On the Effectiveness of Vertical and Horizontal Measures in Railway Deregulation

<u>Working Paper</u>

By

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1 Introduction

Many railways all over the world have been subject to various deregulation activities during the last decades. The motives behind these changes in railway policy are *often* to be found in the negative development of the financial and market performance of the railways. The European Commission has described the negative development of the European railways in its White Paper (EC, 2001). Governments in Europe have made major changes of their railway policies since the late 1980s, starting in Sweden and Great Britain. Examples of such policy measures are:

- Vertical separation of infrastructure from traffic operations, either in terms of separate and transparent cost accounting or complete organisational separation
- Organisational and other measures to increase competition such as giving new train operators access to the railway network
- Stimulation of private ownership in the railway sector

The policy mix of these ingredients as well as the speed with which the changes are implemented varies considerably between countries. There are examples of both instant thorough changes in regulation and of limited gradual changes over extended time periods.

The regulators may have had several goals for the deregulation of the railway sectors, and the goals may not have been completely clear at the outset. However, it can be safely assumed that improved *economic efficiency* in terms of reduced costs per unit of output is one of the most important goals. Therefore, it is extremely important to undertake research aiming at analysing whether the deregulation policy really leads to improved economic efficiency or not. In this paper we interpret economic efficiency as cost efficiency expressed as cost per unit of output.

In Swedish railway policy (see Bruzelius et al., 1994), the importance of cost efficiency can be deduced from a Government directive to a special investigator appointed in the spring 1992 in which the Minister says:

> *"A predominant objective of the deregulation and of competition in general is to stimulate efficiency in utilisation of resources."*
>
> *"My basic opinion is that an abolition of competitive limitations and in general a more severe legislation related to competition are an important prerequisite for increased cost efficiency within the sectors reporting to the Ministry of Transport and Communication."*

Cause and effect research in the railway sector encounters several difficulties. How can output be defined? Is the cost per unit of output empirically measurable? Can changes in unit costs be explained by the deregulation policy or are they caused by other factors? Our paper deals with these difficult research questions, and our purpose is to explore how the deregulation of the Swedish railway sector has impacted its cost efficiency. The deregulation policy is composed of a number of more or less visible measures. Within our purpose, we will focus on three main issues:

- Is it likely that the deregulation policy as such, whatever it contains, has been effective in terms of improved cost efficiency?
- Are there any indications showing that the competition enhancing measures of the deregulation policy have been effective in terms of improved cost efficiency?
- How has the vertical organisational separation of infrastructure from train operations affected cost efficiency?

Swedish transport policy has never been static. Gradual changes have been made. However, the new transport policy decision in 1988 represents a major break in policy being effective from 1 January 1989. Therefore, operationally, we define the deregulation policy and the deregulation process as being effective as of that date. Our aim is to study the impact that the deregulation policy, defined in this way, may have had on cost efficiency.

Little is known in general about the impacts of regulatory reforms on railway efficiency. We are not aware of any paper having been focusing on the impact of regulatory reforms on cost efficiency in an in depth, single country time series analysis like the one we have done. With mainly different focus and different methodology, a few studies analyse physical efficiency measures based on panel data from European railways. Cantos Sanchez et al. (1999), analysing panel data from 1970-1995, find that vertical separation and managerial autonomy both seem to have a positive effect on efficiency. Gathon and Pestieau (1995), using panel data from 1961-1988 (prior to the deregulation period) also find that managerial autonomy impacts efficiency in a positive way. Jorge-Moreno and Garcia-Cebrian (1999), using panel data from 1984-1995, conclude that the regulatory reform has not influenced technical efficiency in a negative manner. Rather, productive efficiency of railway systems may be significantly enhanced by an institutional and regulatory framework that provides a greater freedom for managerial decision-making according to Oum and Yu (1994).

2 The Swedish deregulation process

The Swedish deregulation process was described in Bruzelius et al. (1994) and later by Alexandersson and Hultén (1999). Therefore, the process will only be briefly described here. The Transport Policy Act of 1979 aimed at creating a new institutional structure for local and regional public transport. County Public Transport Authorities (CPTA s) having the formal responsibility for bus traffic and parts of local and regional rail traffic were established in 24 counties. This was a first step towards transferring the cost responsibility from the State to the counties. The aim was also a reallocation of costs between transport modes so that the infrastructure costs would come closer to marginal costs. However, during the 1980s, the development of Statens Järnvägar (SJ), the

National State Railway monopoly, was not regarded as satisfactory by the owner. The railway law of 1985 aimed at improving the financial status of SJ and allowing SJ to act as a market-like actor in at least some respects, e.g. as a borrower in the financial markets. Important elements in the railway law of 1985 were separation of the accounting of infrastructure from that of traffic operations, the increase in total investment appropriation to SJ, and decreased central governing of SJ. However, the financial situation in SJ continued to deteriorate.

In 1988, a new transport policy decision was made. By this decision, Sweden as the first country in the world separated the construction and administration of the railway infrastructure organisationally and legally from the operation of trains. The responsibility for the infrastructure was placed in the Swedish National Rail Administration, Banverket (BV), formally founded on 1 July 1988, but considered in effective operation as from 1 January 1989[1]. The responsibility for train operations remained within SJ. Further, the railway network was segmented in main lines and county lines, and an extensive infrastructure investment programme was introduced. From the 1 of July 1990, passenger transportation rights were exclusive for SJ on main lines, but on county lines, the CPTA s were given the responsibility. Freight transportation rights were exclusive for SJ on all network parts. However, if SJ or CPTA s ceased their traffic, the new infrastructure authority BV could give the transportation right to a third party.

This made it possible for new actors to enter the market. In 1989, the first competitive tendering for passenger transport on railway in Sweden took place, and in 1990, the first new entrant started regional traffic. Encouraged by the success of American shortlines, small entrepreneurial feeder lines started in 1991. In 1992, the first tenders for passenger transport on interregional lines were held. In 1993, the rights of ore transports in Northern Sweden were transferred to the mining company LKAB. On the 1 of July 1996, BV took over traffic control and allocation of track capacity from SJ. CPTA s were given increased rights for traffic on main lines in their respective counties. In principle, free

[1] As an example, accounting in BV started on January 1, 1989

access to tracks now exists for freight train operators from 1 July 1996. However, SJ was given grandfather's right to slot times.

Since then the number of new entrants has increased, and the organisational change of the railway has been thorough. In 2001, SJ was split up in 6 State owned companies, among them SJ AB (passenger transport) and Green Cargo AB (freight transport).

Summarising, we can distinguish three main steps in the deregulation process:

- The vertical separation of infrastructure provision from traffic operations.
- The introduction of competitive tendering for passenger transports on some lines.
- The opening of the railway freight transport market.

3 Research design

We have chosen a longitudinal econometric approach in our study, and we analyse the efficiency development between 1970 and 1999 based on annual data. This section develops some methodological aspects.

3.1 Model coverage

There are two sets of train operators in the railway sector for which it seems most relevant to analyse efficiency and its development:

- SJ, the main operator and former monopolist
- All operators in the railway sector

Prior to the vertical separation of infrastructure and train operations, SJ was an integrated legal monopolist responsible for both train operation and infrastructure. The effect of the gradual opening up of the market for train operators is illustrated in Table 1.

Table 1. Number of private entrants

The cost of output from the two sets of train operators can be measured either excluding or including the costs of infrastructure services used for the production of train services. Considering both groupings of costs makes sense, since the costs of the provision of infrastructure services arise within BV. Since BV is a state-owned monopoly, the train operators cannot control these costs, so they should not be included when measuring the efficiency of train operators. Studying the two sets of train operators with and without the cost of infrastructure facilitates comparisons of efficiency between open markets for train operations and integrated sectors where actors are responsible for both train operations and infrastructure. This means that we have four segments of the sector for which cost efficiency will be analysed in this paper.

3.2 Output measure

Output from the railway sector is a multiproduct concept. There are output statistics for both passenger and freight services, but costs cannot be allocated to various types of output. Therefore, we have decided to use a composite output concept and to estimate costs per unit of this concept. We define our output concept as

Output = (Passenger kilometres) + (Freight tonnes kilometres)

This is a production-oriented output measure that has a long history in railway statistics in practice. Provided that there are no drastic systematic shifts in output volumes between passenger and freight services over time, this measure should represent output reasonably well for analysing efficiency. For a discussion of different output measures, see e.g. Oum and Yu (1994). We are interested in the effect of deregulation on cost efficiency in general and not in the effect on different train products. We have tested the composite output measure

Output = a (Passenger kilometres) + (1-a) (Freight tonnes kilometres) in our econometric models. It turns out that we get the same conclusions for all values of "a" within a reasonable interval between 0 and 1. Therefore, we have chosen (Passenger kilometres) + (Freight tonnes kilometres) as our output measure.

3.3 Data

Railway cost accounting is designed for other purposes than to satisfy data needs deriving from scientific studies. Therefore, extreme care was taken to explore the statistical data from the accounting systems in order to learn what the key data represent and how they were created. The guiding principle has been to find the correct correspondence between output, cost, and year.

Output data are taken from the annual official statistics “Sveriges Järnvägar” 1970-1992, “Järnvägar” 1993-1999, and “Bantrafik” 2000-2001, published by SJ, Banverket, and SIKA respectively.

Cost data are based on accounting costs from BV, the National Rail Administration, and all train operators of any significance, among others SJ, A-train, BK Tåg, Tågkompaniet, and MTAB. In some cases, the compilation of valid cost data has required special estimation or adjustment of the accounting data (see description below). Information sources for the compilation of cost data are official publications, internal documents from the railway organisations, and interviews with key informants within the railway organisation in addition to data from the accounting systems.

Cost data for some of the new small operators have not been available, e.g. because some of the early entrants went into bankruptcy. However, in some cases, costs were estimated on the basis of turnover. If this approximation was impossible, costs and outputs from these operators were excluded. Since they are very small, these approximations can safely be disregarded.

Before 1989, all costs arose within the monopolist, SJ. After 1988, all costs related to infrastructure became the responsibility of BV, and some costs of train operations arose within the new operators. However, the costs of the new operators are small in comparison with those of SJ's. Therefore, we have paid most attention to the compiling of relevant and valid cost data for SJ and BV. In this study, *the cost of train operations* includes all costs of a train operator except depreciation and infrastructure costs. In functional terms, *the cost of train operations* includes operating costs, maintenance costs, administration costs, and marketing costs. *The cost of infrastructure* includes all costs of an infrastructure service provider except costs of new investments and re-investments in railway tracks. This means that operating expenses, maintenance and administration all contribute to *the cost of infrastructure* as defined here. All costs have been deflated to the 2001 monetary value using PPI (Producer Price Index) as a deflator. Table 2 explains the principles for allocating costs to the four segments to be modelled in this paper.

Table 2 Coverage of costs for four segments of the railway sector.

3.4 Data adjustments and validity checks

There is almost always a need for adjusting railway accounting data before using them in econometric studies. However, the handling of such data problems is seldom reflected in the scientific literature. If data problems are not searched for, they will remain undetected. As a contribution to the knowledge about identification and adjustment of data problems in railway cost research, we summarise the problems encountered and the solutions chosen in this study:

- Until 1989, infrastructure costs are included in the costs of SJ and shown in the books of Banavdelningen (SJ's former infrastructure department). However, data are missing for the years 1977-1983. For these years, data were created using statistical interpolation methods together with some additional information from Banavdelningen, SJ Central Staff, and BV.

- Until 1981, investments in tracks and real estate were accounted for as operating costs of infrastructure. From 1981, the balance sheet was redefined, and these costs were now included, correctly, as investments not belonging to maintenance or replacement activities. As a correction, careful estimates made by a cost accountant within SJ, who is familiar with the time period, were subtracted from the infrastructure costs for the period 1970-1980 in order to follow our definitions.
- Segment 2 in Table 2 represents the development of SJ including infrastructure. For segment 2, one problem is to allocate the costs of SJ's traffic after the entry of other train operators. We have calculated SJ's relative share of BV's costs as equal to SJ's relative share of total railway traffic.
- The accounting year of SJ was shifted. By 30 June 1985, the closing of the books was shifted to follow the calendar year. Before that, SJ followed a broken accounting year ending on June 30. We have used the formula C(t) = (C(t-) + C(t+))/2 for estimating data for calendar years before 1985. In this formula, C is cost, t is calendar year t, t- is the broken accounting year ending on June 30 in year t, and t+ the broken year starting in calendar year t.
- SJ Buss and SJ Ferry became subsidiaries of SJ in 1990 and 1991 respectively, and SJ Travel Bureau was sold in 1990. Before that, they were all parts of SJ and included in the cost accounting of SJ. Their costs should be subtracted from the costs of SJ, since they do not represent any train output. However, data are missing for some years. To solve this problem, data were created for missing years by statistical interpolation.
- From 1996, the ore transport operator MTAB buys the service of 80 locomotive drivers from SJ. This is accounted for as costs in both SJ and MTAB. We have subtracted the costs of this service from the costs of SJ.
- From 1992, intermodal transports are produced by SJ, but marketed and sold by Rail Combi. The costs of administration, marketing and sales have been estimated for Rail Combi based on labour costs and added to the costs of SJ.

- From 1995, foreign transports in Sweden are accounted for as gross revenues and costs instead of being measured as contribution to profit. This has been adjusted for.

Various validity checks were made of the data adjustments and estimations described above. In cases where missing subsets of consecutive yearly data were estimated by means of statistical interpolation or extrapolation, these approximations were checked one at a time using dummy variables in models (4) – (7) below. The dummy variables were set equal to 1 for years with approximations and equal to 0 elsewhere. The coefficients of these dummies were highly insignificant and very close to 0. In connection with the vertical organisational separation of infrastructure and traffic after 1988, it is not unreasonable to suspect that "creative accounting" might have been used in order to give the new organisation a good start by taking some costs before instead of after the change. This was checked by defining a dummy variable as equal to 1 for 1988, equal to -1 for 1989, and equal to 0 elsewhere. However, when tried in the models (4) – (7) below, the coefficient of the variable representing "creative accounting" also turned out to be highly insignificant and very close to 0, which shows that no such "creative" thinking seemed to have taken place. Finally, accounting specialists at SJ have validated the figures and the methods used for compiling data for the four cases. The overall impression from the validation is that the cost data are free from systematic errors.

3.5 Two methods

For each of the four segments, we analysed the impact of the deregulation measures by means of two different methods. This made a convergent validity evaluation of some aspects of the approach possible by comparison (see Churchill (1995), p.539, about "convergent validity"):

- We specified models representing important deregulation measures in terms of independent variables by extending the basic models, estimated them on data from 1970 to 1999 using three different estimation principles, and analysed the models (Method one).

- We specified and estimated the basic models from data prior to the deregulation. Using these models, we then predicted the outcomes of the cost efficiency for the period after the start of the deregulation. In this way, we assume that we have described a scenario representing what would have happened without the shift to the deregulation policy. This scenario was then compared with the actual outcomes of costs under the deregulation policy (Method two).

3.6 Instrumental hypotheses

Econometric method gains in strength if model building can be based on hypotheses that can help to identify and define explanative variables to be included in the models and to predict the signs of estimated model coefficients. Such hypotheses may be derived from theory, prior studies, or plausible reasoning (e.g. based on experience). Our model specifications are supported by three instrumental hypotheses.

The aim of the first hypothesis is to facilitate specification of models having sufficient explanative power for our research purpose. The explanative power of various representations of traffic density in railway cost models has been demonstrated in several empirical studies such as Braeutigam et al. (1984), Graham et al. (2003), Harris (1977), Ivaldi and McCullough (2001), Keaton (1991), Keeler (1974), and Savage(1997). Although made under different conditions and using different definitions, these studies are sufficiently consistent to motivate a hypothesis on the existence of economies of traffic density in the Swedish railway sector too. The same hypothesis could be derived from general theory on economies of scale and scope. Our hypothesis calls for inclusion of a variable representing traffic density in our models.

According to Jensen (1998), there are three effects on cost from the vertical separation of infrastructure from traffic. The first one is an increase in costs due to vertical sub-optimisation in resource allocation between infrastructure and traffic. The second effect is the transaction costs caused by the separation. The third effect springs from the fact that the infrastructure, now organisationally within BV as a state monopoly, is cut off from pressure from intermodal competition. The intermodal competitive pressure, which works through the demand for freight and passenger transportation, will now exert an influence only on the train operators. This will lead to an increase in costs. The joint impact of these three effects on costs, as described by Jensen (1998), leads us to our second hypothesis: There is a cost driving effect associated with the vertical separation of infrastructure from traffic. Therefore, a variable representing vertical separation will be included in the models.

Our third hypothesis is concerned with the impact on cost efficiency from various measures taken by the regulator to increase the competitive pressure on the provision of train services. We have found no empirical railway studies giving guidance as to this impact. However, a hypothesis about negative association between competitive pressure and cost would be in accordance with general economic theory and general opinion in practice. Competitive pressure on incumbent operators originates from their perception of competitive stimuli. Stimuli can be events like market openings or market entry by new operators. Stimuli can also be generated by conditions such as number of competitors in the market or number of potential entrants. Perception can originate from both actual observations of stimuli and from expectations about their occurrence. Therefore, it is clear that there does not necessarily have to be a time lag between competitive stimuli and cost pressure. Since the number of new operators in the market is an important competitive stimulus and also probably strongly associated with other stimuli, we have found it reasonable to assume that the cost pressure in year t from all these competitive stimuli is proportional to a function of the number of new operators in the sector year t. The number of new operators can be found in Table 1 (equal to the number of private entrants). We have chosen to define this function as (number of new operators)$^{0.75}$. The choice of simultaneity is assumed to be reasonable considering the joint effects of incumbents' lead-times associated with possible competitive stimuli. Some experimentation with lagged variables in models (4) – (7) confirms this assumption.

4 Specification of models

4.1 Method one

In method one, three estimation principles have been used: separate estimation, seemingly unrelated regressions (SUR), and time-series and cross-section regression (TSCS).

4.1.1 Separate estimation

We specified the models according to the function

$$C_{kt} = \beta_{0k} + \beta_{1k}\ln TD_{kt} + \beta_{2k}VS_t + \beta_{3k}NO_t + e_{kt} \qquad (1)$$

separately for segment k, k=1, 2, 3, 4, year t. C_{kt} is the cost per unit of output. TD_{kt} is the traffic density, i.e. the sum of passenger kilometres and freight tonne kilometres divided by the length of the network in use ($TD_{1t} = TD_{2t}$, and $TD_{3t} = TD_{4t}$). VS_t is a dummy variable equal to 0 until 1988 and equal to 1 from 1989. $VS_t=0$ represents vertical integration between infrastructure and traffic operations, whereas $VS_t=1$ represents vertical separation. NO_t = (number of new operators year t)$^{0.75}$ is used to represent the cost pressure of competition, and e_{kt} , finally, is an error term. We expect the coefficients of ln TD_{kt} and NO_t to be negative and that of VS_t to be positive as a consequence of the instrumental hypotheses formulated above.

The impact of deregulation on cost efficiency in terms of our model is the joint effect of vertical separation and competitive pressure. The joint effect of these two forces is represented by ($\beta_2 VS_t + \beta_3 NO_t$) in (1).

We have used the SAS software starting with an ordinary least square (OLS) estimation of the models. If the Durbin-Watson test indicated the presence of positive first order autocorrelation at the 5% level, we included the autoregressive term $e_{kt} = \rho_k e_{k,t-1} + v_{kt}$ in the models and estimated them using maximum likelihood (ML) estimation. The error term e_{kt} is assumed to follow standard assumptions for AR(1) processes (e.g. see Pindyck and Rubinfeld (1998), p. 160). The differences between OLS and ML estimates were very small.

To analyse whether our models are structurally stable over the two regulatory regimes, we divide the data into one subset representing the integrated monopoly period (1970 -1988) and another representing regulation (1989-1999). We use a Chow test to see if the regression coefficient vector of model (1) is the same in both periods. Homoscedasticity is tested using Q and LM tests for autoregressive conditional heteroscedasticity (ARCH) as described in Johnston and DiNardo (1997). The presence of homoscedasticity was also checked by inspecting plots of observed residuals against independent variables, dependent variables, and time.

Several variations of the specification given by (1) were tried. Representing technological change by time as an independent variable in (1) did not add explanative power to the model in terms of adjusted R square, and the coefficient of the time variable turned out to be insignificant. In order to analyse the sensitivity of the composite output variable to the balance between freight and passenger transport output, we tried (freight tonne kilometres)/(passenger tonne kilometres) as an independent variable in (1). This variable did not improve the adjusted R square, and its coefficient was not significantly different from zero. This analysis validates the choice of using the composite output variable for the purpose of this study.

4.1.2 SUR and TSCS.

Capitalising on the structure of the problem and the data set, two other estimation principles were tried. One of them considers the models of the four segments represented by (1) as a system of seemingly unrelated regressions (SUR). This choice is based on the assumption that the same external factors may influence all four segments in more or less the same way leading to cross-correlation among them and also that minor elements in the cost allocation procedures could lead to cross-correlation among segments. The error term $e_{kt} = \rho_k e_{k,\, t-1} + v_{kt}$ is now specified to represent cross-section correlation and cross-section specific first order autocorrelation (v_{kt} is assumed to be uncorrelated across segments).

The choice of TSCS is motivated by similar assumptions as that of SUR. In TSCS regression, we pool the data from the four segments and 30 years into a pooled time-series cross-sectional data set of 120 observations and specify the following model:

$$C_{kt} = \beta_{01} + \theta_2 Z_{2t} + \theta_3 Z_{3t} + \theta_{4t} Z_{4t} + \beta_{11} Z_{1t} \ln TD_{1t} + \beta_{12} Z_{2t} \ln TD_{2t} + \beta_{13} Z_{3t} \ln TD_{3t} +$$

$$+ \beta_{14} Z_{4t} \ln TD_{4t} + \beta_{21} Z_{1t} VS_t + \beta_{22} Z_{2t} VS_t + \beta_{23} Z_{3t} VS_t + \beta_{24} Z_{4t} VS_t +$$

$$+ \beta_{31} Z_{1t} NO_t + \beta_{32} Z_{2t} NO_t + \beta_{33} Z_{3t} NO_t + \beta_{34} Z_{4t} NO_t + e_{kt} \qquad (2)$$

where k= 1, 2, 3, 4. The dummy variable Z_{kt} is equal to 1 for segment k, and equal to 0 for other segments. The error term e_{kt} is specified in the same way as for SUR above, in addition to also allowing for heteroscedasticity between segments. The 20 parameters in (2) have been estimated using the TSCSREG procedure in SAS with an estimation method developed by Parks(1967).

4.2 Method two

Here we estimate models of unit costs based on data for the period 1970 - 1988 according to the following specification:

$$C_{kt} = \beta_0 + \beta_1 \ln TD_{kt} + v_{kt} \qquad (3)$$

Each estimated model is then used to predict the unit cost C_{kt} in (3) for the period 1989 - 1999 by substituting real outcomes on the independent variable TD_{kt} for the prediction period into the model. This gives us cost predictions based on the cost structure prevailing prior to the deregulation. In other words, these cost predictions are interpreted as the unit costs that would have appeared given that the deregulation had never taken place. The predictions can be compared with the actual outcomes. Where applicable, the same diagnostic statistical tests for homoscedasticity were used as for model (1).

5 Estimated models

5.1 Method one

Estimated models for the four segments are presented below together with some diagnostic statistics. The standard deviations of the coefficients are stated in brackets below each model, and the t-ratios are stated on the line underneath.

Segment 1. Costs of SJ excluding infrastructure costs for the period 1970-1988:

$$C_{1t} = 1.0260 - 0.6774 \ln TD_{1t} + 0.0338\, VS_t - 0.0125\, NO_t - 0.2132\, e_{t-1} \quad (4)$$

(0.0342)	(0.0528)	(0.0158)	(0.0020)	(0.2173)
29.97	-12.82	2.14	-6.36	-0.98

R^2=0.9691

DW=1.9549

Chow=0.29

Q= 0.0000

LM=0.0062

Segment 2. Costs of SJ plus SJ's share of the costs of BV:

$$C_{2t} = 1.2249 - 0.8113 \ln TD_{2t} + 0.0511\, VS_t - 0.0132\, NO_t - 0.3054\, e_{t-1} \quad (5)$$

(0.0432)	(0.0665)	(0.0198)	(0.00253)	(0.2139)
28.36	-12.19	2.58	-5.21	-1.43

R^2=0.9646

DW=1.9207

Chow=0.23

Q=0.7641

LM=0.8483

Segment 3. Costs of all operators excluding infrastructure costs for the period 1970-1988:

$$C_{3t} = 0.9747 - 0.6468 \ln TD_{3t} + 0.0323\, VS_t - 0.0096\, NO_t - 0.3909\, e_{t-1} \qquad (6)$$

	(0.0323)	(0.0527)	(0.0166)	(0.0024)	(0.1959)
	30.18	-12.28	1.95	-4.02	-2.00

R^2=0.9740

DW=1.7521

Chow=0.93

Q=0.1882

LM=0.2370

Segment 4. Costs of all operators plus the costs of BV:

$$C_{4t} = 1.1578 - 0.7636 \ln TD_{4t} + 0.0506\, VS_t - 0.0096\, NO_t - 0.4916\, e_{t-1} \qquad (7)$$

	(0.0440)	(0.0711)	(0.0226)	(0.0034)	(0.1882)
	26.29	-10.74	2.24	-2.84	-2.61

R^2=0.9631

DW=1.6195

Chow=1.28

Q=0.2683

LM=0.2754

The models all have good explanative power with coefficients of determination exceeding 0.96, and the outcomes of the diagnostic statistics are satisfactory. The Durbin

-Watson statistics (DW) allow acceptance of the null hypothesis of no serial correlation at the 5% level for all four models. The Chow tests do not indicate structural breaks between the two sub periods from 1970 to 1988 and from 1989 to 1999. The analyses of error variances using Q and LM tests (shown) and inspection of error plots (not shown) confirm hypotheses of homoscedastic error disturbances. Overall, the estimated models seem to be of good statistical quality.

Table 3 below shows the parameter estimates, their standard errors, and t-values from the SUR and TSCS models. When comparing Table 3 with the separate estimates described in (4) – (7) above, it is apparent that all estimates are very close and consistent. The standard errors of the key parameters are slightly lower in the TSCS model. Therefore, this model is chosen as the main alternative of method one for testing the impact of vertical separation and competitive pressure.

Table 3. Estimates, standard errors, and t-values of the SUR and TSCS models.

When comparing the parameter estimates from the three estimation principles, it can be seen that all parameters have the expected signs and that their estimates are very close. They are significantly different from zero and estimated with low standard errors. Based on the TSCS estimates (Table 3), there are two main conclusions that can be drawn for the four segments. Firstly, the competitive pressure from new entrants represented by the variable NO_t has had a significant impact on the cost efficiency of the sector and of the main operator SJ. Our instrumental hypothesis about competitive pressure is statistically confirmed by one-sided tests ($p < 0.005$). Secondly, the vertical separation has raised the cost level of the sector and SJ. Our instrumental hypothesis, in this respect, is statistically confirmed with $p < 0.05$ for all segments.

In our models, the effect of deregulation is the joint effect of vertical separation and competitive pressure represented by the deregulation component $\beta_2 VS_t + \beta_3 NO_t$. Estimating (2) with and without this component and using the residuals from these two estimated versions of (2) in an F-test shows that the added explanative power from the deregulation component is statistically significant at the 0.1 per cent level. This F-test is described in e.g. Stewart (1991, p. 67). The same test has also been applied to the four separate models expressed by (1) and found significant at the 0.1 per cent level. Table 4 shows the deregulation effect represented by ratios defined as real cost per unit of output divided by predicted cost C_{kt} from the estimated models (4) – (7) for the years 1989-1999[2]. The predicted costs are calculated from the models with $VS_t = 0$ and $NO_t = 0$ for the prediction period and interpreted as the costs that would have appeared without the deregulation. Ratios less than one are interpreted as improved cost efficiency from deregulation. The F-tests together with the ratios of Table 4 prove the significant positive impact on cost efficiency from the deregulation component $\beta_2 VS_t + \beta_3 NO_t$.

Table 4

5.2 Method two

The four models were estimated separately using both OLS and SUR. The estimates from the two approaches were very equal in terms of parameter estimates and standard errors. Therefore, we base our results on the OLS estimates.

<u>Segment 1.</u> Costs of SJ excluding infrastructure costs for the period 1970-1988:

$$C_{1t} = 1.0471 - 0.7106 \ln TD_{1t} \qquad (8)$$

(0.0308) (0.0478)

34.03 -14.88

$R^2 = 0.9287$

DW=1.5132

<u>Segment 2.</u> Costs of SJ plus SJ's share of the costs of BV:

$$C_{2t} = 1.2514 - 0.8537 \ln TD_{2t} \qquad (9)$$

[2] Models (4) – (7) were used instead of the TSCS model due to the limited calculation capability of TSCS in the SAS system

(0.0376) (0.0584)

33.25 -14.62

R^2=0.9263

DW=1.2355

<u>Segment 3.</u> Costs of all train operators excluding infrastructure costs for the period 1970-1988:

$$C_{3t} = 0.9857 - 0.6657 \ln TD_{3t} \tag{10}$$

(0.0223) (0.0370)

44.11 -17.98

R^2=0.9500

DW=1.5238

<u>Segment 4.</u> Costs of all train operators plus the costs of BV:

$$C_{4t} = 1.1764 - 0.7976 \ln TD_{4t} \tag{11}$$

(0.0300) (0.0497)

39.23 -16.06

R^2=0.9381

DW=1.1619

Table 5 shows effectiveness ratios from method 2 defined as real costs per unit of output divided by their predicted counterparts computed from models (8) to (11), quite in analogy with those of Table 4.

Table 5.

5.3 Comparing deregulation effectiveness between methods

The efficiency ratios in Tables 4 and 5 are based on two different methods. Corresponding ratios are almost identical between tables, an outcome indicating the presence of convergent validity. The ratios are greater than one during the first years after the vertical separation, which means that the deregulation is ineffective at first, thus supporting a hypothesis put forward by Jensen (1998). Then, the ratios drop below one with a few minor exceptions, a development that has been interpreted here as an impact from the increasing competitive pressure created by the deregulation.

The development has not been uniform between segments. The deregulation has been more effective in improving the cost efficiency of SJ than that of the entire sector and also more effective in improving the cost efficiency of train operations than that of train operations and infrastructure. Average ratios for the years 1989 to 1999 for segments 1-4 are 0,94; 0,98; 0,96; 1,01 when calculated from Table 4, and 0,95; 0,99; 0,97; 1,02 when calculated from Table 5. These figures indicate, that for the sector, including costs of infrastructure (segment 4), the deregulation seems to have been ineffective. However, the corresponding average ratios for the period 1993-1999 are 0,88; 0,92; 0.90; 0,95 (from Table 4) and 0,89; 0,93; 0,91; 0,97 (from Table 5). The ratios from the latter period show that the trend is positive. During these years, the deregulation seems to have been effective for all segments, even for the entire railway sector including costs of infrastructure.

6 Conclusions and discussion

6.1 On the effectiveness of the deregulation policy

The methodology used in this study makes it possible to predict unit costs of output under the assumption that the old policy had continued and thus to compare unit costs under new and old policies after 1988. In the analysis that follows, the resulting numbers are based on Tables 4-5 and the average ratios from section 5.3.

The deregulation policy does not seem to have been effective over the period 1989-1999 on the entire railway sector including costs of both train operations and infrastructure service provision. Our figures indicate a slight increase in unit cost of output by 1-2% (based on average effectiveness ratios over the period) compared with the unit cost that would have occurred had the old policy been continued. However, making the same kind of comparison over the period 1993-1999, the deregulation policy seems to have been effective resulting in a decrease of unit cost by 3-5%, so the trend appears to be positive. Taking the costs of train operation in the entire sector, unit costs have been reduced, on average, by 3-4% during 1989-1999 and by 9-10% during 1993-1999 compared with the likely outcome of the old policy. The fact that the trend is more positive for the operation of trains than for train operation and infrastructure service provision is quite logical, since only train operation is under competitive pressure.

Making the same analysis for the main operator SJ, we found that the unit cost of output including train operations and infrastructure service provision has been reduced, on average, by 1-2% over the period 1989-1999 and by 7-8% during 1993-1999. Restricting attention to the unit cost of train operation only, the improvement in unit costs, on average, has been 5-6% during 1989-1999 and 11-12% during 1993-1999. It is important to notice once again that the improvements are expressed in per cent of the unit costs that can be predicted given that the railway sector had been run under the old policy.

6.2 On vertical separation and competition-enhancing measures

In Swedish railway policy, vertical separation of infrastructure and train operations is regarded as a necessary prerequisite for the introduction of competition in the sector. The separation as such has contributed to a statistically significant increase in unit costs that may be due to both temporary costs of re-structuring the sector and on a more permanent change of cost level. The new monopoly role of the infrastructure provider with reduced exposure to external competition may represent a new cost level (see Jensen, 1998). However, the introduction of various competition elements in the railway sector, which was made possible by the vertical separation of infrastructure from the operations of trains, seems to have had a statistically significant positive impact on cost efficiency in the production of train services by train operators. The reduced cost efficiency from the vertical separation is more than compensated for by the increased cost efficiency of operators' production of train services due to increased competitive pressure, and the latter impact seems to have a positive trend.

6.3 On the contribution to efficiency of the deregulation policy

In the general debate, there is a tendency to attribute the reduction in costs since 1988 to the deregulation policy. It is not realised that part of the cost reduction most probably would have occurred anyway. Taking the unit cost of output of the entire railway sector from 1988 as an example and comparing it with the average unit cost of output between 1993 and 1999, the reduction was 19 % for train operations and infrastructure service provision and 23 % for train operations only. However, as can be calculated from Table 4, only 5 % and 10 % respectively of these cost reductions seem to be an effect of the deregulation policy. The remaining 14 % and 13 % would have occurred also under the old railway policy. For SJ, the corresponding nominal reductions are 14 % and 17%, but only 8 % and 12 % respectively seem to be assignable to the deregulation policy. The remaining 6% and 5% probably would have occurred also under the old policy. These figures should, of course, be interpreted with caution, but it seems safe to say that more than half of the improvement of the cost efficiency of the entire railway sector would have occurred also with the old railway policy.

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Tables

Table 1. Number of private entrants

Year	Number of private train operators in passenger transports	Number of private train operators in freight transports
1990	1	0
1991	1	0
1992	1	0
1993	4	5
1994	2	8
1995	3	10
1996	4	11
1997	4	13
1998	4	13
1999	5	12

Source: SIKA *Järnvägar 1993-1999*.

Table 2. Coverage of costs for four segments of the railway sector

Vertical coverage	Train operators	
	SJ, the main operator	All operators
Train operations	Segment 1. Costs of SJ excluding infrastructure costs for the time period 1970-1988.	Segment 3. Costs of all train operators excluding costs of infrastructure for the time period 1970-1988.
Infrastructure provision and train operations	Segment 2. Costs of SJ plus SJ's share of the costs of BV.	Segment 4. Costs of all train operators plus the cost of BV.

Table 3. Estimates, standard errors, and t-values of the SUR and TSCS models

Segment	Parameter	SUR				TSCS			
		Estimate	Standard error	t-value	R^2	Estimate[3]	Standard error	t-value	R^2
1	β_{01}	0.9706				0.9696			
	β_{11}	-0.5933	0.0468	-12.67		-0.5883	0.0357	-16.46	
	β_{21}	0.0233	0.0168	1.39		0.0204	0.0129	1.58	
	β_{31}	-0.0131	0.0025	-5.20		-0.0132	0.0017	-7.58	
	ρ_1	0.5286				0.1998			
					0.9648				
2	β_{02}	1.1489				1.1508			
	β_{12}	-0.6924	0.0566	-12.24		-0.6946	0.0450	-15.44	
	β_{22}	0.0357	0.0200	1.78		0.0364	0.0161	2.26	
	β_{32}	-0.0142	0.0030	-4.79		-0.0144	0.0022	-6.60	
	ρ_2	0.5091				0.2816			
					0.9597				
3	β_{03}	0.9208				0.9189			
	β_{13}	-0.5581	0.0469	-11.90		-0.5531	0.0382	-14.49	
	β_{23}	0.0237	0.0170	1.40		0.0231	0.0136	1.70	
	β_{33}	-0.0114	0.0027	-4.23		-0.0119	0.0020	-5.99	
	ρ_3	0.5852				0.4003			
					0.9705				
4	β_{04}	1.0927				1.0912			
	β_{14}	-0.6544	0.0600	-10.92		-0.6538	0.0490	-13.34	
	β_{24}	0.0391	0.0221	1.77		0.0414	0.0176	2.35	
	β_{34}	-0.0120	0.0035	-3.44		-0.0122	0.0027	-4.60	
	ρ_4	0.5666				0.4898			
					0.9592				

[3] In this column, β_{0k} is equal to $\beta_{01} + \theta_k$ from equation (2) for k= 2,3,4.

All	0.9754

Table 4. Real unit costs per year divided by predicted unit costs for the period 1989 to 1999, models (4)-(7), VS=0 and NO=0

Year	Segment 1 SJ excl. infra	Segment 2 SJ incl. infra	Segment 3 All train operators excl. infra	Segment 4 All train operators incl. infra
1989	1,05	1,07	1,06	1,08
1990	1,11	1,15	1,15	1,19
1991	1,03	1,04	1,09	1,10
1992	1,03	1,06	1,00	1,02
1993	0,88	0,90	0,82	0,82
1994	0,89	0,92	0,88	0,92
1995	0,96	1,01	0,92	0,95
1996	0,93	0,97	0,94	0,99
1997	0,83	0,89	0,90	0,99
1998	0,85	0,88	0,93	0,98
1999	0,83	0,89	0,94	1,02

Table 5. Real unit costs per year divided by predicted unit costs for the period 1989 to 1999

Year	Segment 1 SJ excl. infra	Segment 2 SJ incl. infra	Segment 3 All train operators excl. infra	Segment 4 All train operators incl. infra
1989	1,07	1,09	1,07	1,10
1990	1,11	1,15	1,13	1,17
1991	1,04	1,07	1,10	1,12
1992	1,05	1,08	1,02	1,06
1993	0,90	0,93	0,86	0,88
1994	0,91	0,94	0,90	0,94
1995	0,96	1,01	0,92	0,97
1996	0,93	0,97	0,94	1,00
1997	0,84	0,89	0,91	1,00
1998	0,85	0,88	0,93	0,99
1999	0,83	0,89	0,94	1,02