UNIVERSITÀ DEGLI STUDI DI PADOVA

Dipartimento di Scienze Economiche "Marco Fanno"

PRIVATISATION, REGULATION AND PRODUCTIVITY IN THE ITALIAN MOTORWAY INDUSTRY

LUIGI BENFRATELLO
Università di Torino and Ceris-CNR

ALBERTO IOZZI
Università di Roma "Tor Vergata" and
University of Leicester

PAOLA VALBONESI
Università di Padova

June 2005

"MARCO FANNO" WORKING PAPER N.2

Privatisation, regulation and productivity in the Italian motorway industry*

Luigi Benfratello[†] Università di Torino and Ceris-CNR

Alberto Iozzi[‡] Università di Roma "Tor Vergata"

Paola Valbonesi[§] Università di Padova

June 2005

*We wish to thank Andrea Boitani, Luca Manzi, Raffaele Miniaci, Massimiliano Piacenza, and seminar participants at the University of Naples, Pavia and Bergamo and participants to the 2005 IIO Conference in Atlanta (USA) for their useful comments. We also thank Luigi Giamboni for his valuable research assistance. Financial support from MIUR (grants No. 2002131535_001 and 004) is gratefully acknowledged.

[†]Dip. di Scienze Economiche e Finanziarie "G. Prato", Università di Torino, Corso Unione Sovietica 218bis, 10134 Torino, Italy. E-mail: benfratello@econ.unito.it

[‡]Università di Roma "Tor Vergata", Dip. SEFEMEQ, Via Columbia 2, I-00133 Rome, Italy. E-mail: alberto.iozzi@uniroma2.it

[§]Dip. di Economia "Marco Fanno", Università di Padova, Via del Santo 33, 35100 Padova, Italy. E-mail: paola.valbonesi@unipd.it

Abstract

The Italian highway industry has undergone an institutional and regulatory reform through the last decade, characterised by changes in ownership and a new price cap framework. To assess the effect of the reforms on firms' performance, we use information on all the 20 Italian concessionaires over the 1992-2003 period and 1) estimate the technical progress in the industry, thereby providing a reference value for the X factor in the price cap formula; 2) assess the relative productivity of private vs. public concessionaires; 3) evaluate whether price cap regulation has induced firms to use resources efficiently, 4) determine the possible effect of the inclusion of the quality index in the price cap formula.

We find that the introduction of a price cap regime does not increase firms' productivity whereas a sharp increase in maintenance costs is recorded, arguably due to the quality indicator in the price cap formula. Furthermore, firms appear to have gained from the privatisation process and from a technical progress occurred in the period. We also find high density economies and a steady and large increase in traffic. Overall, these results suggest that the X factor has been set too conservatively in past years which in turn explains the high profits recorded by franchisees under price cap regulation.

JEL numbers: L51, L92.

Keywords: Price Cap Regulation, Motorways.

1 Introduction

Since the beginning of the last decade, the institutional and regulatory set-up of the Italian motorways sector has undergone in-depth reform. The ownership of most of the concessions holders, which maintain the motorways and provide the motorways services, has been transferred from public to private hands. Also a new regulatory framework has been adopted introducing price cap to regulate motorways charges.

Both the design for the regulatory framework and its application have recently raised some concerns. These are mostly related to the sharp increase in profits for the firms operating in the industry since the introduction of the new regulatory framework. This very high levels of profits, the relationship between this phenomenon and the regulatory framework and the appropriate regulatory policy to put in place have been the subject of a very hot policy debate on the occasion of the recent re-setting of the X factor for some concessionaires.

In spite of the importance of the industry for the national transport infrastructure system and the high profile of the debate which has accompanied its reform, rather surprisingly, the motorway industry has not been studied extensively in recent years, not even in the occasion of its regulatory reform. Therefore, there is very little evidence on judge the history of the regulatory intervention in the industry or to support the implementation of the current regulatory framework or the need of its further reform.

The aim of this paper is to start filling these gaps. To this end, a unique dataset has been collected by inspecting all the 20 Italian concessionaires' official reports and of the AISCAT publications (the concessionaires' association). The database contains, over the 1992-2003 period, firms' financial indicators (such as costs, revenues, inputs), characteristics of the sections served (such as length, number of stoneworks, mountain sections, total number of kilometers travelled) and concessionaires' institutional characteristics (ownership, i.e. private vs. public ownership, and type of regulation, i.e. price cap vs. rate of return).

We use the dataset to estimate a total cost function augmented with hedonic variables reflecting characteristics of the sections served, ownership and regulation dummy variables and a temporal trend. This research strategy enables us: 1) to estimate the technical progress occurred and the density economies in the highway industry, thereby providing a reference value for setting the X factor in the price cap formula; 2) to evaluate whether the (change in) ownership of the concessionaries has had an effect on their productivity; 3) to evaluate whether the introduction of the price cap regulation has had an effect on the efficient use of resources; 4) to consider the possible effects of the inclusion of the quality index in the price cap formula.

Our results show significant technical progress and high density economies, thereby suggesting that the X factor has been set too conservatively in past years. As for the impact of institutional factors on productivity, a mixed picture emerges. On the one hand, the privatization process seems to have brought about a better use of resources, as firms under private ownership appear to be more productive than those under public ownership. On the other hand, the replacement of the cost plus regulation with the one based on price cap does not seem to have induced firms to a better use of resources. In particular, concessionaires have considerably increased their maintenance costs; their behaviour seems to be motivated by the (possible perverse) incentive provided in this direction by the quality index in the price cap formula.

The paper is organized as follows. The next section describes the regulation reform that has occurred in the Italian highway sector, whereas Section 3 illustrates some critical issues in the implementation of the regulation reform. Sections 4 to 6 describe the dataset, the model used, and the results from our empirical analysis. Finally, Section 7 discusses the findings. A data appendix concludes the paper.

2 A very brief history of the motorway industry in Italy

Motorways services are provided in Italy by about 20 different concession holders, with the exact number depending on the definition of motorway used. The object of the franchise contract is usually the motorway maintenance and the provision of motorways services; in some cases, the franchise contract has also included the construction of new motorways or the enlargement of existing ones. Mostly for historical reasons, concessions holders are very different in nature and size, whatever working definition of size and nature is adopted. For instance, the concession holder "Autostrade per l'Italia" controls about half of the entire national network, with this figure increasing to more than 60% if one also takes into account other franchisees under its proprietary control. Also in terms of kms per year "Autostrade per l'Italia" is clearly the largest franchisee, as the kilometers travelled on its network account for 65% of the nationwide figure. In terms of ownership structure, ASTM (AutoStrada Torino-Milano, now SIAS) has been quoted in the Italian stock market since the early 80s, while Consorzi Siciliani is still fully controlled by local public authorities.

The construction of a toll motorways network in Italy started in the 50s, and was undertaken partly directly by ANAS, the State Department for toll and no-toll motorways, and partly under the terms of franchisee contracts. Franchisees were mostly state-owned and not selected on a competitive basis. Where concessions involved large investments (either in new motorways or for the enlargement of existing ones) funding was largely granted by the State. Even when this was not the case, the State guaranteed the loans taken up by the franchisee to finance the investment. Prices were meant to grant revenues sufficient to cover costs and were changed yearly by the Ministry of Transport; the same rate of change was in general applied to each franchisee and to the unit price charged in each vehicle class. Franchisee's costs were assessed by means of the so-called "Piano Finanziario" (PF henceforth), which was to be presented at the beginning of the concession period and detailed the forecast for all costs and revenues for the whole period of the concession.

During the 90s, a radical reform of the industry was undertaken.[1] For the purposes of this study, the two most important changes relate to the ownership of the franchisees and the regulatory framework. As to the change in ownership, many franchisees were privatised, with the most evident example being the privatisation of

[1] For a full account of the history of the industry since its regulatory reform, see Iozzi (2002), Ponti (2004) and Ragazzi (2004).

"Autostrade" (now "Autostrade per l'Italia"), which took place in 1999. However, this was not the only change of ownership for motorways concessionaires in recent years. Inspection of Table A4 indeed reveals that the number of privately owned franchisee increased from 2 in 1992 to 13 in 2003 (or from 5 to 15, if the majority of shares and not the largest shareholders is used to define private ownership).

The other important change occurred refers to the reform of the regulatory regime. The new regulatory framework was defined in December 1996 with the CIPE Directive, which concluded a process that lasted several years. This Directive provided for the renegotiation of all the existing franchise contracts. The new contracts had to adhere to the principles laid out in the Directive, amongst which the main ones are:

- price regulation based on a price cap formula, with the X factor set every five years;
- cost observation based on the PF, provided by the franchisee at the beginning of the franchise contract and being part of the contract itself. The PF is meant to be valid for the whole period of the concession and has to be updated only in special circumstances.

The price cap formula adopted in the new contracts is applied to the prices charged by the concessionaire to each vehicle belonging to a given class for each km travelled on the motorway. The price cap formula limits the increases of a Laspeyres index of these prices to the rate of inflation, adjusted for the expected productivity gains and changes in the quality of services provided. In particular, the price cap formula takes the following form:

$$\left[\frac{\sum_{i=1}^{n} p_i^t q_i^{t-1}}{\sum_{i=1}^{n} p_i^{t-1} q_i^{t-1}} - 1\right] \times 100 \leq \Delta RPI - X + \beta \Delta Q \qquad (1)$$

where p_i^t and p_i^{t-1} are the (per Km) price paid by a vehicle of type i in year t and $t-1$ respectively, and q_i^t and q_i^{t-1} are the total number of kms travelled by vehicles of type i in year t and $t-1$ respectively. Also, ΔRPI is the (expected) change in the Retail Price Index and X is the offset productivity factor. The final term is the change in a composite quality index Q, multiplied by a scaling factor β.

3 Critical issues of the new regulatory framework and related literature

The first period of application of the new regulatory regime in the motorways sector has highlighted some critical issues related to the settings of the X factor and the inclusion of the quality index Q in the price cap formula. In this section we provide some general discussion on these issues; we also summarize the empirical evidence on the effects of PC vs ROR regulation.

3.1 X factor, theoretical issues and empirical evidence

In price cap regulation, the X factor grants that the price level follows any change in productivity. To avoid reducing the power of the incentives to cost reduction, the X factor should be set equal to expected rather than realised productivity gains (due to technical progress, scale and/or density economies, reduction of inefficiency). This feature of PC regulation, and the related fact that the X factor is predetermined for a given number of years, differentiate this form of regulation from ROR regulation, where, at least in principle, prices follow closely realised costs.

Theoretical literature on regulation has celebrated the PC rule as superior to ROR, emphasizing the differences in providing incentives for better production technology and overall greater efficiency of the production process. Cabral and Riordan (1989) firstly showed that PC regulation leads to greater investment in cost reduction than the ROR: the intuition of their result lies on what is known as the "Arrow effect"[2] where the incentive for cost reduction (i.e.: process innovation in their context) is larger in a competitive market than in a monopolistic one, as the inventor's incentive under competition relates to the cost reduction on the competitive output which – in turn – is larger than the monopolistic output.[3] Since PC regulation specifically allows downward price flexibility, by the Arrow effect, it results as superior to ROR regulation. Moreover, the firm's level of investment in cost reduction is nondecreas-

[2] Arrow, (1962).

[3] See Cabral and Riordan (1989), p. 158.

ing in the length of time between revisions: this follows from the fact that larger the regulatory lag, longer the period over which the firm is able to appropriate of cost reduction.

The Cabral and Riordan (1989) stilized model produces ambiguous results with respect to consumer welfare. Clementz (1991) shows in a three period model that consumer's surplus is larger under PC than under ROR regulation. The relevant hypothesis for this result is that the distribution $F(c, e)$ - where c and e are respectively the firm's cost and the effort in cost-reducing investment - is known to the regulator and, thus, that PC is always adjusted to cost.

Whilst both analyses are useful, they share the significant shorcomings of assuming no information asymmetries between the firm and the regulator and/or no uncertainty about cost and demand conditions. Sibley (1989) shows that when the firm has superior information with respect to costs and demand compared to the regulator, PC regulation - under specific assumption - may come close to second-best solutions. Schmalensee (1989) and Lewis and Sappington (1989) shows that the superiority of PC regulation become far less clear cut when there is uncertainty about cost and demand condition.

Empirical research on the comparison between PC and ROR regulation focuses on the effects on costs, prices and productive efficiency; these contributions show how difficult is to sort out the effect of regulation from the effect of other factors and - in summary - they lead to mixed evidence.

As for the effects on costs and productive efficiency, telecommunication sector is the most investigated. Shin and Ying (1993) carried the first econometric test on the effect of incentive regulation on costs over the 1988-91 period for the local exchange carriers (LECs) and they find no evidence that PC regulation has significant effects on cost reduction. Over the more recent period 1988-94, similar results are obtained - combining translog cost function estimation and total factor productivity growth decomposition for a sample of LECs - by Resende (1999). Schmalensee and Rohlfs (1992) compared total factor productivity (TFP) growth for AT&T switched services before and after the introduction of PC regulation (1986-1988; 1989-1991): their results show that TFP grew faster under the PC regulation than it did in the previous three years before its introduction. Tardiff and Taylor (1993) using cross section and time series data for large LECs found that incentive regulation increases annual TFP by 2.8%. Also the impact on efficiency has been investigated. Majumdar (1997) and Resende (2000) employ Data Envelopment Analysis (DEA) to evaluate efficiency gains for distinct regulatory regimes and both conclude that incentive regulation induce higher level of productive efficiency than traditional ROR regulation. Rather opposite results have been obtained by Uri (2001) by using both DEA and stochastic frontier methodologies. This dicrepancy, although striking, might be due to the different choice of inputs and outputs and by different sample analysed. Finally, the impact of PC vs ROR regulation in industries other than telecommunications have been analysed. The overall results are mixed.[4]

In the regulatory practice of the motorways industry in Italy, the actual determination of the X factor took into account a much wider range of issues rather than simply expected productivity gains, as it is common under price cap regulation. The CIPE Directive of December 1996 itself provided for the X factor to be determined mainly on the basis of expected productivity gains, but also to ensure a fair return on capital, to grant enough revenues to finance some investment programs, to take into account estimates of demand growth and change in the competitive conditions of the industry. In practice, the X factor was set to ensure an average price level able to grant the equilibrium of the whole PF, from the moment of the determination of X (for a five-year period) up to the end of the franchise contract.

This procedure is not far from one could expect, provided that the costs and revenues detailed in the PF are good enough estimates of actual trends. On the ability of the X factor to capture the gains in productivity to be expected, we will comment at length in the rest of the paper. However, it is interesting to note the value of X in the different years was set identically for 9 (out of 20) concession holders.[5]

[4] For a study in the electricity generation sector in the US, see Knittel (2002).

[5] More specifically, these values are 1.09 for the year 2000, 0.98 for 2001, 0.90 for 2002, 0.83 for

These values seem to indicate what the regulator thought was the expected gain in productivity according to the industry-wide technological dynamics, or, in other words, the regulator's expectation on the the firm's actual performance against some predefined reference or benchmark performance.

In a recent contribution, Jamasb, Nillsen, and Pollit (2004) note that the use of benchmarking can lead the firm to pursue virtual rather than true performance improvements by gaming the regulator benchmarking in several ways that do not reduce the issue of asymmetric information on firm's cost and efficiency improvement efforts. They conclude with suggestions to avoid that using benchmarking adds a new dimension to strategic firm's behaviour.

The regulator's correct prevision of demand represents another relevant issue in price cap determination. In fact, if economies of scale or density exist, an increase in output will lead to a decrease in average costs and the X factor should be adjusted accordingly. To forecast the demand several methodological alternative exist, ranging from autoregressive models to conditional models once good explanatory variables have been found. As a rule-of-thumb, the growth of GDP has been used as a proxy for demand growth in the Italian motorway industry. As we will see in the next section, this has led to a clear underestimation of the actual demand.

3.2 Q factor

As price cap regulation provides powerful incentives for cost reduction, quality deterioration in the service seems to follows naturally. This has been both proven theoretically (Spence, 1979, and De Fraja and Iozzi, 2004) and observed in practice (Rovizzi and Thompson, 1992).[6] In the absence of specific provision for quality,

2003 and 0.77 for 2004. Departures from these values in the determination of the X factor could have been motivated only by firm-specific issues, such as investment programs, low initial level of prices, etc.

[6] Outcomes from empirical literature on firm's incentive to quality level under different alternative regulations do not produce a clear cut result that price cap would do so badly. Tardiff and Taylor (1993) findings on US telecommunications service provision highlights that there has been

the only discipline for the firm seems to derive from the reduction in demand. In many utilities however, firm's demand seems not to be sufficiently elastic to quality to provide an effective countervailing incentive to quality reduction.[7]

Therefore, regulators have typically adopted two different strategies to overcome this problem, either imposing quality standards in addition to price constraints, or implicitly or explicitly linking the allowed price level to quality improvements. This generates a trade-off between prices and qualities, with the firm being able to "sell" higher quality to consumers, or to provide lower quality and, at the same time, compensate consumers by means of lower prices. In the presence of asymmetry of information on the firm's cost, the use of quality standards suffers from the difficulty of setting the standards equal to the socially optimal levels. On the other hand, some very recent research (De Fraja and Iozzi, 2004) has shown that the inclusion of a quality correction term in the price cap formula may ensure that the firm makes the socially optimal price and quality choice in the long run. Subject to a further requirement on the firm's choices not to be "too erratic", this is ensured if the quality adjustment term is a weighted average of the marginal effect of the quality changes on consumers' welfare and it is not in any way dependent on the firm's cost.

In the case of motorways regulation in Italy both strategies have been in principle adopted. Indeed, the CIPE Directive of December 1996 provided for both the setting

no detectable negative effect of PC regulation on quality for the former Bell operating companies. This result contrasts with the service quality problems detected in the mid - to late 80s in British Telecom following the introduction of PC regulation (Armstrong, Cowan, Vickers 1994).

[7] The effect of PC regulation on the quality of infrastructure has been theoretically investigated by Greenstein, McMaster and Spiller (1995) and by Ai and Sappington (1998). Their results show higher quality of infrastructure under PC regulation as compared to ROR regulation. However, as pointed out by Kridel, Sappington and Weisman (1996), the better quality of the infrastructure can be related to the required investments as precondition for approval of changes in regulation, and - thus - not to the direct effects from the new regulatory mechanism. However, most of the studies mentioned in this and the previous footnote analyse the TLC industry, where market structure is far from being monopolistic and where the market discipline may soften any negative effect of price cap regulation on the quality of the services.

of quality standards and the direct inclusion of a quality correction in the price cap formula. To the best of our knowledge, the first type of regulatory policy has not been enforced so far and we have already briefly discussed how the price cap formula is corrected for quality changes. Since we will be arguing that this feature of the regulatory framework has had a powerful effects on the structure of the incentives to the franchisees, we give here a more detailed description of the mechanism.

The composite quality index used in the price cap formula is a weighted average of two specific quality indicators; the first related to the number of accidents (per km), under the presumption that the better is the security system in force in the motorwyas, the smaller is the number of accidents. The second specific quality indicators relates to the roughness of the surface, which is positively linked to the comfort of the journey. Clearly, the nature of the composite index is not satisfactory, both because it omits a very large number of features of the services actually affecting its quality and the customers' satisfaction (such as, for instance, waiting time at the barrier, emergency systems, disruption from roadworks, methods of payments, etc.), but also because it takes into account quality elements (e.g. the number of accidents) which are to some extent not under the franchisee's control. This was recognised by all parties interested in the renegotiation of the concession contracts at the moment of writing them and led to a mutual commitment to adopt a more comprehensive composite quality index on the occasion of the price cap revision. At the moment, to the best of our knowledge, no definite steps in this direction have been made.

The other constituent element of the quality correction of the price cap formula is the β factor. In principle, this is an adjustment factor which allows the regulator to finely tune, according to her objectives, the change in the quality indicator with the change in the permitted prices. In the case under analysis, β takes on a predetermined value, depending on the firm's performance against its past performance and an industry–wide standard. Although this approach has been maintained in general in all franchisee contracts, the exact way in which the factor is defined is different between "Autostrade" and the other concession holders. In the case of "Autostrade",

β starts from 0 (when the change in the quality performance of the franchisee brings it to a quality level below the industry–wide standard) and increases (step-wise) up to 0.5 (when the change in the quality performance of the franchisee brings it to a quality level well above the industry–wide standard). A similar structure for β has been adopted in the case of later contracts, with the following important changes: i) β changes continuously with the quality of service reached by the franchisee, ii) β assumes negative values in case of a worsening of the quality performance, and iii) β changes more rapidly with the change in the performance when the quality of the service is high, i.e. rewarding (penalising, respectively) more those concessionaries which improve (worsen) a high quality service.

The main feature which is immediately apparent from the way in which quality enters the price cap formula is that, despite the regulator shows to have in mind some "acceptable quality standard", it is willing to reward *any* increase in quality above this level. Moreover, the price increase allowed to the firm is higher the higher is the quality of the service provided. Since the marginal cost of quality is increasing but its marginal benefit to the consumers is generally decreasing (at least above a certain level), this makes immediately apparent that the quality correction is meant to ensure the franchisee covers any cost due the increase in quality.[8] As explained above, this contrasts with the indications derived from economic analysis, which would require that the increase in the price level were related to the consumers' higher benefits due to the higher quality of the services. Moreover, it introduces in the price cap formula an automatic mechanism to ensure the cover of (at least some type of) cost very much in the spirit of rate of return regulation.

[8] Informal contacts with executives of Anas, which originally suggested the present structure of quality regulation, confirms this. It appears that the β factor was set having in mind, on the one hand, the increase in cost that would have been needed for a given increase of the quality of the services and, on the other hand, the increase in price that this would have needed to cover this additional cost.

4 The data

We collected a unique dataset containing information on all the 20 Italian concessionaires via inspection of several sources: concessionaires' official reports, some publications from AISCAT (the concessionaires' association), and other sources.[9] The database contains the following variables for the 1992-2003 period: firms' financial indicators (such as costs, revenues, inputs), characteristics of the sections served (such as length, number of stoneworks, mountain sections, total number of kilometers travelled) and concessionaires' institutional characteristics (ownership, i.e. private vs. public ownership; type of regulation, i.e. price cap vs. rate of return).

Figures from 1 to 3 and Table A2 depict the sector and its evolution in recent years.[10] The main features of our data set can be summarized as follows. First, the Italian motorway network is composed of one huge concessionaires ("Autostrade per l'Italia") and 19 relatively small ones. The difference between the mean and median values of kms travelled and network in Table A2 highlights this asimmetry.

Second, a costant upward trend in total kms travelled is recorded, the order of the yearly growth rate being approximately 3.5%.

Finally, since 1999, a sharp increase in profits before tax (notably in 2002-03) and in maintenace costs is found, whereas a slight decrease in labour costs has occurred all over the period. Although it would be tempting to directly comment these changes we defer the interpretation to the last section, in order to relate these figures with the econometric results.

5 The model

We estimated a total cost function with three inputs, one output and a variable representing the network length. We also added neutral technical progress, some hedonic

[9] For more details on data sources and variable construction, see the data appendix.

[10] All figures report median values and not average values as the latter are highly affected by the size of "Autostrade per l'Italia" which is much larger than the other concessionaires. Furthermore, costs and profits have been deflated with the consumer price index to allow comparability over time.

(control) variables reflecting the characteristics of the network and, most importantly for the purposes of this paper, we also added some ownership and regulation dummies. The most general model we estimate is the following translog specification:

$$\begin{aligned} \ln\left(\frac{TC}{p_m}\right)_{i,t} &= \beta_0 + \beta_o \ln\left(\frac{p_o}{p_m}\right)_{i,t} + \beta_l \ln\left(\frac{p_l}{p_m}\right)_{i,t} + \frac{1}{2}\beta_{oo}\left[\ln\left(\frac{p_o}{p_m}\right)_{i,t}\right]^2 + \qquad (2) \\ &+ \frac{1}{2}\beta_{ll}\left[\ln\left(\frac{p_l}{p_m}\right)_{i,t}\right]^2 + \beta_{ol}\left(\ln\left(\frac{p_o}{p_m}\right)_{i,t}\ln\left(\frac{p_l}{p_m}\right)_{i,t}\right) + \\ &+ \beta_y \ln y_{i,t} + \beta_{yy}\ln y_{i,t}^2 + \beta_{oy}\ln\left(\frac{p_o}{p_m}\right)_{i,t}\ln y_{i,t} + \beta_{ly}\ln\left(\frac{p_l}{p_m}\right)_{i,t}\ln y_{i,t} + \\ &+ \beta_n \ln n_{i,t} + \beta_{nn}\ln n_{i,t}^2 + \beta_{on}\ln n_{i,t}\ln\left(\frac{p_o}{p_m}\right)_{i,t} + \beta_{ln}\ln\left(\frac{p_l}{p_m}\right)_{i,t}\ln n_{i,t} + \\ &+ \beta_{yn}\ln y_{i,t}\ln n_{i,t} + \beta_t T + \beta_{own} own_{i,t} + \beta_{reg} reg_{i,t} + \beta_c controls_{i,t} + \upsilon_i + \varepsilon_{i,t} \\ & \qquad\qquad i = 1, ..., 20 \text{ and } t = 1992, ..., 2003 \end{aligned}$$

where TC is total operating cost, p_m, p_o, and p_l are prices for maintenance, other inputs, and labour. y is the total number of kilometers travelled (the output) and n is the network lenght. T is a time trend (i.e. $T = 1$ if $t = 1992$,..., $T = 12$ if $t = 2003$), *ownership* and *reg* are two time variant dummy variables. The former indicates whether the concessionaire is under private or public ownership (1 for private, 0 public) and the latter takes a value of 1 if the firm is under price cap regulation and 0 if it is under a ROR regime. Controls are some characteristics of the network served which should capture some observable heterogeneity among concessionaires. The first two control variables are *Stonework*, the number of stoneworks standardised for the length of the network, and 3*band network*, the percentage of the network with three bands (most of the Italian network is composed of two bands sections). We also include among controls (log of) Q, an index of quality of the service derived from the price cap formula.[11] υ_i is an individual effect (either random or fixed) and $\varepsilon_{i,t}$ is an

[11] We could not find neither the overall measure of quality used in the price cap formula nor the two components (quality of surface and number of accidents) for the whole 1992-2003 period. The best we could do was to recover the overall measure from concessionaires' official report. Unfortunately, the measure we recovered is a poor proxy of the actual quality. See the data appendix for more details.

idiosincratic error term.

To impose homogeneity, all prices have been stardardised by the maintenance price as shown in expression (2). In order to ease the computation of elasticities in the traslog model, we also standardised all prices, the network variable, kms travelled, and total cost by their value evaluated at some relevant percentile, i.e. 10%, 50% (the median), and 90%. Notice that as the translog model can be criticised on the ground that parameters are imprecisely estimated due to multicollinearity among regressors, we also present the results obtained by using a restricted Cobb-Douglas specification of model (2).

As for the underlying technology, three measures are quite important and, to the best of our knowledge, never investigated so far in the motorway industry, neither in Italy nor in other countries.

A first measure is *scale elasticity*, given by

$$\varepsilon_s = \frac{1}{\varepsilon_y + \varepsilon_n} \tag{3}$$

where ε_y and ε_n are the elasticity of total cost with respect to output (kilometers travelled) and the network length respectively. Therefore, ε_s measures the inverse of the percentage increase in total cost due to a percentage increase in output *and* in the network length. A value above (below) 1 indicates increasing (decreasing) returns to scale.[12]

A second measure is *density elasticity*, defined as

$$\varepsilon_d = \frac{1}{\varepsilon_y} \tag{4}$$

which measures the inverse of the percentage increase in total cost due to a percentage increase in output holding the network length fixed. A value above (below) 1 indicates increasing (decreasing) returns to density. In other words, a value larger than 1 indicates that the network is underexploited, so that an increase in output induces a less-than-proportional increase in total costs.

[12] On the definitions of scale and density elasticities see Caves, Christensen, and Tretheway (1984).

The last important measure reflecting the characteristics of the underlying technology is the yearly rate of technical progress, measured by

$$\varepsilon_T = \frac{\partial \ln TC}{\partial T} \tag{5}$$

a negative (positive) value showing technical progress (regress).

6 Regression results

We estimated the model (2) by using standard panel data techniques.[13] More specifically, instead of adding cost shares and estimating the model with a SUR technique, we preferred to take into account the presence of unobservable heterogeneity and use random and fixed effects methods. Furthermore, as the translog results might be dominated by second order and interaction terms, we also estimated a simplified version of model (2) corresponding to a Cobb-Douglas cost function.

As the parameters of the Cobb-Douglas are easier to interpret than those of the translog, we begin by commenting the results of six Cobb-Douglas specifications, shown in Table 1. In column (1) estimates of the basic model are presented. Coefficients of prices are positive and highly significant as well as the network length and the total number of kms travelled. Both density and scale elasticities are larger than 1 (respetively 2.4 and 1.17) thereby confirming that - on average - the Italian motorway network is underexploited and suggesting that an increase in concessionaires size might reduce average cost. Results also show that a yearly rate of technogical progress of the order of 0.7% has occurred. This is probably due to the introduction of automatic toll systems, and should be read in combination with the small reduction in labour expenses outlined in the previous section. Firms under private ownership prove to be more productive than public concessionaires. In fact, the ownership dummy is negative and very significant in both specifications, showing that private firms enjoy a cost advantage of approximately 6% with respect to public

[13] The software used is Stata, version 8.2.

ones.[14] Finally, the introduction of a price cap regime does not seem to affect firms productivity as the regulation dummy is not significant at any reasonable statistical level.

We performed some robustness checks of these results. First, we estimated the same model by using fixed effects panel data techniques. The advantage of this method over the random effect technique is that it allows correlation of the individual effects υ_i with regressors. The drawback is that fixed effects estimation is very imprecise for regressors with small within-variation (in our case, the length and the other network characteristics). The results, presented in column (2), tend to confirm those obtained with random effects with only minor differences: technological progress appears to be less pronounced and less significant; density and scale elasticities are higher than before. The Hausman test suggests that the results of the fixed effects model are to be preferred to those of the random effects model. As a second robustness check, we used Instrumental Variable (IV) techniques on pooled data by instrumenting the two prices with their values lagged one period. The rationale here is that prices constructed as described in the Appendix (costs divided by a quantity measure) might be endogenous. Results in column (3) are quite similar than those obtained with fixed and random effects, the only notable exception being a stronger technical progress and a smaller and less significant ownership dummy. Finally, we included some additional network characteristics which might affect costs: quality, number of stoneworks, and the percentage of network with 3 bands. Although the three variables have the expected positive coefficient, they prove to be imprecisely estimated, the percentage of network with 3 bands being the only variable very marginally significant.

Results for the translog model are presented in Table 2. Columns from (1) to (6)

[14] In the estimated models shown in Tables 1 and 2, the ownership dummy takes a value of 1 if the concessionaires is under the *control* of private firms or individuals, i.e. private subjects own at least 51% of the shares. We checked the robustness of our results by using the alternative ownership dummy which takes a value of 1 if the *largest shareholder* is a private firm or individuals. Results are very similar to those presented in the text.

closely follow the corresponding columns in Table 1. Notice however that now density and scale elasticities are no more constant over the sample and must be evaluated at a specific sample point. We evaluated elasticities at the sample median of the variables in the first six columns, at the 10^{th} percentile in column (7), and at the 90^{th} in column (8). Notice also that the drawback outlined before for fixed effects estimates is more relevant in a translog than in a Cobb-Douglas model. In fact, slowly variant regressors enter the model not only linearly but also as second order terms, thereby inducing high variability in the estimates. As a consequence, results for the fixed effect model must be taken with caution. Results are very similar than those in Table 1 and can be summarised as follows. Technological progress proves to be robust in size (around 0.6%) and significant. Ownership dummy is positive and significant in all columns but in column (3) (IV estimates), and regulation dummy is mostly negative but its p-value is never below 0.18. Therefore, there is a strong evidence of the superior productivity of concessionaires under private control whereas price cap regulation does not seem to induce a cost saving behaviour. Finally, the density elasticity proves to be always larger than 2 whereas scale elasticity displays an interesting pattern: it decreases from 1.34 at the 10^{th} percentile to 1.13 at the median to 1.00 at the 90^{th} percentile. Therefore, the optimal size of the networks appears to be of the order of 300 kms, suggesting that aggregation of concessionaires should be welcome - or even encouraged - by public authorities.[15]

7 Concluding remarks

This paper aimed at providing, for the first time, empirical evidence on the effects of the regulatory reform of the Italian motorway industry. It is now time to combine theoretical literature with descriptive statistics and our econometric results in order to interpret the evolution of the industry, to evaluate regulatory mechanisms, as well as to provide some suggestions on how these mechanisms should be improved in the

[15] The idea that concessionaires should be reorganised on regional basis is put forward in Scarpa *et al.* (2005).

future.

Our analysis shows that, from the first years of the 90s to 2003, the productivity of the motorway industry has steadily increased. This was only partly due to technological progress, mainly due to availability of new technologies for the toll payments. Another motivation of the increase in productivity was the increase in demand and, consequently, of the kms travelled on the network. Since our analysis shows that the production technology clearly exibits increasing returns to density, the sharp increase in motorways traffic (and revenues) observed in the last 10 years has caused a less than proportional increase in cost.

Our results highlighted that some factors influenced the ability of the firms to exploit the profits opportunities made available by the change in the economic environment in which they operate. Rather surprisingly, price cap regulation is not one of these factors. In other words, the introduction of the new regulatory regime based on a price cap formula has not made the franchisees, ceteris paribus, more productive. On the other hand, we shown that ownership has mattered. Private franchisees are found to have been more able than those still state-owned to improve their productivity.

Two further phenomena emerge from our analysis. Firstly, maintenance costs have sharply increased since the introduction of the new regulatory regime. This increase might explain, at least partially, the lack of a positive impact of price cap regulation on firms' productivity. We also posit that the increase in maintenance costs is the effect of the quality correction term in the price cap formula, which create a mechanism through which the franchisee can influence the allowed average price level by choosing the quality of its services. Theoretical analyses suggest that, in principle, there is nothing wrong with such a mechanism which, under some conditions, can even lead to socially optimal outcomes. Also, it is not possible to determine whether the actual level of the services is (socially) inefficiently high. However, our critique is addressed to how the quality correction is determined and, more specifically, to the possibility firms have to raise indefinitely the quality of their services and having a corresponding increase of the allowed average price level.

The second phenomenon relates to the sharp and systematic increase in profits observed in the industry in recent years. Basically, this shows that the X factor has been set too low, possibly because of an underestimation of the technological progress and/or the increase in demand which have both affected the industry in recent years.[16] Moreover, if our conjecture relative to the rather artificial increase in quality-related investment is correct, the underestimation of the X factor on the occasion of its first determination is even more severe. With this respect, we cannot do other than call for more accurate and sound forecasting methodology to be used by the regulator on the occasion of the periodic review.

References

[1] Ai, C. and D. Sappington (1998): "The impact of state incentive regulation on the U.S. Telecommunication industry", University of Florida, Department of Economics Working Paper.

[2] Armstrong, M., S. Cowan and J. Vickers (1994): *Regulatory Reform: British experience and economic analysis*. Cambride (MA): MIT press.

[3] Arrow, K. (1962): "Economic welfare and the allocation of resources ifor invention", in *National Bureau of Economic Research*, The Rate and Direction of Inventive Activity, Princeton: Princeton University Press.

[4] Cabral, J. and M. Riordan (1989): "Incentives for cost reduction under price cap regulation", *Journal of Regulatory Economics*, 1/1:93-102.

[16] As shown in footnote 5, the average value of the X factor is below 1%. The increase in costs for a median firm due to a 3% increase in demand evaluated at a $\beta_y = 0.5$ is $\left[\exp\left(\beta_y \ln 1.03\right) - 1\right] = 1.5\%$. By adding the 0.6% for technical progress a reasonable value for the X factor would be around 2%.

[5] Caves, D. W., Christensen, L. R. and M. W. Tretheway (1984): "Ecomomies of density versus economies of scale: why trunk and local service airlines costs differ", Rand Journal of Economics, 15/4: 471-489.

[6] Clementz G. (1991): "Optimal price-cap regulation", *Journal of Industrial Economics,* 39/4: 391-408.

[7] De Fraja, G. and A. Iozzi (2004): "Bigger and Better: A Dynamic Regulatory Mechanism for Optimum Quality", *Centre for Economic Policy Research*, Discussion Paper No. 4502, August 2004.

[8] Greenstein, S., McMaster S. and P. Spiller (1995), "The effect of incentive regulation on infrastrucure modernization: local exchange companies' developmentof digital technology", *Journal of Economics and Management Strategy,* 4:187-236.

[9] Heyes A.G. and C. Liston-Heyes (1998): "Price-cap regulation and technical change", *Journal of Public Economics*, 68: 137-151.

[10] Iozzi, A. (2002): "La riforma della regolamentazione del settore autostradale", *Economia Pubblica*, 32/4: 71-93.

[11] Jamasb, T, Nillesen, P. and M. Pollitt (2004): "Strategic behaviour under regulatory benchmarking", *Energy Economics,* 26: 825-43.

[12] Knittel, C. (2002): "Alternative regulatory methods and firm efficiency: stochastic frontier evidence from the U.S. electricity industry", *Review of Economics and Statististics*, 84/3: 530-540

[13] Kridel, D.J., Sappington D. and D. Weisman (1996): "The effects of incentive regulation in the telecommunication industry: a survey", *Journal of Regulatory Economics,* 9: 269-306.

[14] Lewis, T. and D. Sappington (1989): "Regulatory options and price-cap regulation", *The RAND Journal of Economics,* 20/3: 405-416.

[15] MAJUMDAR, S. (1997): "Incentive regulation and productive efficiency in the U.S. telecommunication industry", *Journal of Business*, 70/4: 547-576.

[16] MATHIOS A. AND R. ROGERS (1989): "The impact of alternative forms of State regulation of AT&T on direct-dial, long-distance telephone", *The RAND Journal of Economics,* 20: 437-543.

[17] PONTI, M. (2004): "Autostrade: considerazioni aggiuntive di un ex regolatore", *Economia Pubblica,* 34/4: 35-44.

[18] RAGAZZI, G. (2004): "Politiche per la regolamentazione del settore autostradale e il finanziamento delle infrastrutture", *Economia Pubblica,* 34/4: 5-33.

[19] RESENDE, M. (1999): "Productivity, growth and regulation in US local telephony", *Information Economics and Policy,* 11: 23-44.

[20] RESENDE, M. (2000), "Regulatory regimes and efficiency in US local telephony", *Oxford Economic Papers* 52: 447-470

[21] ROVIZZI, L. AND D. THOMPSON (1992): "The regulation of product quality in the public utilities and the Citizens's Charter", *Fiscal Studies,* 13: 74-95.

[22] TARDIFF, T. AND W. TAYLOR (1993): "Telephone company performance under alternative forms of regulation in the US", *National Economic Research Associates.*

[23] SCARPA C., A. BOITANI, P. M. PANTEGHINI, L. PELLEGRINI AND M. PONTI (2005): "Come far ripartire le liberalizzazioni nei servizi", *mimeo.*

[24] SCHMALENSEE, R. (1989): "Good regulatory regimes", *The Rand Journal of Economics*, 20/3: 417-436.

[25] SCHMALENSEE R. AND ROHLFS (1992), "Efficiency gains resulting from interstate price cap for AT&T", mimeo, *National Economic Research Associates.*

[26] Shin, J. and R. Ying (1993): "Costly gains to breaking up: LECs and the Baby Bells", *Review of Economics and Statististics*, 75/2: 357-361.

[27] Sibley, D. (1989): "Asymmetric information, incentives and price-cap regulation",*The Rand Journal of Economics*, 20/3: 392-404.

[28] Uri, N. (2001): "Productivity change, technical progress and efficient improvement in telecommunication", *Journal of Policy Modelling,* 23: 825-846

[29] Vogelsang, I. (2002): "Incentive regulation and competition in public utility markets: a 20-year perspective", *Journal of Regulatory Economics,* 22/1: 5-27.

A Tables

Table 1: regression results, Cobb-Douglas

		(1)	(2)	(3)	(4)	(5)	(6)
Constant	β_0	1.99	2.79	1.53	1.63	1.99	2.00
		(0.00)	(0.00)	(0.00)	(0.18)	(0.00)	(0.00)
Price other inputs	β_o	0.34	0.32	0.53	0.34	0.34	0.33
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Price labour	β_l	0.43	0.45	0.28	0.42	0.43	0.43
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Kms travelled	β_y	0.42	0.35	0.42	0.43	0.42	0.40
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Network	β_n	0.43	0.37	0.50	0.43	0.44	0.45
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Time trend	β_t	-0.007	-0.004	-0.019	-0.008	-0.007	-0.007
		(0.00)	(0.19)	(0.00)	(0.00)	(0.00)	(0.01)
Ownership dummy	β_{own}	-0.06	-0.07	-0.02	-0.06	-0.06	-0.07
		(0.00)	(0.00)	(0.17)	(0.00)	(0.00)	(0.00)
Regulation dummy	β_{reg}	0.00	-0.00	0.02	-0.00	0.00	0.00
		(0.99)	(0.87)	(0.52)	(0.88)	(0.98)	(1.00)
Quality	$\beta_{quality}$	..	..	..	0.08	..	..
					(0.64)		
Stoneworks	$\beta_{st.work}$	..	..	..	..	0.01	..
						(0.91)	
3bands network(%)	β_{3band}	..	..	..	..	..	0.001
							(0.11)
Hausman		(0.006)		..	..	..	..
ε_d		2.36	2.84	2.37	2.34	2.38	2.49
ε_s		1.17	1.39	1.09	1.17	1.17	1.17

Note: Random effects panel estimates in columns (1) and (4) to (6). Fixed effects estimates in column (2) and IV estimates in column (3). Hausman is a test of orthogonality between effects and regressors. ε_d is the measure of density elasticity, ε_s is the measure of scale elasticity. In column (3) the two price variables have been instrumented with their one period lags. P-values in round brackets. The number of observations is 232 in all columns but column (3) where the number of observations is 212.

Table 2: regression results, translog

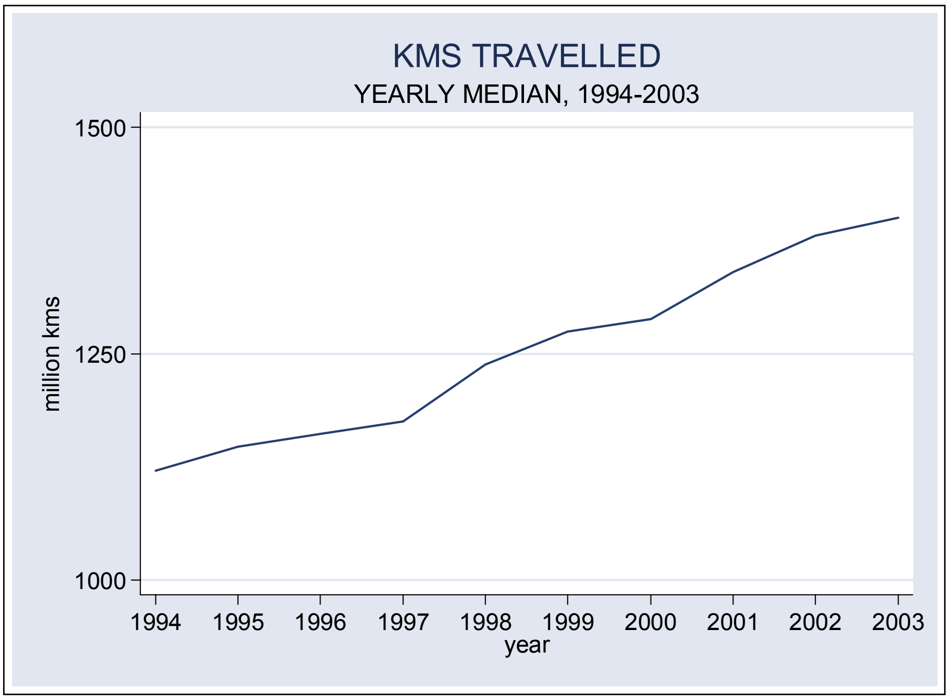
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	β_0	0.00	-0.24	0.00	0.00	0.02	0.00	-0.57	0.60
		(0.87)	(0.00)	(0.87)	(0.87)	(0.64)	(0.87)	(0.00)	(0.00)
Price other	β_o	0.31	0.31	0.38	0.31	0.31	0.32	0.31	0.36
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Price labour	β_l	0.39	0.39	0.37	0.39	0.39	0.38	0.57	0.23
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Price other ^{2}	β_{oo}	0.04	0.04	-0.04	0.04	0.04	0.04	0.04	0.04
		(0.00)	(0.00)	(0.22)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Price labour^2	β_{ll}	0.08	0.08	0.09	0.08	0.08	0.08	0.08	0.08
		(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Price lab.×*Price other*	β_{ol}	-0.05	-0.05	0.05	-0.05	-0.05	-0.06	-0.05	-0.05
		(0.02)	(0.02)	(0.53)	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)
Kms travelled	β_y	0.47	0.41	0.43	0.48	0.46	0.49	0.39	0.47
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Kms travelled^2	β_{yy}	0.12	0.10	0.21	0.13	0.12	0.13	0.12	0.12
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Price other×*Kms trav.*	β_{oy}	-0.08	-0.08	-0.05	-0.08	-0.08	-0.08	-0.08	-0.08
		(0.00)	(0.00)	(0.39)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Price lab.×*Kms trav.*	β_{ly}	0.02	0.01	-0.09	0.01	0.01	0.02	0.02	0.02
		(0.38)	(0.48)	(0.11)	(0.41)	(0.40)	(0.33)	(0.38)	(0.38)
Network	β_n	0.41	0.82	0.54	0.41	0.41	0.41	0.36	0.52
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Network^2	β_{nn}	0.19	0.46	0.23	0.19	0.20	0.18	0.19	0.19
		(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Table 2: regression results, translog (contd)

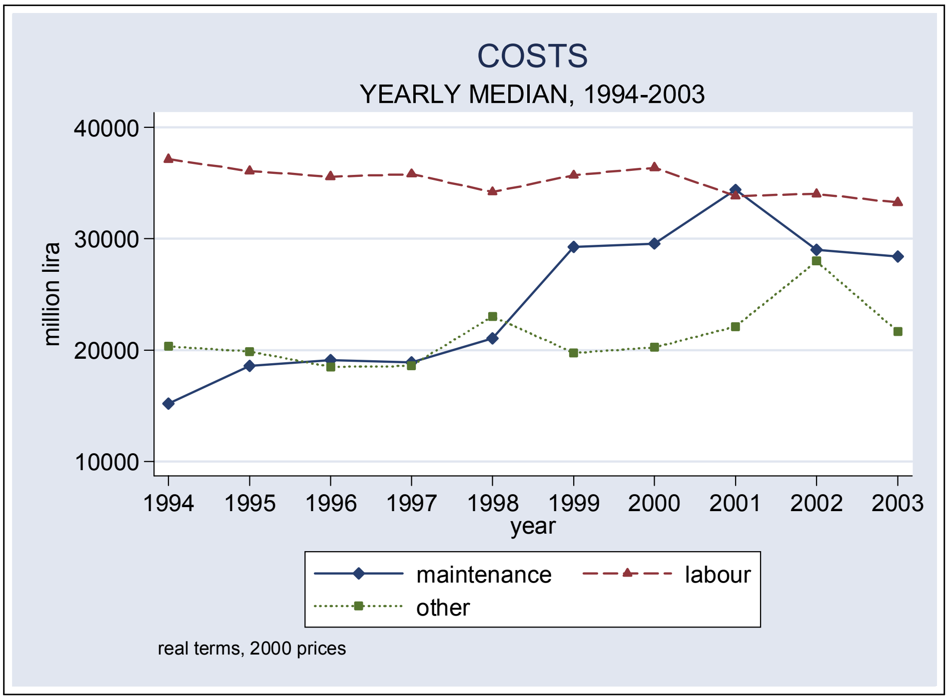
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Price other×Network	β_{on}	0.10	0.11	-0.03	0.09	0.10	0.08	0.10	0.10
		(0.00)	(0.00)	(0.68)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
Price lab.×Network	β_{ln}	-0.08	-0.08	0.09	-0.08	-0.08	-0.07	-0.08	-0.08
		(0.00)	(0.00)	(0.25)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
Kms trav.×Network	β_{yn}	-0.27	-0.26	-0.44	-0.27	-0.27	-0.28	-0.27	-0.27
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Time trend	β_t	-0.006	-0.005	-0.012	-0.005	-0.005	-0.007	-0.006	-0.006
		(0.00)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Ownership dummy	β_{own}	-0.04	-0.04	-0.00	-0.04	-0.04	-0.04	-0.04	-0.04
		(0.00)	(0.00)	(0.98)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Regulation dummy	β_{reg}	-0.01	-0.01	0.01	-0.01	-0.01	-0.01	-0.01	-0.01
		(0.18)	(0.46)	(0.68)	(0.29)	(0.21)	(0.24)	(0.18)	(0.18)
Quality	$\beta_{quality}$	..	..	..	-0.12	..	..	..	..
		..	..	..	(0.23)	..	..	..	..
Stoneworks	$\beta_{st.work}$	..	..	..	..	-0.05	..	..	..
		..	..	..	..	(0.37)	..	..	..
3bands network(%)	β_{3band}	..	..	..	..	..	0.00	..	..
		..	..	..	..	..	(0.88)	..	..
Hausman		(0.059)		..	..	..	..	..	..
ε_d		2.12	2.46	2.31	2.08	2.18	2.03	2.58	2.12
ε_s		1.13	0.81	1.03	1.13	1.15	1.11	1.34	1.00

Note: Random effects panel estimates in columns (1) and (4) to (8). Fixed effects estimates in column (2) and IV estimates in column (3). In columns (7) and (8) variables have been standardised by the 10^{th} and 90^{th} percentile. Hausman is a test of orthogonality between effects and regressors. ε_d is the measure of density elasticity, ε_s is the measure of scale elasticity. In column (3) the nine price variables have been instrumented with their one period lags. P-values in round brackets. The number of observations is 232 in all columns but column (3) where the number of observatons is 212.

B Figures


KMS TRAVELLED
YEARLY MEDIAN, 1994-2003
million kms
1500
1250
1000
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
year


PROFITS BEFORE TAX
YEARLY MEDIAN, 1994-2003
million lira
50000
30000
10000
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
year
real terms, 2000 prices



C Data appendix

This appendix aims at describing the data sources, at illustrating how some of the variables have been computed, and at presenting some descriptive statistics.

We collected our balance sheet data mainly through direct inspection of concessionaires' official statements. In a couple of cases, we resorted to the AIDA database released by the Bureau Van Dijk which contains balance sheet data for a very large sample of Italian firms. We retrieved information on the number of kilometers travelled, on some characteristics of the network (such as the number of stoneworks) as well as the number of accidents 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. The type of regulation and the values of the single components of the price cap formula have been collected by inspecting concessionaires' official reports.

Despite our database contains information on all 20 Italian concessionaires, the sample used is not balanced as 8 observations are missing (see Table A1). This is due to two reasons: two concessionaires started operations in 1994 and two concessionaires refused to provide us the necessary data and was not possible to recover these data.

Table A1: Structure of the panel

	Frequency	Period Observed
	15	1992-2003
	2	1993-2003
	3	1994-2003
Total	20	
Total observations	232	

The variables used in the empirical analysis are described below and summarised 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 variable costs, including depreciations. Maintenance (resp. other inputs, labour) price has been constructed by dividing maintenance (resp. other, labour) costs by the number of kms travelled (resp. network length, average number of employees). The number of stoneworks is the number of bridges and tunnels longer than 100 meters, devided by the network length. Quality has been constructed by setting the value of this variable equal to 100 up to the price cap introduction year and then updating according to the ΔQ value in the price cap formula. In most cases a separate indication of ΔQ was missing; in these cases, we estimated it by dividing $\beta\Delta Q$ by 0.25, the average value of β.

Table A2. Descriptive statistics

variable	mean	st. dev.	min	25th	median	75th	max
costs							
maintenance	48605.76	100620.08	319.00	10154.13	19800.26	37930.50	614376.00
labour	65541.92	138686.70	6730.58	19208.79	32707.13	46905.46	692732.00
other	41028.77	80027.04	4281.00	11725.05	18808.74	34592.45	620545.75
profits	65945.90	209506.87	-67818.00	2734.00	16358.00	45776.69	1764019.42
prices							
maintenance	22.33	21.92	1.83	11.46	17.19	25.33	198.31
labour	85.72	10.99	60.23	77.97	85.21	92.39	157.30
other costs	248.75	195.63	48.32	121.60	187.31	300.41	1236.43
Other variables							
Kms travelled	3302.41	8409.73	32.00	644.53	1195.59	1913.22	45858.57
network	256.53	609.24	20.00	51.60	120.10	165.20	2854.60
Q	101.58	3.72	88.32	100.00	100.00	102.00	119.48
stoneworks	0.41	0.35	0.03	0.09	0.33	0.61	1.40
3band network	23.50	34.78	0	0	0	42.60	100.00

Note: costs and prices are in millions lira, current prices. The number of kilometers travelled is in millions kilometers and network is in kilometers. Stoneworks is the number of stoneworks devided by the network lenght and 3band network is in percentage of total network.

Regulation regime is indicated by a time-variant dummy variable which takes a value of 1 if at the end of fiscal year the concessionaire is under a PC regime (0 if ROR). Most of concessionaires have been regulated under ROR until 2000, as shown in the following table.

Table A3: Changes in the regulatory regime (from ROR to PC), by year

Year	1998	2000	2001	2002	2003	Total
Frequency	1	15	1	1	2	20

Note: absolute frequencies

Finally, we constructed two time-variant firm specific dummies for ownership. The first dummy takes a value of 1 (0 otherwise) if the *largest shareholder* is a private firm or individuals for at least six months in the fiscal year; the second one takes a value of 1 (0 otherwise) if the *majority of shares* belongs to a private firm or individuals for at least six months in the fiscal year. Table A4 describes the distribution over time of these two dummies, whereby showing the privatisation process occurred in the 1992-2003 period.

Table A4: Public and private ownership, by year

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Private I	5	5	7	8	8	8	8	8	14	14	14	15
Public I	15	15	13	12	12	12	12	12	6	6	6	5
Private II	2	2	2	4	4	5	6	6	12	12	12	13
Public II	18	18	18	16	16	15	14	14	8	8	8	7
Total	15	17	20	20	20	20	20	20	20	20	20	20

Note: Absolute frequencies. Private I is a dummy variable which takes a value of 1 if the largest shareholder is a private one (0 otherwise); Private II is a dummy variable which takes a value of 1 if the majority of stakes belongs to private firms (0 otherwise).