\times$ **ln p_l**	-	-	-	-	-	-	**-0.002*** **	**0.001**
t $\times$ ***own*** $\times$ **ln p_o**	-	-	-	-	-	-	**0.001** **	**0.000**
t $\times$ ***own*** $\times$ **ln p_m**	-	-	-	-	-	-	**0.001** **	**0.000**
Network density economies	1.87		1.86		1.97		1.95	
Global scale economies	0.95		0.96		0.99		1.00	
Firm-specific fixed effects	(0.000)		(0.000)		(0.000)		(0.000)	
R^2 cost function	0.989		0.990		0.990		0.991	

[a] All regressions contain firm-specific fixed effects (the p-value of a joint test of significance of these effects is reported in the Table). The total number of observations is 316. */**/*** illustrates significance levels of 1%/5%/10% level.

Appendix

This appendix describes data sources and illustrates how the main variables included in the estimated cost function have been computed. It also presents some descriptive statistics.

Our database contains information on 21 Italian concessionaires which almost represent the entire motorway industry in Italy. Only three concessionaires are excluded from our sample: two of them run only tunnel sections (Gran San Bernardo and Monte Bianco tunnels), whereas for another one we could not retrieve homogeneous data due to its peculiar status ("Consorzio delle Autostrade Siciliane"). We collected our balance sheet data mainly through direct inspection of concessionaires' official statements. We retrieved information on the number of travelled kilometres from the AISCAT (concessionaires' association) official reports. We retrieved information on ownership mainly from concessionaires' official reports, integrating when needed with the R&S directory, yearly published by the Mediobanca investment bank, and with the information provided by concessionaires' web sites.

Our sample is slightly unbalanced for several reasons (see Table A1). First, four concessionaires started operations after 1992, the first year of our sample (accounting for 16 observations missing). Furthermore, two concessionaires merged in 2004 (8 observations missing). To avoid heterogeneity, we included the company resulting from the merger as a separate entity in the estimation sample. This explains why the number of concessionaires in Table A1 is 22.

Table A1. Structure of the panel

Firms	Time period
15	1992-2007 (240 observations)
2*	1994-2007 (28 observations)
1*	1993-2007 (15 observations)
2**	1992-2003 (24 observations)
1**	2004-2007 (4 observations)
1*	2003-2007 (5 observations)
22 concessionaires	**316 total observations**

Note: * refers to concessionaires starting operations after 1992; ** refers to two firms involved in a merger and to the resulting entity

The variables used in the empirical analysis are described below and summarized in Table A2. Maintenance and labour costs are taken from the corresponding heading of concessionaires official statements (or from the auditors' notes), whereas other costs is the sum of materials, services (different from maintenance) and other operating expenses, including depreciations. Maintenance (resp. other inputs, labour) price has been constructed by dividing maintenance (resp. other inputs, labour) costs by the number of travelled kilometres (resp. network length, average number of employees).

Table A2. Descriptive statistics

Variable	Mean	st. dev.	min	25th	median	75th	max
Costs							
Maintenance	26,095.77	51,659.07	164.75	5,749.81	11,025.56	20,134.59	317,298.72
Labour	34,525.66	71,076.14	3,328.57	10,927.09	17,706.95	25,802.56	357,766.16
Other	25,876.93	56,974.51	2,210.95	6,721.32	11,377.57	19,399.62	458,594.13
Input prices							
Maintenance	11.71	11.86	1.29	5.87	8.60	13.19	102.42
Labour	46.54	6.60	30.96	41.52	46.19	50.93	62.63
Other costs	141.95	117.92	24.95	67.48	110.60	179.61	967.96
Other variables							
Travelled kilometres	3,494.12	8,824.96	32.00	699.88	1,313.85	2,125.04	49,211.60
Network	259.18	602.87	20.00	55.55	127.00	179.00	2,854.60

Note: costs and prices are in thousand euros, current prices; the number of travelled kilometres is in millions kilometres and network is in kilometres.

Finally, we construct a time-variant firm specific dummy for ownership (*own*) taking the value of 1 (0 otherwise) if the majority of shares belongs to private firms or individuals for at least six months of the relevant year. Table A3 describes the distribution over time of this dummy, thereby showing the occurrence of the privatisation process in the 1992-2007 time period.

Table A3. Number of public and private firms by year

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Private	1	1	3	5	5	5	6	6	12	12	12	14	13	13	13	13
Public	16	17	17	15	15	15	14	14	8	8	8	7	7	7	7	7
Total	17	18	20	20	20	20	20	20	20	20	20	21	20	20	20	20