European Railway Comparisons: Lessons for Policy

John Preston and Chris Nash
Institute for Transport Studies, University of Leeds
Leeds, England

1. Introduction

This paper reviews recent empirical work on the costs and productivity of western European railways and examines the relevance of this quantitative work to the policy debate concerning the ownership and organization of railways. In a companion paper, we examine this policy debate, particularly as it concerns Britain, from a more qualitative perspective (Nash and Preston, 1993).

The background to our work in this area is as follows. The Institute for Transport Studies (ITS), University of Leeds, and the British Railways Board (BRB) carried out a comparative study of western European railways in the late 1970s (BRB and University of Leeds, 1979). Follow-up work by ITS was financed by the Social Science Research Council and reported by Nash (1985). Given that it was over ten years (1981) since the last set of comparisons were undertaken at ITS, it was felt appropriate to revive this work at ITS. At least three factors influenced our thinking.

Firstly, there has been increased interest in the organizational structure of railways since our last study. This has stemmed from monitoring the deregulatory effects of the 1980 Staggers Act in the US and subsequently the corporatization of the Japanese and New Zealand railways and privatization of the Argentinean railways. This interest is reflected in Europe and manifested by the 1988 Transport Act in Sweden; the EC directive 91/440 promoting open access and vertical separation of infrastructure and operations (at least in terms of accounts); and the publication in July 1992 of a White Paper proposing privatization of British Rail (see, for example, ECMT, 1993).

Secondly, there have been a number of technical developments since our last study that make the use of statistical cost analysis more promising. Total factor productivity measurement was advanced by the work of Caves et al. (1982) on North American rail roads and has recently been applied to Australian railways (Hensher et al., 1992). The use of the translog cost function, and its comparison with less flexible functional forms, was advanced by Caves et al. (1985), again using North American rail road data. Translog cost models have also been developed for Britain using historical data for 1900 to 1912 (Dodgson, 1993), for Eire using time-series data (McGeehan, 1993), and for Switzerland using pooled cross-sectional and time-series data for 48 'private' railways (Filippini and Maggi, 1992). Oum and Yu (1991) used an operations research technique, data envelopment analysis, to compare the passenger railways of Europe with those of Japan, Korea, North America, and Australia.

Thirdly, we hoped that the information technology explosion would lead to better data in terms of both quantity and quality. To some extent this was true, but other trends, notably commercialization and organizational reform, meant that for many railways this data was limited to internal use.

Our work involved two main strands. Firstly, detailed cost and productivity data for 1990 were obtained from the 13 European state railways listed in Table 1. Nine were also studied in the 1979 study. Each of the 13 operators was approached on a Chairman to Chairman basis. All operators agreed to co-operate, and detailed questionnaires were returned by all operators, although in many cases the amount of information provided was limited. The results of this survey are discussed in section two. The question-naires have been supplemented by face to face interviews with twelve operators. These interviews provided useful information on the institutional, managerial, and financial structures of the rail operators, and the

Table 1: Railways Included in the Study

Acronym	Name	Country
BR	British Rail	Great Britain *
CFF	Chemins de Fer Federaux Suisses	Switzerland
CIE	Coras Iompair Eireann	Eire
DB	Deutsche Bundesbahn	West Germany *
DSB	Danske Statsbaner	Denmark *
FS	Ente Ferrovie dello Stato	Italy *
NS	Nederlandse Spoorwegen	Netherlands *
NSB	Norges Statsbaner	Norway *
OBB	Osterreichische Bundesbahn	Austria
RENFE	Red Nacional de los Ferrocarriles Espanoles	Spain
SNCB	Societe Nationale des Chemins de fer Belges	Belgium *
SNCF	Societe Nationale des Chemins de fer Francais	France *
SJ/BV	Statens Jarnvager/Banverket	Sweden *

* Studied also in 1979.

degree of regulation that they face in the passenger and freight markets. This work is reported in detail elsewhere (Preston and Nash, 1992). Secondly, data published by the Union Internationale des Chemins de fer (UIC) was collated and analyzed to determine economies of density and scale. This work is described in detail in section three.

2. Cost and Productivity Analysis

In making comparisons between European railways, we face a number of problems (see, for example, Nash and Preston, 1992). European railways have a more diverse range of outputs than, say, North American rail roads. Wherever possible we attempt to distinguish between the passenger and freight businesses, although data limitations often prevent this. Government policy differs greatly from country to country, making comparisons of demand related output measures difficult. Similarly, the variety of geographical circumstances, such as area (affecting length of haul), population density (affecting passenger demand) and industrial structure (affecting freight demand) make comparisons difficult. These factors need to be borne in mind when making comparisons. Lastly, there are difficulties in measuring factor prices, due to different currencies, standards of living, and taxation systems. We attempt to overcome these problems by converting to pounds sterling through the use of purchasing power parity rates. These may be thought of as shadow exchange rates that take into account cost of living differentials (see, for example, Kravis et al., 1978).

In comparing the 13 railways in our 1990 sample we developed a series of indices as follows:

$$\frac{\text{Receipts}}{\text{Traffic Units}} \cdot \frac{\text{Traffic Units}}{\text{Train Kms}} \cdot \frac{\text{Train Kms}}{\text{Staff Numbers}} \cdot \frac{\text{Staff Numbers}}{\text{Staff Costs}} \cdot \frac{\text{Staff Costs}}{\text{Total Cost}} = \frac{\text{Receipts}}{\text{Total Costs}}$$

Our detailed results are reported in Preston et al. (1993), and the key indices are given by Table 2. Of these indices, we would classify Train Km/Staff Nos as being the key measure of operating performance, Receipts/Traffic Units and Traffic Units/Train Kms as measures of commercial performance, and Receipts/Total Costs as a measure of financial performance. Staff Nos/Staff Costs and Staff Costs/Total

Table 2: Key Indicators for 13 European Railways (1990)

	Receipts/ Traffic Unit (pence per km)	Traffic Unit/ Train km	Train km/ Staff Numbers	Staff Costs/ Staff Numbers	Staff Cost/Total Cost	Receipts/ Total Costs
BR	5.8	113.97	3193	15054	0.59	0.82
CFF	3.9	158.11	3033	21197	0.57	0.51
CIE	3.7	127.48	2693	12804	0.48	0.45
DB	4.3	173.76	2559	26296	0.61	0.44
DSB	4.3	119.27	2709	13360	0.43	0.45
FS	2.4	212.34	1568	21332	0.44	0.16
NS	3.2	120.45	4484	18711	0.50	0.46
NSB	3.5	127.29	2504	13596	0.60	0.49
OBB	3.4	181.48	1750	14935	0.49	0.35
RENFE	2.6	170.64	3459	19473	0.54	0.42
SJ/BV	2.2	249.23	3501	14844	0.45	0.59
SNCB	3.0	96.94	3402	24591	0.68	0.27
SNCF	3.4	234.66	2413	18729	0.49	0.50

Traffic Unit = Passenger Km and Freight Tonne Km

Costs are best regarded as largely determined by factor prices.

In terms of receipts per traffic unit, BR has the highest rates at 5.8 pence per traffic unit km and SJ has the lowest rates at 2.2 pence per traffic unit. However, the use of a homogenous traffic unit is misleading. European railways vary greatly in their mix of output. For example, at one extreme 78 percent of NS's traffic units are passenger kms, whilst, at the other extreme, the corresponding figure for SJ is 24 percent. Table 3 illustrates the point further by providing information for the seven railways where receipts have been disaggregated by the passenger and freight businesses. SJ's low receipts per traffic unit are due to very low freight rates (around one pence per tonne km), which in turn are due to product mix (low value products such as iron ore and timber are important) and length of haul. In fact, SJ has relatively high receipts per passenger km.

High receipts per traffic unit lead to low load factors (traffic units per train km) and vice versa. BR has the second lowest load factor of the 13 railways with only SNCB having lower. SJ has the highest load factor, followed by SNCF and FS. However, aggregating passenger and freight traffics masks important differences. BR's and SNCB's low load factors are due to low passenger loadings, which are related to operating relatively short, frequent trains. SJ's high overall loading is due to freight; its passenger loadings are relatively low and are surpassed by SNCF and FS by a large margin.

Train km per staff shows a large variation. Staff in the most productive railway (NS) produce over 2.5 times the output of the staff in the least productive railway (OBB). Earlier work has suggested that there are large differences in the labor productivity of passenger and freight operations with the latter requiring more labor input per train km due to loading/unloading, marshalling, etc. Previously, we have recommended that passenger operations only require 45 percent of the staff of freight operations and should be weighted accordingly (Nash, 1985). However, only two railways in our sample have allocated staff between the passenger and freight businesses. Of these, SNCB confirms to our earlier findings in that passenger staff are 76 percent more productive than freight staff. However, in the case of BR, freight staff are 150 percent more productive than passenger staff. Our earlier finding may not be appropriate for those

Table 3: Receipts/Traffic Unit for Seven European Railways (1990)

	Passenger (pence per km)	Freight (pence per tonne km)	Parcels (pence per tonne km)
BR	6.2	4.2	-
CIE	3.7	3.8	-
DSB	4.0	5.3	-
NS	3.5	2.1	-
NSB	3.8	2.8	127.1
OBB	2.9	3.7	-
SJ	5.2	1.2	196.4
SNCB	2.9	2.5	-

Table 4: Utilization of Traction Units Kilometres per annum (Excludes Shunt)

	Diesel loco km/ Diesel loco	Electric loco km/ Electric loco	DMU Vehicle km/ DMU vehicle	EMU vehicle km/ EMU vehicle
BR	69571	164483	63624	21863
CFF	2904	79294	N-A	92415
CIE	97373	N-A	N-A	24600
DB	30230	165010	43309	23152
DSB	131244	189000	65242	21572
FS	17814	109288	43631	42999
NS	6987	170089	51783	48049
NSB	32910	123705	45136	50057
OBB	22796	105703	61649	28079
RENFE	61378	115452	65608	101652
SJ	9819	121952	69630	31701
SNCB	74119	108160	68417	59570
SNCF	18075	120608	40509	21113
N-A = Not Applicable, DMU = Diesel Multiple Unit, EMU = Electric Multiple Unit.				

railways that have restructured their freight businesses to concentrate on bulk trainload movements from private siding to private siding, involving mechanized handling and a no-shunt policy.

Table 4 shows that there are large variations in traction unit utilization, although this is partly explained by differing fleet composition and product mix. For example, the low utilization of diesel locomotives by CFF represents their use as back-ups in the case of the failure of the electric railway. The low level of utilization of Electric Multiple Units by BR, DSB, and SNCF reflects their use in serving the London, Copenhagen, and Paris commuter markets with their heavily peaked demands.
In terms of annual staff costs per staff member, DB workers have the highest annual salary with a mean of £26,296 and CIE workers have the lowest mean salary at £12,804. However, this masks large variations in hours worked per staff per annum. The average BR employee works 2,472 hours per annum, compared to 1,458 hours per annum for the average SJ and BV employee. The up-shot of this is that average hourly salary costs range from £5.37 an hour for CIE to £17.46 an hour for DB.

In terms of staff costs as a proportion of total costs, the highest figure is recorded by SNCB (68 percent) and the lowest by DSB (43 percent). In part, this reflects treatment of capital costs. Depreciation (based on historic costs) and interest account for only six percent of BR's costs but 29 percent of DSB's costs. The percentage of costs accounted for by supplies and services, other than fuel, is also highly variable being 34 percent for OBB but only five percent for NSB. This partly reflects differences in accounting conventions.

In terms of our last index, receipts divided by total costs, BR has the highest cost recovery ratio (82 percent) and FS the lowest (16 percent). Our measure in Table 2 is based on data for the rail business only. If data from non-rail businesses are included, the mean cost recovery ratio for our sample of 13 firms increases from 46 percent to 63 percent, indicating that non rail businesses are generally much more profitable than rail.

In Table 5, two of our indices are compared for 1977 and 1990 for nine railways. In terms of receipts divided by operating costs, there is a mixed performance with four railways increasing this ratio (led by BR, up 22 percent) and five railways decreasing this ratio (with FS and SNCB the worst performers, both down 38 percent). In terms of staff productivity (as measured by train km per member of staff), there is a rather better picture with the nine railways increasing productivity by 24 percent during the period (equivalent to a 1.7 percent increase per annum). The best performers in this respect have been SNCB (up 89 percent) and DB (up 46 percent). The smallest increase was for NS (up one percent), but as this railways is by far the most productive in our sample, this may just indicate that efficiency gains have been exhausted for this operator.

3. Economies of Density and Scale

In addressing this issue, a data set has been developed for 13 railways for 1977 to 1990 based on UIC data. This sample is as in Table 1 except the railway of Finland (VR) replaces that of Spain (RENFE), although work is currently in progress to include RENFE in the data base. This work is described in detail by Aldridge and Preston (1992) building on earlier work by Vigoroux-Steck (1989). The main variables developed are listed in Table 6. A number of points should be stressed.

Firstly, our analysis concentrates on operating costs only due to difficulties concerning the comparability of published data concerning depreciation, capital stock, and interest. This is a major shortcoming of our work so far and must be borne in mind when considering our results concerning economies of scale and density. We can only speculate as to how the omission of capital costs has affected our results. Studies of North American railroads (such as Friedlaender et al., 1993) have been able to include capital costs due to the availability of reasonably consistent data. Friedlaender et al. found that North American railroads were overcapitalized, but, if capital is adjusted in an optimal manner, returns to density may increase. They concluded that returns to density may not be a transitory phenomenon due to excessive capital but an inherent feature of rail technology.

Secondly, we concentrate on a supply related output measure, train-kms. This is because demand related measures, such as passenger-kms and freight tonne-kms, are affected by differing government policies concerning fare levels, services operated, and the degree of competition, and, therefore, may be poor measures of managerial performance.

Thirdly, our data is made comparable between time periods by expressing costs in 1990 prices and is made comparable between countries by converting to pounds sterling by making use of purchasing power parities referred to earlier.

Table 5: Comparison of Receipts/Operating Cost and Train Km/Staff Nos (1977 and 1990)

	Receipts/Operating Cost			Train Km/Staff Nos		
	1977	1990	% change	1977	1990	% change
BR	0.71	0.87	+22.5	2417	3193	+32.1
DB	0.61	0.52	-14.8	1750	2559	+46.2
DSB	0.61	0.64	+4.9	2242	2709	+20.8
FS	0.32	0.20	-37.5	1411	1568	+11.1
NS	0.55	0.59	+7.3	4429	4484	+1.2
NSB	0.60	0.54	-10.0	2266	2504	+10.5
SJ	0.83	0.72	-13.3	2830	3501	+23.7
SNCB	0.50	0.31	-38.0	1800	3402	+89.0
SNCF	0.55	0.64	+16.4	2096	2413	+15.1
Mean	0.59	0.56	-5.1	2360	2926	+23.9

The analytical method we choose to use is the transcendental logarithmic (translog) cost function which takes, in our case, the general form:

$$Ln\ RTC = \alpha_0 + \sum_i \alpha_i Ln\, Y_i + \sum_j \beta_j\ Ln\ P_j + \frac{1}{2} \sum_i \sum_k \delta_{ik}\ Ln\ Y_i\ Ln\ Y_k$$
$$+ \frac{1}{2} \sum_j \sum_m \gamma_{jm}\ Ln\ P_j\ Ln\ P_m + \sum_i \sum_j \rho_{ij}\ Ln\ Y_i\ Ln\ P_j + \sum_n \theta_n\ D_n + \phi_p\ T + \varepsilon$$

where
- $Y_{i,k}$ = Output measures (TKT, %TKP, LL, DEN)
- $P_{j,m}$ = Factor price measures (WM, WE, WV)
- D_n = Railway specific dummy variables
- T = Time trend variable
- ε = Error term

Exploratory analysis undertaken by Vigoroux-Steck using ordinary least squares resulted in the model given in Appendix One. The variables used are defined in Table 6. The model involved the estimation of 41 parameter values, of which 11 were insignificant at the 10 percent level. From this model the elasticity of cost with respect to size of output (train km), holding density constant, could be calculated as:

$$\eta_s = \frac{\partial\ Ln\ RTC}{\partial\ Ln\ TKT}$$

with returns to scale (RTS) estimated as $1/\eta_s$ and constant returns where $\eta_s = 1$.
Similarly, the elasticity of cost with respect to traffic density, holding train km constant, was calculated as:

$$\eta_d = \frac{\partial\ Ln\ RTC}{\partial\ Ln\ DEN}$$

Returns to density (RTD) were estimated as $1 - \eta_d$, with constant returns where $\eta_d = 0$.

These initial results are given by Table 7. In terms of returns to density, two railways exhibit decreasing returns (RTD < 1). These two railways (CFF and NS) have high traffic densities with in excess of 40,000

Table 6: Table Six: Definition of Key Variables

RTC	Railway Total Operating Costs (excludes depreciation and interest charges (£ million)
WM	Price of labor (£ per employee) calculated as salary costs divided by staff numbers
WE	Price of energy (£ per thousand train km) calculated as energy costs divided by total train km
WV	Price of materials and services (£ per thousand train km) calculated as materials and services costs divided by total train km
TKT	Total Train km for all types of traction (thousands)
%TKP	Percentage of Total Train km operated by passenger services
LL	Length of route at the end of year (km)
YEAR	Time trend variable
DEN	Traffic Density (TKT/LL)
DBR	Dummy Variable for British Rail
DCFF	Dummy Variable for Chemins de Fer Federaux Suisses etc

train km per line km per annum. Two other railways (DSB and SNCB) exhibit constant returns to density (RTD = 1), whilst all other railways exhibit increasing returns to density (RTD > 1). These include the large state operators (BR, DB, FS, and SNCF), the Nordic operators (NSB, SJ and VR) and the lightly used CIE and, to a lesser extent, OBB networks.

The pattern that emerges is that the larger railways (BR, DB, FS, SJ and SNCF) have decreasing returns to scale (RTS < 1), whilst the smaller railways (CFF, CIE, DSB, NS, NSB, and SNCB) have increasing returns to scale (RTS > 1). Two medium sized railways (OBB and VR) exhibit approximate constant returns to scale (RTD ≈ 1). This suggests that optimal network size may be around 5,000 to 6,000km. This might suggest that the BR network could be split into three units, the DB network could be split into five units, and the SNCF network could be split into six units.

The findings from the exploratory analysis concerning returns to scale and density seemed plausible. The interpretation of the operator dummy variable also has some plausibility indicating that OBB, SNCB, and FS were cost inefficient. However, the finding that, all other things being equal, BR's costs were 40 percent greater than those of VR was not thought to be plausible.

Further analysis was therefore undertaken. This involved four main amendments. Firstly the data was up-dated from 1987 to 1990 and re-indexed to incorporate the most recent information on international prices. Secondly, the cost model was constrained to ensure linear homogeneity of degree one in factor prices, so that if all factor prices increase by 10 percent, costs increase by 10 percent. This was done by introducing the following constraints:

$$\sum_j \beta_j = 1; \quad \sum_j \gamma_{jm} = \sum_m \gamma_{jm} = 0; \quad \sum_i \rho_{ij} = \sum_j \rho_{ij} = 0$$

The constrained model was estimated using the Statistical Analysis Systems computer package (SAS, 1988) with the restrictions imposed by the method of Lagrangian parameters associated with Pringle and Raynor (1971). We have not, at this stage, made use of the cost share equations implied by Shepard's lemma to improve the efficiency of the estimation. Thirdly, problems of heteroscedasticity introduced by the use of pooled time-series and cross-sectional data weres reduced by re-defining variables around the sample mean as suggested by Mundlack (1978). Fourthly, the RTD and RTS measures were redefined to

Table 7: Returns to Density and Scale - Exploratory Results

Operator	Network size (km)	Network density (train km per line km)	RTD	RTS	Operator Comparisons
BR	16584	26837	1.45	0.86	1.40
CFF	2978	41099	0.88	1.35	1.48
CIE	1944	7323	1.30	1.51	0.90*
DB	26949	22405	1.72	0.78	1.46
DSB	2344	22252	0.99	1.45	1.19
FS	16066	19560	1.56	0.83	1.60
NS	2798	41928	0.80	1.46	1.07*
NSB	4044	9076	1.55	1.15	0.94
OBB	5624	20839	1.44	0.96	1.97
SJ	10801	9225	1.83	0.88	0.79
SNCB	3479	26675	1.07	1.23	1.75
SNCF	34070	14314	1.96	0.72	0.99*
VR	5867	6993	1.79	1.04	1.00

* The corresponding dummy variable was insignificant at the 10 percent level.

be consistent with other studies, principally Caves et al. (1985). The measure of RTD used by Vigoroux-Steck was a long run one in that to increase density, given constant total train km, track length must be reduced. A more common, short run, measure of density examines the changes in costs as a result of changes in total train kms given constant track length. Thus, in our further analysis the variable DEN was replaced by LL. The resultant model is in Appendix Two. It should be noted that 14 out of 41 parameters are insignificant at the 10 percent level, including the LL first order term and five out of six cross terms. With this model we define:

$$\eta_1 = \frac{\partial \text{ Ln RTC}}{\partial \text{ Ln TKT}} \quad ; \quad \eta_2 = \frac{\partial \text{ Ln RTC}}{\partial \text{ Ln LL}}$$

$$\text{RTD} = 1/\eta_1 \quad ; \quad \text{RTS} = 1/(\eta_1 + \eta_2)$$

The results of this further analysis are given by Table 8. In terms of returns to scale, our models suggest the largest railways (BR, DB, FS, SJ, and SNCF) exhibit decreasing returns but are now joined by the medium sized railways (NSB, OBB, and VR). The smaller railways have increasing returns to scale with the anomalous exception of the smallest railway in our sample (CIE), which exhibits constant returns to scale.

In terms of return to density, the most densely used railways (CFF, NS) continue to exhibit decreasing returns, whilst DSB and SNCB continue to exhibit broadly constant returns. All other railways exhibit increasing returns to density. In the case of SJ and VR these economies of density are such that the elasticity of rail costs with respect to train kilometers is the wrong sign.

In terms of operators' comparisons, the results appear more plausible. All other things being equal, only SJ's operating costs are lower than VR's (by four percent). A number of railways have significantly higher operating costs than VR, including NSB (by one percent), NS (by six percent), BR, CFF and DSB (by eight percent), FS (by nine percent), and SNCB and OBB (by 13 percent). All other operators' costs are

Table 8: Returns to Density and Scale - Further Results

Operator	η_1	η_2	RTS	RTD	Operators Comparisons
BR	0.66	0.68	0.74	1.50	1.08
CFF	1.25	-0.49	1.30	0.80	1.08
CIE	0.28	0.74	0.97	3.57	1.02*
DB	0.46	1.04	0.66	2.17	1.05*
DSB	0.93	-0.10	1.20	1.08	1.08
FS	0.47	0.96	0.70	2.11	1.09
NS	1.29	-0.55	1.36	0.75	1.06
NSB	0.16	0.97	0.88	6.19	1.01
OBB	0.75	0.37	0.88	1.33	1.13
SJ	-0.06	1.47	0.71	n.a.	0.96
SNCB	0.96	-0.07	1.12	1.04	1.13
SNCF	0.08	1.59	0.60	12.11	0.98*
VR	-0.17	1.44	0.79	n.a.	1.00

* The corresponding dummy variable was insignificant at the 10 percent level.
n.a. Not appropriate

broadly the same as VR. This suggests that most of the big differences in operating cost performance are explained by geography (which determines the scale and density of operations) and factor prices. It should also be noted that the proportion of total costs that are defined as operating costs varies in our sample from 94 percent (BR) to 71 percent (DSB) with the figure for VR being around 82 percent. An analysis that takes into account capital costs could give different results.

4. Conclusions

Our conclusions concern two broad areas: methodology and policy. In terms of methodology, we have illustrated the difficulties in making European comparisons. Despite our hopes, these difficulties do not appear to be easing with time. Our work with the translog model has raised concerns about the robustness of this analytical approach given the large number of insignificant parameter values and the sensitivity of the results to model definition. In future work, we propose to undertake statistical tests to analyze this.

Despite methodological concerns, some policy implications emerge. Western Europe's largest railways (networks of 10,000 km plus) appear to exhibit decreasing returns to scale and increasing returns to density. Some down-sizing may be sensible. Our results are less unequivocal about increasing returns to scale, but railways with less than 3,000 km of route may be below the point of minimum efficient scale. For BR, this might suggest a split into five units might be possible. It might be argued that this has already happened through commercialization of BR (sectorization) whereby BR was reorganized into five vertically integrated business sectors (InterCity, Network SouthEast, Regional, Trainload Freight and Railfreight Distribution). The 20 plus passenger units and several freight companies currently proposed by the White Paper (Cm 2012, 1992) seems excessive.

Western Europe's most densely used rail systems (NS and CFF) exhibit diseconomies of density. Given this, the very high levels of rail investment per capita proposed in these two countries may be sensible (see Table 9).

Table 9: Estimates of Future Investment 1993-2000 (1990 prices)

		Investment (£m) Track & Signalling	Rolling Stock	Total	Per capita investment per annum (£)
BR	Great Britain	4240	3760	8000	17.5
CFF	Switzerland	2150	1420	3560	67.4
CIE	Eire	N-A	N-A	40	1.4
DB	West Germany	10400	3660	14060	28.7
DSB	Denmark	1030	630	1660	40.5
FS	Italy	15500	1720	17220	37.5
NS	Netherlands	4050	1580	5630	47.8
NSB	Norway	500	350	850	25.3
OBB	Austria	2040	530	2570	42.3
RENFE	Spain	N-A	N-A	11520	36.8
SJ/BV	Sweden	990	310	1300	19.1
SNCB	Belgium	1280	450	1730	21.8
SNCF	France	9600	2770	12370	27.7

Adapted from: Department of Trade and Industry (1990) "West European Railway Component Study - Volume II".

Table 10: Partial Productivity Measures - Rankings

	Commercial			Operational	Financial	
	Receipts/ Traffic Units	Traffic Units/Train Km		Train Kms/ Staff Nos	Receipts/ Total Cost	Average Ranking
		Passenger	Freight			
BR	1	11	2	5	1	4.0
CFF	4	5	-	6	3	4.5
CIE	5	4	12	8	6	7.0
DB	3	7	5	9	9	6.6
DSB	2	10	9	7	8	7.2
FS	12	2	3	13	13	8.6
NS	9	8	8	1	6	5.4
NSB	6	12	10	10	5	8.6
OBB	7	6	4	12	11	8.0
RENFE	11	3	7	3	10	6.8
SJ/BV	13	9	1	2	2	5.4
SNCB	10	13	11	4	12	10.0
SNCF	7	1	6	11	4	5.8

Our use of a translog model (which can not easily deal with zero outputs) means that we can not examine economies of scope between passenger and freight operations. We note with interest the work of Jara-Diaz and Munizaga (1992) who used Vigoroux-Steck's original data to find that all railways exhibited increasing returns to scope, except the largest freight railways (DB and SNCF), which exhibited constant returns. However, these findings may be sensitive to the assumption that labor is a fixed factor. Nonetheless, it does suggest that the unbundling of freight and passenger services proposed by DB may be sensible for a railway of that size.

Any policy conclusions we can draw from our cost and productivity analysis are necessarily limited. Table 10 summarizes five of our measures in terms of rankings. We have not included staff costs divided by total costs in this table, as it has no subjective meaning. The general impression that emerges from this Table is that BR, CFF, SJ, and NS are relatively good performers, whilst SNCB, FS, NSB, and OBB are relatively poor performers. These results only match to a limited extent the findings on managerial efficiency derived from the translog model (Tables Seven and Eight). Managerial efficiency seems to help explain the good performance of SJ and the poor performance of OBB, FS, and SNCB. It is less useful in explaining the good performances of BR, CFF and NS or the poor performance of NSB, which are more likely to be explained by external factors. Nonetheless, our impression is that overall efficiency is correlated to some extent with managerial autonomy (see also Gathon and Pestieau, 1991).

We do not as yet have any evidence of the cost implications of vertically separating infrastructure from operations, that has been carried out in Sweden and is proposed in many other European countries. However, we note that the cost recovery ratio for Swedish Railways declined from 0.81 in 1988 to 0.72 in 1990, although this may be partly due to other factors. We believe there may be some costs associated with vertical separation but this is an area where further research is required.

Overall, our comparison of costs and productivity indicate large variations in performance between European railways, not all of which may be attributed to exogenous factors. The translog model suggests that the relatively good performance of BR, CFF and NS in terms of our partial indices may be partly explained by geography in that the size and density of these countries' rail operations is not as unfavorable as in many other countries. However, the size and density of the rail operations of DSB, OBB, and SNCB are at least as favorable but these railways are relatively poor performers in terms of our partial measures. Similarly, the networks of SJ and FS have broadly the same characteristics in terms of scale and density economies, but have radically different performance in terms of our partial measures. Some organizational reform is therefore desirable and our findings give some indications of broad policy directions. However, more detailed recommendations require more detailed (and more disaggregate) analysis.

This work was financed by the British Railways Board. We would like to thank the 13 European railways, and their representatives, that co-operated with or study. We would also like to acknowledge the work of Dave Aldridge, Mark Garlick, Frances Hodgson and Christian Vigouroux-Steck. We are grateful for the comments of Dr Simoncic of the Institute for Transport, Ljubljana. Needless to say, any mistakes are solely our own.

References

Aldridge, D. and Preston, J. (1992). The Translog Cost Function Applied to European Railways". Working Paper 375. Institute for Transport Studies, University of Leeds.

British Railways Board and University of Leeds (1979). "A Comparative Study of European Rail Performance". BRB, London. December.

Caves, D.W., Christensen, L.R. and Diewert, W.E. (1982). "Multilateral Comparisons of Output, Input and Productivity using Superlative Index Numbers". The Economic Journal, 92, 73-86.

Caves, D.W., Christensen, L.R., Tretheway, M.W. and Windle, R.J. (1985). "Network Effects and the Measurement of Returns to Scale and Density for US Railroads". In Daugherty, A. (Ed) "Analytical Studies in Transport Economics". Cambridge University Press, Cambridge.

Cm 2012 (1992). "New Opportunities for the Railways - the Privatisation of British Rail". HMSO, London.

Dodgson, J.S. (1993). "British Railway Cost Functions and Productivity Growth. 1900-1912". Exploration in Economic History.

European Conference of Ministers of Transport. (1993). "Privatisation of Railways: Methods and Obstacles". Round Table 90. OECD, Paris. February.

Filippini, M. and Maggi, R. (1992). "The Cost Structure of the Swiss Private Railways". International Journal of Transport Economics, 19, 3, 307-327.

Friedlaender, A.F., Berndt, E.R., Chiang, J.S., Showalter, M. and Vellturo, C.A. (1993). "Rail Costs and Capital Adjustments in a Quasi-Regulated Environment". Journal of Transport Economics, 27, 2, 131-152.

Gathon, H.J. and Pestieau, P. (1991). "Autonomy and Performance in Public Enterprises: The Case of European Railways". CIRIEC Working Paper 91/04. University of Liege, Belgium.

Hensher, D.A., Daniels, R. and De Mellow, I. (1992). "A Comparative Assessment of the Productivity of Australia's Rail Systems 1971/2 - 1990/1". Working Paper 7. Institute for Transport Studies, University of Sydney.

Jara-Diaz, S. and Munizaga, M. (1992). "The Effect of Network Density in European Railway Costs". Presented to the 6th World Conference on Transport Research. Lyon. June - July.

Kravis, I.B., Heston, A.W. and Summers, R. (1978). "Real GDP per Capita for More Than 100 Countries". Economic Journal. June.

McGeehan, H. (1993). "Railway Costs and Productivity Growth. The Case of the Republic of Ireland 1973-83." Journal of Transport Economics and Policy. 19-32.

Mundlak, Y. (1978). "On the Pooling of Time-Series and Cross-Section Data". Econometrics, 46, 1, 69-85.

Nash, C.A. (1985). "European Railway Companies - What Can We Learn". In Button, K.J. and Pitfield, D.E. (Eds). "International Railway Economics". Gower, Aldershot.

Nash, C. and Preston, J. (1992). "Assessing the Performance of European Railways". Presented to the 6th World Conference on Transport Research. Lyon, June-July.

Nash, C. and Preston, J. (1993) "Competition in Rail Transport: A New Opportunity for Railways?". Submitted to the Third International Conference on Competition and ownership in Surface Passenger Transport. Mississauga, Ontario.

Oum, T.H. and Yu, C. (1991). "An International Comparison of Economic Efficiency of Passenger Railway Systems". Second International Conference on Privatisation and Deregulation in Passenger Transportation. Tampere, Finland.

Preston, J. and Nash, C. (1992). "European Railway Comparisons: Company Profiles". Working Paper 379. Institute for Transport Studies, University of Leeds.

Preston, J., Garlick, M., Hodgson, F. and Nash, C. (1993). "European Railway Comparisons: Interim Report". Unpublished Report for British Railways Board.

Pringle, R.M. and Raynor, A.A. (1971). "Generalized Inverse Matrices with Applications to Statistics". Hafner, New York.

SAS (1988) "SAS/ETS Users Guide. Version 6. First Edition". SAS Inc, Cary, N. Carolina.

Vigoroux-Steck, C. (1989). "Exploratory Analysis in the Estimation of Transport Cost Functions for European Railways". MA Dissertation. Institute for Transport Studies, University of Leeds.

APPENDIX ONE: TRANSLOG MODEL - EXPLORATORY ANALYSIS

$$
\begin{aligned}
\ln RTC = \; & - \underset{(-1.2)}{11.05} + \underset{(3.7)}{5.930 \ln WM} + \underset{(6.1)}{2.726 \ln WE} - \underset{(-3.1)}{1.192 \ln WV} + \underset{(0.5)}{0.575 \ln TKT} \\
& + \underset{(4.4)}{10.940 \ln \%TKP} - \underset{(-0.4)}{0.517 \ln DEN} - \underset{(-9.4)}{0.009 YEAR} \\
& - \underset{(-3.2)}{0.247 (\ln WM)^2} + \underset{(7.0)}{0.070 (\ln WE)^2} \\
& + \underset{(6.5)}{0.054 (\ln WV)^2} + \underset{(2.2)}{0.111 (\ln TKT)^2} - \underset{(-0.8)}{0.241 (\ln \%TKP)^2} + \underset{(4.1)}{0.292 (\ln DEN)^2} \\
& - \underset{(-5.9)}{0.261 \ln WM \cdot Ln WE} + \underset{(1.7)}{0.067 \ln WM \cdot \ln WV} - \underset{(-4.7)}{0.168 \ln WM \cdot \ln TKT} \\
& - \underset{(-5.2)}{1.195 \ln WM \cdot \ln \%TKP} + \underset{(2.0)}{0.164 \ln WM \cdot \ln DEN} - \underset{(-2.9)}{0.044 \ln WE \cdot \ln WV} \\
& + \underset{(0.2)}{0.002 \ln WE \cdot \ln TKT} + \underset{(1.7)}{0.191 \ln WE \cdot \ln \%TKP} - \underset{(-0.3)}{0.012 \ln WE \cdot \ln DEN} \\
& + \underset{(7.0)}{0.076 \ln WV \cdot \ln TKT} + \underset{(2.3)}{0.186 \ln WV \cdot \ln \%TKP} - \underset{(-0.1)}{0.002 \ln WV \cdot \ln DEN} \\
& - \underset{(-1.3)}{0.095 \ln TKT \cdot \ln \%TKP} - \underset{(-2.9)}{0.252 \ln TKT \cdot \ln DEN} + \underset{(2.5)}{0.405 \ln \%TKP \cdot \ln DEN} \\
& + \underset{(2.7)}{0.35 DBR} + \underset{(4.9)}{0.38 DCFF} - \underset{(-1.1)}{0.12 DCIE} + \underset{(2.0)}{0.40 DDB} + \underset{(2.4)}{0.15 DDSB} + \underset{(4.3)}{0.48 DFS} \\
& + \underset{(0.8)}{0.06 DNS} - \underset{(-1.7)}{0.06 DNSB} + \underset{(16.5)}{0.69 DOBB} - \underset{(-3.6)}{0.24 DSJ} + \underset{(10.5)}{0.55 DSNCB} + \underset{(0.0)}{0.00 DSNCF}
\end{aligned}
$$

$R^2 = 0.9996 \qquad F = 14117.9$

Source: Vigoroux-Steck, 1989

APPENDIX TWO: TRANSLOG MODEL - FURTHER ANALYSIS

$$lnRTC =$$

$$\underset{(3.2)}{2.53} + \underset{(35.8)}{1.043\,lnWM} + \underset{(1.9)}{0.008\,lnWE} - \underset{(-2.0)}{0.051\,lnWV} + \underset{(0.5)}{0.557\,lnTKT}$$

$$+ \underset{(1.8)}{0.083\,ln\%TKP} - \underset{(-1.0)}{1.329\,lnLL} - \underset{(-11.6)}{3.119\,YEAR}$$

$$+ \underset{(7.4)}{0.031(lnWM)^2} + \underset{(4.6)}{0.005(lnWE)^2}$$

$$+ \underset{(6.2)}{0.014(lnWV)^2} + \underset{(7.2)}{6.692(lnTKT)^2} - \underset{(-2.6)}{0.025(ln\%TKP)^2} + \underset{(6.6)}{7.638(lnLL)^2}$$

$$- \underset{(-6.0)}{0.011\,lnWM \cdot lnWE} - \underset{(-6.6)}{0.020\,lnWM \cdot lnWV} - \underset{(-1.3)}{0.104\,lnWM \cdot lnTKT}$$

$$- \underset{(2.4)}{0.020\,lnWM \cdot ln\%TKP} + \underset{(0.1)}{0.009\,lnWM \cdot lnLL} + \underset{(4.6)}{0.006\,lnWE \cdot lnWV}$$

$$- \underset{(-1.6)}{0.061\,lnWE \cdot lnTKT} - \underset{(-1.4)}{0.006\,lnWE \cdot ln\%TKP} + \underset{(1.3)}{0.048\,lnWE \cdot lnLL}$$

$$+ \underset{(2.9)}{0.164\,lnWV \cdot lnTKT} - \underset{(-2.4)}{0.014\,lnWV \cdot ln\%TKP} - \underset{(1.2)}{0.057\,lnWV \cdot lnLL}$$

$$- \underset{(-0.6)}{0.077\,lnTKT \cdot ln\%TKP} - \underset{(-5.7)}{13.071\,lnTKT \cdot lnLL} + \underset{(0.4)}{0.049\,ln\%TKP \cdot lnLL}$$

$$+ \underset{(2.5)}{0.07DBR} + \underset{(5.5)}{0.08DCFF} + \underset{(0.8)}{0.02DCIE} + \underset{(1.1)}{0.05DDB} + \underset{(5.9)}{0.07DDSB} + \underset{(3.4)}{0.08DFS}$$

$$+ \underset{(4.1)}{0.06DNS} + \underset{(2.1)}{0.01DNSB} + \underset{(15.0)}{0.13DOBB} - \underset{(-3.2)}{0.04DSJ} + \underset{(11.4)}{0.12DSNCB} - \underset{(-0.3)}{0.01DSNCF}$$

$R^2 = 0.9989$ $\quad$ $F = 6424.7$

Source: Aldridge and Preston, 1992