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Published paper

Smith, Andrew J. (2002) *Are Britain's Railways Costing Too Much? Perspectives Based on TFP Comparisons with British Rail 1963–2002.* Journal of Transport Economics and Policy, 40(1), pp.1-44

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Journal of Transport Economics and Policy, Volume 40, Part 1, January 2006, pp. 1–44

Are Britain's Railways Costing Too Much?

Perspectives Based on TFP Comparisons with British Rail 1963–2002

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This paper was prepared as part of the author's PhD thesis, undertaken at the Judge Institute of Management, University of Cambridge, and funded by Network Rail. The author acknowledges comments from David Newbery, Ian Marlee, Michael G. Pollitt, and John Smith, as well as considerable assistance from Alvaro Angeriz, David Cooke, Richard Goldson, Duncan Hannan, Nigel Salmon, and Richard Smith. Any remaining errors are the author's responsibility.

Abstract

Following the Hatfield accident in October 2000, the cost of running Britain's railways has increased very sharply, leading to considerable debate about whether current cost levels are reasonable. This paper seeks to inform this debate by assessing post-Hatfield cost and TFP levels against the historical precedents set by British Rail and the early experience of the newly privatised industry. The results show that industry cash costs rose by 47 per cent between 1999/2000, the last financial year before Hatfield, and 2001/2002 — but, surprisingly, with train operating costs accounting for 42 per cent of this growth. The results also show that the post-Hatfield cost spike is unprecedented when compared against historical benchmarks. Analysis of long-term data on quality and safety measures indicates that an excessive focus on rail safety may offer part of the explanation for the cost growth.

Date of receipt of final manuscript: August 2004

1.0 Introduction

The privatisation of British Rail has been the source of much controversy over the eight years of private sector ownership since 1997. Although Pollitt and Smith (2002) point to some early successes — in the form of significant operating cost savings — the picture has changed markedly since the Hatfield derailment in October 2000. This accident led to a reappraisal of the level of maintenance and renewal activity required to sustain the network, and resulted in a sharp increase in infrastructure costs. However, while attention has focused on infrastructure, the data presented in Section 5 of this paper shows that train operator (TOC) costs have also been on the rise in recent years. Taken together, the data show that (annual) total industry cash spend increased by £2.9bn (47 per cent) in real terms between 1999/00 and 2001/02.

The post-Hatfield rise in industry costs poses a major financial challenge for the government, and in turn raises the following question: how can policy makers determine whether post-Hatfield cost and productivity levels are reasonable, and whether increased funding to the railways should be permitted? The Office of Rail Regulator (ORR) has recently completed (December 2003) a review of the finances of Britain's rail infrastructure provider, Network Rail (2002/03 Interim Review).[1] As part of this review the ORR commissioned a range of studies aimed at answering this question in respect of infrastructure costs. In particular, internal benchmarking proved to be a useful approach in defining the scope for Network Rail to reduce costs by eliminating intra-company cost differences (see Kennedy and Smith, 2004; and LEK, 2003).

However, a key difficulty for the ORR has been the lack of external benchmark information against which to make objective and conclusive judgements about Network Rail's productivity levels, based on hard evidence concerning best practice achieved elsewhere. Quantitative comparisons with international operators have proved illusive due to lack of comparable data, while comparisons with other privatised industries only provide information about productivity trends; and not levels (see Section 2 for a fuller discussion of these studies). On the train operation side, the SRA has carried out TOC-on-TOC comparisons, but we are not aware of any comparisons with external benchmarks. The government's dissatisfaction with the outcome of the 2002/03 Interim Review, and with the lack of cost

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[1] Railtrack owned and operated Britain's rail infrastructure from April 1994 before being placed into administration in October 2001. Network Rail subsequently took over from Railtrack in October 2002.

control in the industry more generally, was one of the key factors behind its decision to announce a further review of the structure of railways in January 2004.

Of course, the question raised above — whether post-Hatfield cost levels are reasonable — leads to a second and important question: what is the cost, at the total industry level, of running Britain's railways in the post-Hatfield environment? Following industry restructuring, with the creation of approaching a hundred new companies, answering this question turns out to be non-trivial. The difficulties are compounded during the period after the Hatfield accident as a result of large increases in intra-industry transfer payments (between Railtrack and the TOCs; and between TOCs and customers and the SRA), which potentially frustrate attempts to obtain measures of true underlying costs.

The purpose of this paper is to address both the questions outlined above. First, of all, total rail industry costs are constructed from the relevant company data over the post-privatisation period. The post-privatisation period is defined here as 1993/94 to 2001/02 (see Section 4). Second, post-Hatfield (2000/01 to 2001/02) cost and total factor productivity (TFP) levels are judged against historical precedents set both by British Rail and also the early experience of the newly privatised industry (1963 to 1999/00). Analysis is presented at the total industry level, due to the considerable problems of splitting out infrastructure costs under British Rail. TFP measures are derived by estimating a total cost function, using Zellner's (1962) seemingly unrelated (SURE) method, and the econometric results are complemented by analysis based on simple unit cost measures and Tornqvist TFP indices. In order to ensure comparability over time, a cash-based measure of total costs is used in the analysis (see Section 2).

Of course, in recent years both Railtrack and Network Rail have pointed to the fact that much of the existing track was installed during the 1970s, thus creating the need for a substantial increase in track renewal activity (both now and in the future).[2] Both companies have therefore argued for increased funding to pay for this investment 'bow-wave', noting also that the problem has been exacerbated by extended periods of under-investment during the British Rail era. It has also been argued (by the ORR and others) that investment was insufficient during the early years after privatisation (although Railtrack was not funded for a rise in track renewal activity at vesting).

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[2] These arguments were made during the 2000 Periodic Review and during the 2002/03 Interim Review.

The impact of the investment cycle, and lagged effects relating from previous under-investment, causes some problems for assessing productivity trends over time. Traditional productivity measures relate inputs to final outputs (for example, train km). However, variations in intermediate outputs, such as the volume of track renewals, will impact on costs[3] without necessarily affecting final outputs, and might therefore distort productivity measures. This point is particularly relevant in the present context since track renewal volumes have increased substantially since the Hatfield accident and therefore would be expected to explain part of the recent cost rises.[4]

This paper addresses the issue first by considering productivity trends in a long-term context (1963 to date). This approach enables post-Hatfield productivity performance to be benchmarked against periods with similar levels of track renewal activity (such as the 1970s). Second, the annual volume of track renewals is explicitly added to the cost function specification in order to test the extent to which the investment cycle impacts on productivity trends, particularly over the post-Hatfield period. The paper also examines changes in key quality and safety measures over the period (punctuality, broken rails, and passenger fatalities), and asks whether changes in these variables can explain movements in cost and productivity levels.

Previous academic studies have not addressed the questions raised in this paper. First of all, the time period considered exceeds those attempted elsewhere. Earlier contributions do not extend beyond Hatfield, with most stopping at privatisation. Second, many previous studies have been based on physical input measures, such as length of track for infrastructure capital, therefore missing the point of the current debate, which is concerned with track investment and asset condition. Third, those studies using cost-based input measures have used data that are heavily distorted by changes in accounting policy over the BR period. These data problems have not previously been noted in the literature (see Section 2 for further details). Finally, previous studies have not considered the impact of track renewals and quality measures on costs and productivity levels.

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[3] This is not just a problem for cash-based measures of total costs. Between 1975 and 1991/92 most track renewal costs were charged to operating costs. As a result, fluctuations in track renewal volumes also impact on previous studies using alternative cost measures (i.e. operating costs; or total costs, defined as operating costs plus accounting depreciation). Even productivity analysis based on 'physical' measures are affected by this issue, since they usually include 'other material costs' as an input (alongside staff numbers and fuel consumption), where other costs include track renewal costs, at least for the period 1975 to 2001/02. See Section 2 for further details.

[4] Although there is a separate question as to whether current renewal volumes are at the 'correct' level.

The paper is arranged in six sections. Sections 2 and 3 review the literature and outline the methodology. Section 4 describes the data. Finally, Section 5 presents the results, while Section 6 offers some conclusions.

2.0 Literature Review

The relevant literature can be broadly divided into studies commissioned as part of the regulatory review processes (2000 Periodic Review and 2002/03 Interim Review), and academic contributions. The 2000 Periodic Review studies were described in Kennedy and Smith (2004). This section briefly describes the studies carried out during the 2002/03 Interim Review, as well as the academic contributions that are relevant to the assessment of productivity and efficiency performance on Britain's railways.

As noted in the introduction, the ORR has so far struggled to establish clear external benchmarks against which to assess Network Rail's productivity levels. This problem first became apparent during the 2000 Periodic Review (see Kennedy and Smith, 2004). More recently, during the 2002/03 Interim Review, the ORR made some progress in developing international comparisons (see Halcrow, TTCI, and LEK, 2003). However, this study produced only limited quantitative results, being based on identifying areas of best practice for a subset of activities, and for a small sample of companies.

The ORR also commissioned a number of other external benchmarking studies during the Interim Review. The OXERA (2003a) study benchmarked some of Network Rail's non-core business processes (for example, HR, Finance) against external comparators. However, their analysis dealt with only around £200m of Network Rail's cost base and did not consider the company's core operations. Accenture (2003) sought to benchmark Network Rail's maintenance and renewal contracting processes against international best practice. However, the conclusions of this study were based on subjective judgements about the possible savings from achieving best practice in this area, expressed in terms of a fairly generic set of principles, and not on input–output comparisons with similar rail maintenance/renewal contracts elsewhere.

Of course, analysis of productivity trends in other industries did not shed any light on Network Rail's relative productivity levels (see OXERA, 2003b). On the train operation side, to our knowledge, the SRA has not reported international comparisons of TOC costs. To our knowledge, neither the SRA or ORR has commissioned original analysis of costs under British Rail.

Table 1
Summary of 'Britain-only' Rail Productivity/Efficiency Studies

Study	*Sample*	*Inputs used*	*Outputs used*
Bishop and Thompson (1992)	1970–1990 British Rail	Number of employees Other materials Capital (PIM-based)[a]	Passenger km Freight (net) tonne km Loaded wagons
Affuso, Angeriz, and Pollitt (2002)	1996/97 to 1999/00 25 TOCs	Number of employees Labour costs Other costs (excl. track) Number of rolling stocks	Passenger train km Passenger km Punctuality index Safety index
Cowie (2002)[b]	1972–1998/99; British Rail and 25 TOCs	Number of employees Tractive rolling stock Track kilometres	Total train km
Pollitt and Smith (2002)	1988/89 to 1999/00 Privatised industry	Operating costs (excluding depreciation)	Passenger train km Freight tonne km
Kennedy and Smith (2004)	1995/96 to 2001/02 Seven Railtrack zones	Maintenance and track renewal costs Quality measures	Passenger train km Freight tonne km Track km

[a] Perpetual inventory method. See Christensen and Jorgenson (1969).
[b] Cowie recognises the lack of direct comparability between the TOCs (train operation only) and BR.

In the academic literature there have been a number of studies concerned with measuring productivity and efficiency levels/trends on Britain's railways, either over time, or as part of broader international comparisons. These contributions are listed in Tables 1 and 2.

As is clear from the tables, the choice of outputs is broadly the same across the different studies.[5] The key features relevant to the present discussion are the choice of inputs and the time period covered. The studies listed in Tables 1 and 2 can therefore be divided broadly into two types: those that are based on physical measures of inputs (such as employee numbers; network length); and those adopting cost-based input measures (such as variable or total costs). However, analysis using physical input measures is inappropriate in the present context, since the use of network length to measure infrastructure capital misses the point of the current debate, which is concerned with track investment and condition. Cost-based measures are therefore more relevant in the present context.

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[5] The main differences concern whether 'available outputs' (train kilometres) or 'revenue outputs' (tonne kilometres) are used, whether passenger and freight variables are considered separately, or added together, and whether track or route length is included as an output. In the analysis that follows, alternative models are presented, with total train kilometres included as the single output, and then together with track kilometres. As noted below, the results are little affected if passenger and freight train kilometres (or passenger and freight tonne kilometres) are used as separate outputs.

Table 2

Summary of British Rail Productivity/Efficiency Studies based on International Comparisons

Study	*Sample*	*Inputs used*	*Outputs used*
Nash (1985)	1971 and 1981 Europe	Number of employees	Total train km, weighted and unweighted
Deprins and Simar (1989)	1970–1983 Europe + Japan	Number of employees Number of coaches/wagons Energy consumption Route kilometres	Total train km
Gathon and Perelman (1992)	1961–1988 Europe	Number of employees	Passenger train km Freight train km Route km
Nash and Preston (1994)	1980 and 1990 Europe	Number of employees	Total train km
Oum and Yu (1994)	1978–1989 OECD	Number of employees Energy consumption Number of rolling stocks Way and structures capital (PIM-based)	Passenger km Passenger train km Freight tonne km Freight train km
Gathon and Pestieau (1995)	1961–1988 Europe	Number of employees Number of rolling stocks Route kilometres	Sum of passenger tonne km and freight tonne km
Cowie and Riddington (1996)	1992 Europe	Number of employees Capital (financial measure)	Passenger train km Service provision index
Preston (1996)	1977–1990 Europe	Variable costs (excludes capital costs)	Passenger train km Freight train km Route km Passenger km Freight tonne km
Andrikopoulos and Loizides (1998)	1969–1993 Europe	Total cost. Includes capital costs (historic cost depreciation + interest)	Sum of passenger km and freight tonne km
Cantos, Pastor, and Serrano (1999)	1970–1995 Europe	Number of employees Energy/materials costs Number of rolling stocks Track kilometres	Passenger km Freight tonne km
Coelli and Perelman (1999 and 2000)	1988–1983 Europe	Number of employees Rolling stock capacity Route kilometres	Passenger km Freight tonne km
Tsionas and Christopolous (1999)	1969–1992 Europe	Number of employees Energy consumption Capital (financial measure)	Sum of passenger km and freight tonne km

Table 2
Continued

Study	*Sample*	*Inputs used*	*Outputs used*
Cantos, Pastor, and Serrano (2000)	1970–1995 Europe	Number of employees Energy consumption Materials consumption Number of locomotives Number of passenger and freight carriages/cars Track kilometres	Passenger km Passenger train km Freight tonne km Freight train km
Christopolous, Loizides, and Tsionas (2000)	1969–1992 Europe	Total cost. Includes capital costs (historic cost depreciation + interest)	Total train km
Sanchez and Villarroya (2000)	1970–1990 Europe	Variable cost (excludes capital cost)	Passenger train km Freight train km
Cantos and Maudos (2001)	1970–1990 Europe	Operating costs	Passenger km Freight tonne km
Cantos, Pastor, and Serrano (2002)	1970–1995 Europe	Operating costs Track kilometres	Passenger km Freight tonne km
Loizides and Tsionas (2002)	1969–1992 Europe	Operating costs Capital stock (financial measure)	Passenger km Freight tonne km

The cost-based studies listed in the two tables have been carried out using either variable or total costs to measure inputs. However, changes in accounting policy during the British Rail period mean that it is inappropriate to consider variable costs in isolation. In particular, the accounting treatment of track investment changed twice between 1975 and 1992. From 1975 track investment (except major projects) was funded through the P&L each year (previously it was capitalised).[6] From 1991/92, the policy was changed again, with all track investment subsequently capitalised. The results of previous studies based on variable cost measures are therefore likely to be significantly distorted (the change in 1991/92 saw operating costs fall by about 10 per cent). To our knowledge, this point has not been noted previously in the literature.[7]

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[6] It was charged to the profit and loss account as depreciation over the life of the asset.

[7] Such changes will also affect the computation of capital stock based on the perpetual inventory method, as in Bishop and Thompson (1992), since large elements of investment were simply expensed each year for significant periods of time. Furthermore, this change will also impact on the analysis of total costs including depreciation, since in the year of change, operating costs will change by more than the corresponding change in depreciation.

Some studies (Andrikopoulos and Loizides, 1998; Christopolous *et al.*, 2000) have conducted analysis of British Rail productivity based on total costs (operating costs plus historic cost depreciation). However, the use of historic cost depreciation to measure capital costs represents a serious weakness in an industry with long asset lives, and given the many changes in accounting policy over the period.[8] Furthermore, the problems are compounded by inaccuracies in the UIC[9] depreciation data used in the studies. In the case of Britain, capital grants are (incorrectly) included in the depreciation charge reported by the UIC, which distorts the data by plus or minus 60 per cent in some years as a result (see Appendix 1). To our knowledge, this point has not been previously noted in the literature.[10]

Finally, it should be noted that of the studies listed in Tables 1 and 2 only one extends beyond the Hatfield accident (Kennedy and Smith, 2004). However, the analysis in the latter study considers productivity trends for infrastructure maintenance and renewal activity only, and does not include a comparison with infrastructure costs under British Rail.[11] Of the remaining studies, only three continue the analysis beyond privatisation — Affuso, Angeriz, and Pollitt (2002); Cowie (2002); and Pollitt and Smith (2002) — with each stopping short of the Hatfield accident. This means that rail industry productivity levels and trends — for the post-Hatfield period — have not yet been reported in the literature.

Given the above discussion, this paper therefore makes its contribution first by computing total industry costs post-privatisation (and post-Hatfield), and then by carefully constructing a cost series for the BR period to enable a robust historical comparison. The analysis is based on total industry cash costs — operating costs plus capital expenditure — a measure that is invariant to the changes in accounting policy noted above. Furthermore, this paper adds to previous approaches by also considering the impact of fluctuations in annual track renewal activity, as well changes in key quality and safety measures over the period (punctuality, reliability, broken rails, and passenger fatalities).

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[8] In 1991/92, as noted above; again at privatisation; and more recently in 2001/02. The impact of the 2001/02 change was to reduce Network Rail's depreciation charge from £1,915 to £316m in the year.

[9] International Union of Railways.

[10] Furthermore, all studies based on UIC data (based either on variable or total costs) do not distinguish between rail and non-rail (such as hotels) costs.

[11] As noted earlier it is problematic to split BR data accurately between infrastructure and other costs; and such data was certainly not available by zone for the BR period.

3.0 Methodology

Three complementary methodologies are used in Section 5 in order to address the questions raised by this paper. First of all, unit (total cash cost) measures are computed and compared over the period.

However, since unit cost measures are affected by changes in input prices (average wages; fuel prices) as well as productivity movements, Tornqvist indices of total factor productivity are also calculated. The Tornqvist index is defined as:[12]

$$\ln(TFP_k/TFP_l) = \sum_i^m (R_{ik} + R_{il})/2 \times \ln(Y_{ik}/Y_{il}) - \sum_j^n (S_{jk} + S_{jl})/2 \times \ln(X_{jk}/X_{jl}), \quad (1)$$

where k and l are adjacent time periods, the i and j subscripts denote the m outputs and n inputs, the Rs and Ss are the output revenue shares and input cost shares respectively, and the Ys and Xs are outputs and inputs. Diewert (1992) notes that the Tornqvist index is preferred to the other indices (such as the Paasche or Fischer indices) based on its relationship with economic theory. However, the Tornqvist index requires the assumption of constant returns to scale[13] and is therefore unable to distinguish underlying productivity changes from productivity movements resulting from scale and/or density effects.

Econometric analysis is therefore required in order to model scale/density effects. Econometric estimation also allows the impact of other variables to be tested (for example, Hatfield effects, and the impact of renewal volumes on costs).[14] The main analysis in this paper, therefore, is based on the estimation of a total cost function using the translog function originally proposed by Christensen, Jorgenson, and Lau (1973). The translog — one of the so-called flexible functional forms — provides a second-order approximation to any twice differentiable cost function. It places no a priori restrictions on the input elasticities of substitution, and allows the extent of scale economies to vary across different output levels.

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[12] See Christensen and Jorgenson (1970).

[13] See Diewert (1992), p. 190.

[14] The latter would be hard to incorporate within a Tornqvist index, as there would be no obvious weight to attach to the renewals (as an intermediate output), as compared with other final outputs.

The translog cost function may be written as:

$$\begin{aligned} LnC = \alpha_0 &+ \sum_i \alpha_i LnY_i + \sum_j \beta_j LnW_j + 1/2 \sum_i \sum_k \delta_{ik} LnY_i LnY_k \\ &+ 1/2 \sum_j \sum_m \gamma_{jm} LnW_j LnW_m + \sum_i \sum_j \rho_{ij} LnY_i LnW_j + \theta_t.T \\ &+ 1/2\theta_{tt}.T^2 + \sum_j \theta_{jt} LnW_j.T + \sum_i \pi_{it} LnY_i.T, \end{aligned} \tag{2}$$

where C is a measure of total costs, Y_{ik} are the outputs, W_{jm} are the inputs, and T is a time trend representing technological progress.[15] Conformity with theory requires the imposition of symmetry and linear homogeneity of degree one in input prices. Symmetry requires that:

$$\begin{aligned} \delta_{ik} &= \delta_{ki}, \qquad i \neq k \\ \gamma_{jm} &= \gamma_{mj}, \qquad j \neq m \end{aligned} \tag{3}$$

while linear homogeneity requires the following restrictions:

$$\sum_j \beta_j = 1; \quad \sum_j \gamma_{jm} = 0; \quad \sum_j \rho_{ij} = 0; \quad \sum_j^n \theta_{jt} = 0. \tag{4}$$

However, instead of using the linear homogeneity restrictions in equation (4) it is more convenient to impose linear homogeneity by dividing costs and input prices by one of the input prices (arbitrarily chosen). Note that prior to imposing linear homogeneity all data is normalised by the sample means (except the time trend and Hatfield dummy variables).[16] For the preferred model shown in Section 5 (Model 2), the normalised translog can therefore be written as:[17]

$$\begin{aligned} Ln(CASH/W_{MC}) = \alpha_0 &+ \alpha_1 LnTRAC + \alpha_2 LnTTM + \beta_1 LnP_L + \beta_2 LnP_F \\ &+ \delta_{11} 1/2(LnTRAC)^2 + \delta_{22} 1/2(LnTTM)^2 \\ &+ \delta_{12} LnTrac.LnTTM + \gamma_{11} 1/2(LnP_L)^2 \\ &+ \gamma_{22} 1/2(LnP_F)^2 + \gamma_{12} LnP_L.LnP_F \\ &+ \rho_{11} LnTRAC.LnP_L + \rho_{12} LnTRAC.LnP_F \\ &+ \rho_{21} LnTTM.LnP_L + \rho_{22} LnTTM.LnP_F \\ &+ \theta_t T + 1/2\theta_{tt} T^2 + \theta_{1t} LnP_L.T + \theta_{2t} LnP_F.T \\ &+ \pi_{1t} LnTRAC.T + \pi_{2t} LnTTM.T + \theta_D HAT, \end{aligned} \tag{5}$$

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[15] Note that some of the time interaction terms are dropped in the final estimation — see Section 5.

[16] That is, the translog approximation to the underlying cost function is taken at the sample mean.

[17] Note that symmetry has been imposed in equation (5). Note also that not all of the time interaction terms are included in the final estimation — see Section 5.

where $CASH$ is total cash costs (operating cost plus capital expenditure), the chosen output measures are $TRAC$ (track kilometres) and TTM (total train kilometres) respectively (in order to distinguish between economies of scale and density), W_L is the price of labour, W_F is the price of fuel, W_{MC} is the price of materials and capital expenditure inputs, $P_L = (W_L/W_{MC})$, $P_F = (W_F/W_{MC})$, T represents technological progress, and HAT is a dummy to take account of Hatfield effects.[18] Two alternative specifications are also reported in the results in Section 5: first, excluding the $TRAC$ variable from equation (4) (Model 1); and second, by adding annual track renewal volumes ($RENEW$) as an additional, intermediate output (Model 3); see Figure 2.

To improve the precision of the estimates, the above cost function is estimated together with the factor share equations derived from Shephard's Lemma:

$$\begin{aligned} S_L &= \beta_1 + \gamma_{11} LnP_L + \gamma_{12} LnP_F + \rho_{11} LnTRAC + \rho_{21} LnTTM + \theta_{1t} T \\ S_F &= \beta_2 + \gamma_{12} LnP_L + \gamma_{22} LnP_F + \rho_{12} LnTRAC + \rho_{22} LnTTM + \theta_{2t} T, \end{aligned} \tag{6}$$

where S_L and S_F are the labour and fuel cost shares respectively. The above system of equations is estimated using Zellner's (1962) seemingly unrelated (SURE) method; implemented using the statistical package MICROFIT.

Before proceeding, it has been pointed out in the literature that total cost function estimation may not be appropriate in the railway sector, since managers may not be able to adjust the level of capital input optimally (Caves, Christensen, and Swanson, 1981). However, in the present context, it can be argued that managers are able to control the capital input measure chosen in this paper — namely the level of annual capital expenditure in a given year — and therefore that the assumption of total cost minimisation can be justified here. Furthermore, the cost impact of different network structures and densities are reflected through the inclusion of track kilometres, alongside measures of traffic volumes, in the cost function specification (following, for example, Friedlaender and Spady, 1981).

Of course, it should be noted that total cost function estimation is common in empirical studies of railway productivity: see, for example, Friedlaender and Spady, 1981; Caves, Christensen, Tretheway, and Windle, 1985;[19] Andrikopoulos and Loizides, 1998; Christopolous, Loizides, and Tsionas, 2000; and NERA, 2000.[20]

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[18] HAT takes the value 0.5 in 2000/01 (since the Hatfield accident occurred mid-way through 2000/01), unity in 2001/02 and zero elsewhere.

[19] The authors note that they also estimated a variable cost function with similar results.

[20] Report prepared for the ORR during the 2000 Periodic Review (with Tae Oum and Bill Waters II).

4.0 Data

This section describes the dataset used in the empirical analysis described below; a summary of the key data is shown in Table 3 (for further details see Appendix 2).

4.1 Cost information

As noted in the introduction, in this paper the post-privatisation period is taken to start in 1993/94, the first year impacted by the restructuring and

Table 3

Data Summary

		Period annual averages		
	Units	*Pre-privatisation*[a] *1963 to 1992/93*	*Post-privatisation Pre-Hatfield 1993/94 to 1999/00*	*Post-privatisation Post-Hatfield 2000/01 to 2001/02*
Cost data				
Total cash cost (*CASH*)	£m real[b]	6,095	5,633	8,419
Input prices[c]				
Labour (W_L)	£ real	16,318	25,200	28,740
Fuel (W_F)	£ real	257.7	139.1	139.6
Materials and Capex (W_{MC})	Index (1963 = 100)	95.7	89.6	93.0
Final outputs/network size				
Total train kilometres (*TTM*)	thousands	405,048	410,560	467,872
Passenger train kilometres (*PTM*)	thousands	335,514	381,463	431,550
Freight tonne kilometres (*FTON*)	million	19,757	15,366	18,750
Track kilometres (*TRAC*)	kilometres	37,193	32,704	32,757
Intermediate outputs				
Rail kilometres renewed (*RENEW*)[d]	number	694	359	990
Quality measures				
Broken rails[e]	number	745	772	621
Train performance[f]	Per cent on time	88.1	90.0	81.5
Passenger fatalities[g]	number	42	22	16

Notes

[a] 1992/93 is the last year before the impact of privatisation was felt.

[b] All financial values in 2001/02 prices, based on the RPI.

[c] Labour price per head; fuel price per tonne oil equivalent.

[d] See Figure 2 and associated notes and discussion.

[e] Data series starts in 1969.

[f] Data series starts in 1974. Train performance is a composite measure of the punctuality and reliability data published by British Rail. See Appendix 2 for further details.

[g] Data starts in 1964.

Sources: see Section 4 and Appendix 2.

privatisation process (see Pollitt and Smith, 2002). For the pre-privatisation period (1963 to 1992/93 inclusive), all cost information is taken from the British Rail Annual Reports. However, as discussed in Section 3, constructing a comparable cost series over the British Rail period requires great care. Of course, the decision to use a cash-based measure of total costs in this paper makes this easier. Nevertheless, a number of adjustments and assumptions have been made and these are briefly outlined below.

Where relevant, operating grants (such as level crossing grants) and capital grants (such as regional development grants) have been added back to operating and capital costs in order to construct measures of gross costs. Non-rail costs, such as those associated with hotels, have been excluded from the cost base. In addition, in respect of capital costs, non-operational property capital expenditure is excluded from the analysis. Finally, Channel Tunnel capital expenditure (completed in 1994/95) is excluded from the capital cost series in order to obtain comparable investment information as it relates to the existing network, rather than to new routes.

The post-privatisation period in this paper can be divided into two sub-periods: the transitional years (1993/94 to 1995/96) and the post-privatisation period proper (1996/97 to 2001/02). Cost data for the transition period (1993/94 to 1995/96), before the existence of a full set of privatised company accounts, are constructed from a combination of British Rail and Railtrack Annual Reports[21] (for 1993/94 and 1994/95), although cost data for 1995/96 had to be extrapolated.

For the post-privatisation period proper (1996/97 to 2001/02), industry operating costs are computed as the difference between total industry revenue and total industry operating profits, following Pollitt and Smith (2002).[22] Revenue and profit data are readily available from the relevant company accounts (TOCs, freight operators, rolling stock companies, and Railtrack). Total industry cash costs can then be derived for this period by adding the capital expenditures incurred by each element of the industry.[23] Capital expenditure data are available from the relevant company accounts, supplemented by data provided by Network Rail. Non-operational (or investment) property capital expenditure is excluded from the data, as is capital expenditure relating to the Channel Tunnel Rail Link,[24] in line with the treatment of the first stage Channel Tunnel project.

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[21] Note that Railtrack was created as a separate company in 1994/95, but was still owned by the government until the end of the financial year 1995/96. See Pollitt and Smith (2002) for further details.

[22] Note that ORR and SRA (non-subsidy) costs are included within the post-privatisation cost base.

[23] Since intra-industry payments have already been dealt with in arriving at industry operating costs.

[24] A high speed train link connecting London with the Channel Tunnel.

It should be noted that the calculation of industry operating costs over the post-Hatfield period (2000/01 and 2001/02) is further complicated by the very large intra-industry compensation payments resulting from the Hatfield accident and the 2000 Periodic Review of Railtrack's access charges.[25] Detailed analysis was carried out in order to ensure that these items did not distort the calculation of industry costs, and a number of adjustments were made where required. This analysis was based on information provided in the notes to the company accounts, as well as detailed access charge revenue data provided by Network Rail. Any assumptions made have been verified following discussions with National Express Group.[26] Further details are provided in Appendix 2.

The lack of available profit data for Railtrack's suppliers[27] means that the approach taken here may overstate post-privatisation costs (to the extent that these contracts are profitable). However, it is expected that this lack of data should not significantly affect the analysis here. First, although contractor profit data are not available from the company accounts, a significant element of contractor profits/losses — relating to the performance regime — is taken into account in the analysis, based on data from Network Rail. Second, there is no evidence that post-Hatfield infrastructure cost rises have been driven by increased contractor profit margins. Indeed, in 2003, one of Network Rail's contractors, Jarvis, announced its decision to pull out of maintenance activities altogether[28] (this development suggests that the company was not making excessive profits, and perhaps the reverse).[29]

Finally, as noted in Pollitt and Smith (2002), any overstatement in costs due to lack of data on contractor profits will be partially offset by potential cost understatements resulting from lack of data on minor (open access) freight operators. Of course, it should also be noted that some activities

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[25] These payments include: (1) performance regime compensation paid by Railtrack to the TOCs (£590m in 2000/01); (2) TOC penalty payments to the SRA (c. £100m per year); (3) Clause 18.1 payments made by TOCs to the SRA following the 2000 Periodic Review (£182m in 2001/02); and (4) the post-Hatfield passenger compensation package paid by train operators (£70m in 2000/01). See Appendix 2 for further details.

[26] Finance Director, Trains Division.

[27] The relevant company accounts do not provide sufficient information to derive profits on work carried out for Railtrack.

[28] Furthermore, in the zonal efficiency analysis presented in Kennedy and Smith (2004), the results show that the process of renegotiating the vesting maintenance contracts (which took place at different times between 1999 and 2002) had no systematic impact on relative contract payments across the zones. Once again, this finding suggests that recent cost increases were not driven by changes in contractor profitability resulting from the contract re-negotiation process.

[29] The announcement by Jarvis was followed, shortly afterwards, by Network Rail's decision to bring all maintenance activities in-house.

were also contracted out under British Rail, particularly following the sale of BREL[30] in 1988.

4.2 Input prices and cost share information

Input price information has been derived from a number of sources. For the pre-privatisation period, the price of labour (W_L) is computed as staff costs divided by staff numbers (in line with the approach used in previous studies), with the data taken from the British Rail Annual Reports. For the period after privatisation the price of labour is based on average salary information for those elements of the industry for which data is available, namely TOCs, freight operators, rolling stock companies and Railtrack (and, during the transition period, British Rail).

A fuel price (W_F) index for the period up to 1993/94 is calculated based on total fuel costs (from British Rail accounts) divided by fuel consumption in million tonnes of oil equivalent (data provided by the OECD). Since fuel cost data is not available beyond 1993/94, this price index is extrapolated forward based on (pre-tax) price data for diesel and electricity prices also provided by the OECD.[31] The approach taken differs from that adopted in previous studies, where the fuel price index has been calculated based on fuel costs per train kilometre (see for example, Sanchez and Villarroya, 2000). Note that, in the latter case, movements in fuel costs resulting from changes in fuel efficiency are (incorrectly) counted as price changes.

The price of materials and capital expenditure inputs (P_{MC}) is based on a relevant price index supplied by the ONS (transport equipment).[32] It should be noted that some previous studies have used materials cost per train mile to reflect materials prices (for example, Sanchez and Villarroya, 2000),[33] therefore raising a similar issue to that noted in the previous paragraph for fuel costs. Cost share information as between staff, fuel and materials, and capital expenditure for the BR period is taken directly from the BR Annual Reports. After privatisation, cost shares are based on the split between operating and capital expenditure costs over the post-privatisation period.[34]

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[30] British Rail Engineering Limited (rolling stock production).

[31] OECD, Energy Prices & Taxes: Quarterly Statistics; and Energy Balances of OECD Countries. Automotive diesel for commercial/industrial use; electricity for industrial use.

[32] This is the price index for gross fixed capital formation, and is a combination of indices based on, in the earlier years: transport and communications; then transport; and finally transport equipment. Since the materials and capital expenditure cost data is already deflated by the RPI, the materials price measure is taken to be the ratio of the transport equipment price index to the RPI.

[33] Other approaches (such as Andrikopoulos and Loizides, 1998) appear to have ignored materials costs altogether, or else have included them implicitly alongside depreciation within capital costs.

[34] However, the split of operating costs as between staff, fuel costs and materials is based on the final year under British Rail, due to lack of data on these items post-privatisation.

4.3 Other data

Data for the outputs and quality measures are taken from a variety of sources, predominantly the British Rail Annual Reports, National Rail Trends (SRA) and Transport Statistics Great Britain. In addition, Network Rail provided data on rail renewal volumes and broken rails. (See Appendix 2 for further details.) The calculation of Tornqvist indices also requires information on physical input measures, in order to separate out the effects of input price and productivity changes. For this purpose, equivalent physical measures for labour, fuel and materials/capital, are derived by dividing the relevant costs of each element (from the cost share data), by the input prices.[35]

5.0 Results

As noted in the introduction, the aim of this paper is to contribute to the current debate about rail industry cost and productivity levels in Britain, by comparing recent experience (since Hatfield, 2000/01 to 2001/02) with historical precedents under British Rail and during the first few years of the privatised structure (1963 to 1999/00). This section sets out the results of the analysis, and is divided into three parts. The first part (5.1) compares post-Hatfield cost levels with historical precedents based on simple unit cost measures. The second part (5.2) contains the main productivity analysis of the paper, consisting of TFP estimates based on total cost function estimation as well as Tornqvist indices. The impact of changes in track renewal activity (an intermediate output) on observed productivity measures is also evaluated.

The final part (5.3) uses long-term data on quality and safety measures (train performance, broken rails, and passenger fatalities) to consider whether observed productivity trends can be explained by movements in these important variables (which are usually ignored in productivity analysis). However, attempts to incorporate these measures directly into the total cost function — outlined in Section 3 — did not produce sensible results. As a result, the analysis in 5.3 is based mainly on simple observation of cost/quality data over time. In addition, some econometric work is conducted, aimed at understanding the determinants of quality and safety measures over the period.

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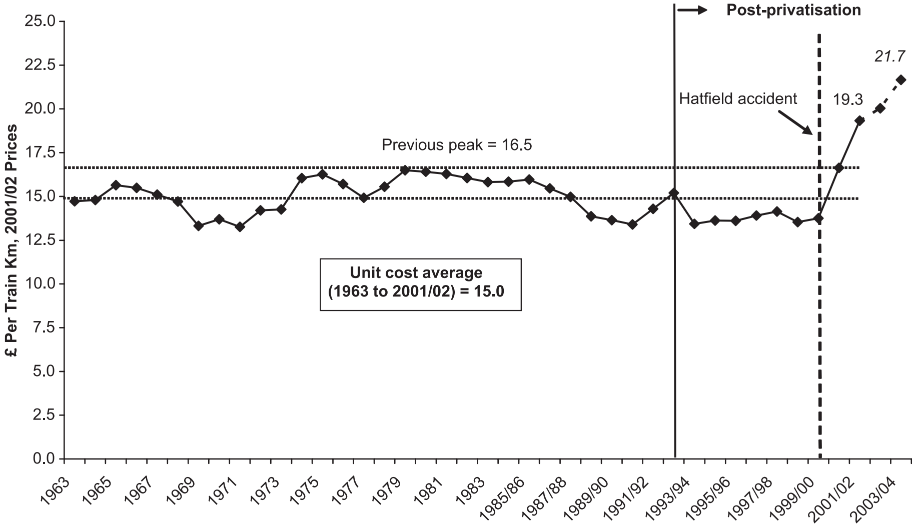
[35] Physical measures are derived from the cost and input price data, and are therefore not equivalent to the physical measures used in previous studies — where, for example, the capital input has been represented by track kilometres.

Figure 1
Total Rail Industry Cash Costs per Train Kilometre



Note: preliminary estimates for 2002/03 and 2003/04 are based on rises in Network Rail costs since 2001/02. Other industry costs are assumed constant in real terms, as data are not yet fully available beyond 2001/02.
Sources: ORR (2003) and Network Rail 2004 Business Plan.
See also Section 4 and Appendix 2.

5.1 Unit cost trends on Britain's railway (1963 to 2001/02)

Before considering more complex approaches to productivity measurement, it is worth briefly looking at what has happened to unit costs over the period in question. Figure 1 shows total industry cash costs per train kilometre (TTM) between 1963 and 2001/02. In addition, preliminary estimates of unit costs for 2002/03 and 2003/04 are also provided.[36] The trends in Figure 1 can be described according to a number of distinct time periods. First, following cost reductions achieved during the large-scale closure of routes and stations in the 1960s ('The Beeching era'),[37] unit costs started to rise during the 1970s, reaching a peak in 1979. This growth in cost coincided with a major programme of track renewals, comparable with post-Hatfield levels (see Figure 2), as well as rising (real) fuel and labour prices.

Unit costs then fell steadily during the 1980s, interrupted briefly by a period of unit cost increases at the start of the 1990s, as the economy

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[36] The estimates for the last two years are based on the increases in Network Rail costs since 2001/02, with other industry costs (passenger and freight operators; rolling stock companies) assumed to be constant in real terms (since data are not yet fully available beyond 2001/02).

[37] Richard Beeching (later Lord Beeching) was appointed chairman-designate of the British Railways Board in 1962 and was responsible for two reports on the state of Britain's railways (see Beeching, 1963 and 1965).

Table 4

Sources of Post-Hatfield Cost Increases

Rail industry cash costs £m, 2001/02 prices	*1999/00 Pre-Hatfield*	*2001/02 Post-Hatfield*	*Cost rise*	*Percentage growth*	*Percentage of total rise*
Infrastructure					
Operating costs	1,438	2,049	610	42	21
Capital expenditure	1,748	2,826	1,077	62	37
	3,187	**4,874**	**1,688**	**53**	**58**
Passenger train operation					
TOC-own operating costs	1,980	2,491	511	26	18
ROSCO operating costs	278	291	13	5	0
ROSCO/TOC capital expenditure	312	898	586	188	20
	2,570	**3,680**	**1,110**	**43**	**38**
Other, including freight	484	595	110	23	4
Total industry cash costs	6,241	9,149	2,908	47	100
Total costs per train km (£)	13.76	19.32	5.57	40	

Sources: see Section 4 and Appendix 2.

moved into recession and traffic volumes fell.[38] These data are in line with previous papers reporting strong productivity growth during the 1980s (for example, Bishop and Thompson, 1992). However, the cost reductions may also reflect the declining volume of track renewals during the period (discussed in more detail below). With the onset of restructuring and privatisation — starting in 1993/94[39] — unit costs then fell further before rising sharply between 1999/00 and 2001/02, following the Hatfield accident. The preliminary estimates for 2002/03 and 2003/04 also indicate that unit costs have continued to rise since 2001/02.[40]

Given the scale of cost increases post-Hatfield, it is informative to look at how these break down between the different parts of the privatised industry (see Table 4). Not surprisingly, Table 4 shows that infrastructure costs have increased considerably since 1999/00. What is surprising, however, is that TOC costs have also been rising sharply since Hatfield, with TOC cost rises (including rolling stock costs) accounting for 38 per cent of the total industry cost increase over the period. Perhaps of more concern, the data indicates that much of the TOC cost hike has come from rises in the basic cost of delivering services[41] and not simply from higher capital costs relating to new rolling stock. We are carrying out ongoing work in

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[38] Note that this growth does not reflect Channel Tunnel investment, since the latter is excluded from the cost data (as is investment in the Channel Tunnel Rail Link after privatisation).

[39] 1992/93 is the last year unaffected by privatisation — see Pollitt and Smith (2002) for further details.

[40] See note to Figure 1.

[41] That is, TOC-own operating costs in Table 4.

this area, aimed at providing a more comprehensive analysis of post-Hatfield cost drivers.[42] For now, it is sufficient to note that the data in Table 4 point to the need for close attention to cost trends across the whole industry — and not just infrastructure.

Returning to the long-term, industry-level story, it is clear from Figure 1 that post-Hatfield unit costs (in 2001/02) are much higher than the average over the period (by 29 per cent) and also substantially higher than the previous peak during the 1970s (by 17 per cent). These results suggest that it is difficult to find precedents for post-Hatfield levels of cost in the railway industry — based on experience from the last four decades — even when today's costs are compared with periods of very high track renewal activity (for example, the 1970s). Of course, before reading too much into these findings, it should be noted that the analysis so far is based on simple observation of trends in unit costs, and that more advanced methods are required to make conclusive judgements on relative productivity levels (Tornqvist and econometric approaches).

5.2 TFP estimates based on total cost function and Tornqvist methods (1963 to 2001/02)

The aim of this sub-section is further to investigate long-term rail productivity trends in Britain, using the econometric methodology set out in Section 3. This method is able to take account of both input price changes (for example labour/fuel prices) and scale/density effects. The econometric results are also checked against Tornqvist indices.

As noted in the introduction, Network Rail has recently argued the need for substantially higher track activity, as track installed in the 1970s comes up for renewal (see Figure 2), and to address under-investment during the BR era and immediately after privatisation (renewal volumes have also been significantly impacted by the West Coast Mainline Project).[43] It was also noted that these investment cycle effects potentially hinder attempts to measure productivity trends accurately over time[44] — a point that is particularly relevant in the present context due to the sharp rise in track renewal activity since Hatfield. This issue is addressed in the analysis that follows, by comparing recent costs with earlier periods of significant investment (for example, the track renewal boom in the 1970s, the West Coast upgrade in the 1960s and 1970s, and the East Coast upgrade in the 1980s); and by explicitly including track renewal volumes as an output variable in one of the cost function specifications (see Table 5).

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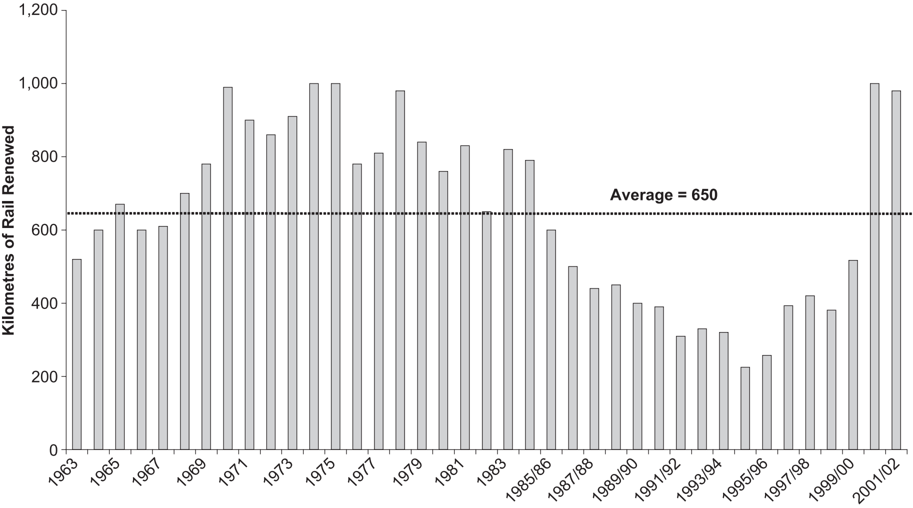
[42] Clearly staff cost rises play a part, but there remains a large element of unexplained cost rises.

[43] The renewal and enhancement of Britain's West Coast Main Line (linking London and Glasgow).

[44] As noted in the introduction, this is not just a problem for cash-based cost measures.

Figure 2

Track Population by Year of Installation[a]



Source: Network Rail 2003 Business Plan supplemented by data from the Railtrack Annual Returns for some of the post-privatisation years.

[a] These data are used as a proxy for annual renewal volumes. However, since some of the track laid in the early years of the sample, for example the 1960s, may now have been replaced, this data series may understate the true level of renewal volumes during that period. This graph is sourced from Network Rail's 2003 Business Plan, though has been supplemented with data on actual track renewal volumes from Railtrack's Annual Returns for some of the post-privatisation years.

It could be argued, of course, that the volume of track renewals is an intermediate output and not a final output, and that we should not be concerned with changes in this variable. As such, increased track renewals might only be considered valuable to the extent that they translate into improvements in measures that are valued by users (for example, safety and performance). Nevertheless, changes in the volume of track renewal activity will clearly affect cost levels from year to year, and it would therefore seem unwise to ignore such effects. Final output (safety and performance) measures are considered separately in the next sub-section (5.3).

Before proceeding it should be noted that the data in Table 4 show a substantial increase in rolling stock capital costs over the period since Hatfield. To the extent that this investment represents higher volumes of new rolling stock purchased, relative to any previous time period under British Rail, this increase could be used partly to justify recent cost increases.[45] Nevertheless, unless the new rolling stock — an intermediate output — translates into real benefits to customers, for example in

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[45] However, it has not been possible to obtain equivalent physical measures against which to measure the volumes and unit cost of new rolling stock purchased in previous years. A consistent time series of rolling stock investment, for the period of this study, is illusive, since trains were leased by British Rail during some time periods (though this issue does not affect the comparability of the total industry cash cost measure).

Table 5
Restricted Seemingly Unrelated Regression (1963 to 2001/02)
Dependent Variable: $Ln(Cash/W_{MC})$

	Traditional Models		*Renewals Model*
	Model 1 *Coefficient*	*Model 2* *Coefficient*	*Model 3* *Coefficient*
Constant	0.3070^{**}	0.1784^{**}	0.0874
$LnTRAC$	–	1.1214^{**}	1.4030^{**}
$LnTTM$	0.9613^{**}	0.3483^{*}	0.1371
LnP_L	0.6637^{**}	0.6694^{**}	0.6601^{**}
LnP_F	0.0357^{**}	0.0283^{**}	0.0270^{**}
HAT (Hatfield Effect)	0.3324^{**}	0.2933^{**}	0.2364^{**}
T (Time Trend)	-0.0147^{**}	-0.0074^{**}	-0.0024
$1/2(LnTRAC)^2$	–	1.5696	3.0358
$1/2(LnTTM)^2$	4.2463^{**}	6.2238^{**}	2.8668
$1/2(LnP_L)^2$	0.0531	0.1077	0.0959
$1/2(LnP_F)^2$	0.0311^{**}	0.0338^{**}	0.0331^{**}
$LnTRAC.LnTTM$	–	-3.7352	-3.4506
$LnTRAC.LnP_L$	–	0.1961	0.2029^{*}
$LnTRAC.LnP_F$	–	0.0907^{**}	0.0926^{**}
$LnTTM.LnP_L$	-0.3889^{**}	-0.4798^{**}	-0.4926^{**}
$LnTTM.LnP_F$	0.0546^{**}	0.0019	-0.0018
$LnP_L.LnP_F$	-0.0401^{**}	-0.0296^{**}	-0.0310^{**}
$LnP_L.T$	-0.0058^{**}	-0.0058^{**}	-0.0054^{**}
$LnP_F.T$	0.0007^{*}	0.0011^{**}	0.0012^{**}
$RENEW$	–	–	0.0699^{**}
R^2 statistic	0.8606	0.9312	0.9432
Durbin Watson statistic	0.9258	1.4238	1.626

* = significant at the 5 per cent level; ** = significant at the 1 per cent level.

improved reliability and comfort (a case that is not yet proven),[46] this justification might still be weak. Of course, the rise in rolling stock capital expenditure represents only about one fifth of the increase in costs over the period, and the results that follow are not materially affected if this increase is excluded from the data.[47]

5.2.1 *Presentation of econometric results*

Table 5 shows the econometric results for the three specifications described in Section 3. The first two specifications (Models 1 and 2) use traditional

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[46] Reliability problems have been experienced by some new rolling stock introduced in recent years.

[47] The available data on rolling stock investment suggest that the 2001/02 value was unusual compared with previous time periods (though see footnote 45). The sensitivity referred to in the text therefore excludes the increase in rolling stock investment between 2000/01 and 2001/02 from the 2001/02 cost base. The results show a small improvement in the post-Hatfield productivity index, though this change is not sufficient to alter the conclusions of the paper.

measures to represent the outputs of the railway industry, that is, total train kilometres (TTM)[48] and/or track kilometres (TRAC). Models 1 and 2 do not take account of track renewals directly in the regression, although the long-time period chosen for the analysis enables productivity levels and trends to be compared over periods with similar track renewal volumes (for example the post-Hatfield period *vs*. the 1970s). Model 3 seeks to model track renewal volumes explicitly by including the RENEW variable directly in the regression equation as an additional, intermediate output (see Figure 2).

For each of the models in Table 5, the translog total cost function is estimated as a system, together with the factor share equations (see Section 3). Starting with the first two (traditional) models, as stated above, railway outputs are represented by TTM (in Model 1) and by both TTM and TRAC (in Model 2). The latter specification enables the effects of scale and density to be evaluated separately.[49] Note that passenger and freight outputs are not considered separately in order to reduce the number of regressors, given the relatively small sample size.[50] Note also that some of the second-order time variables are excluded from the regression equation (only those that are statistically significant are retained).[51] Hatfield effects are modelled through the inclusion of a Hatfield dummy variable (HAT; see Section 3).

Models 1 and 2 perform well in terms of the degree of fit, and the significance of the variables, with all first-order terms and most of the second-order terms being significant. Model 1 suggests broadly constant returns to scale, while Model 2 indicates economies of density combined with diseconomies of scale (evaluated at the sample mean). Although previous studies of the structure of rail costs in Britain are limited in their approach (as described in Section 2 above), it is worth considering how the scale and density results in this paper compare with those earlier studies. In the only previous study to report scale and density economies separately for Britain, Preston (1996) also found diseconomies of scale alongside economies of density. The remaining literature provides varying results, with US studies

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[48] Passenger train kilometres plus freight train kilometres.

[49] Note that TTM and TRAC are not closely correlated, and their inclusion together is therefore unlikely to cause problems of multicollinearity.

[50] The inclusion of separate passenger and freight outputs also introduces potential collinearity problems, and the resulting models do not perform as well in terms of the significance of the output variables. However, these models produce almost identical results in respect of the coefficient on the time trend and Hatfield dummy variables. The use of a single railway output measure is common in previous studies, for example, Andrikopoulos and Loizides (1998), who used the sum of sum of passenger kilometres and freight tonne kilometres to reflect railway output in a single measure.

[51] The inclusion of all second-order time variables caused some first-order output terms to become insignificant.

suggesting constant returns to scale and increasing returns to density, while the majority of European studies have found evidence of decreasing returns to scale in respect of the British network.[52]

On balance, Model 2 is preferred to Model 1, for a number of reasons. First, Model 2 is able to distinguish scale and density effects. The finding of decreasing returns to scale (alongside increasing returns to density) seems credible, based on the evidence from previous studies, and the apparently high cost of expanding capacity.[53] Model 2 also performs better in terms of the R^2 and Durbin Watson statistics. While the inclusion of TRAC alongside the time trend variable might raise some concerns regarding multicollinearity, there is no evidence of any serious effects on the results.[54] However, to reflect the differing interpretations offered by the two approaches, the results of both models are referred to in the discussion that follows.

Turning to the renewals model (Model 3), this specification includes the track renewal variable (*RENEW*) directly in the cost function as an additional output, and is identical to Model 2 in all other respects. Note that the coefficient on the *RENEW* variable has a positive sign and is statistically significant, confirming the expected positive relationship between renewal volumes and costs (note that only the first-order term is included in order to conserve degrees of freedom).[55] Model 3 performs well in terms of fit and significance of the variables, although the first-order *TTM* variable becomes insignificant with the addition of the *RENEW* variable. Note, however, that the *RENEW* variable is not statistically significant when included in Model 1 (results not shown).

In line with theory, the estimated cost functions in Table 5 are monotonically increasing (since the predicted cost shares are positive), and the Allen-Uzawa own (partial) elasticities of substitution, evaluated at the sample means, have the required negative signs (see Table 6).[56]

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[52] That is, where scale and density effects are not reported separately (and only returns to scale are reported). See Gathon and Perelman (1992) and Sanchez and Villarroya (2000). On the other hand, Andrikopolous and Loizides (1998) reported increasing returns to scale for the British network.

[53] Furthermore, greater than proportional cost reductions resulting from the Beeching cuts (in the 1960s) may be expected — relative to track mileage — given the very large number of stations closed during that period.

[54] All the first-order variables are significant, and the standard errors are low. Furthermore, the Model 2 results are robust to changes in the sample period.

[55] The first-order renewal variable is positive but insignificant if all interaction terms are included, perhaps as a result of the large number of regressors relative to the sample size.

[56] Global concavity requires the own partial elasticities of substitution to be negative at all points in the sample (or, more precisely, for the matrix of second-order derivatives of the cost function — the Hessian — to be negative semi-definite throughout). The required properties are satisfied globally in respect of labour and capital and materials prices; though they are violated for a handful of data points in respect of fuel prices. The latter is not considered serious since fuel costs account for less than 5 per cent of total costs on average.

Table 6
Allen-Uzawa Partial Elasticities of Substitution (evaluated at the sample mean)

	Own elasticities		
	Model 1	*Model 2*	*Model 3*
Labour input	−0.641	−0.461	−0.500
Fuel input	−6.324	−5.178	−5.466
Materials and capex input	−1.491	−0.980	−1.075

5.2.2 Discussion of results

What do the results in Table 5 tell us about comparative productivity levels and trends over the period in question? Beginning with the traditional models, Models 1 and 2, the first point to note is that the Hatfield dummy variable is large and strongly significant in both models, indicating a 'Hatfield effect' on unit costs of 39 and 34 per cent (Models 1 and 2 respectively),[57] or a deterioration in productivity of 28 and 25 per cent respectively. These findings are in line with the results reported in Kennedy and Smith (2004). They suggest that the post-Hatfield cost increases reported earlier are exceptional when compared with historical precedents, including periods such as the 1970s, which saw similar levels of track renewal activity to those observed in recent years.

The coefficients on the time-trend variables also indicate, alongside the observed Hatfield effects, annual TFP growth of approximately 1.4 and 0.7 per cent (for Models 1 and 2) over the period 1963 to date. The difference in time trend between the models is apparently driven by the alternate findings on scale effects reported above. Interestingly, it was not possible to identify a significant privatisation effect (in either of the two models) separate from the Hatfield effect (the coefficient on a privatisation dummy took the expected negative sign, but was not statistically significant).

This latter finding appears to contrast with the results obtained in Pollitt and Smith (2002), where substantial reductions in operating costs were reported for the post-privatisation, pre-Hatfield period, compared with the counterfactual scenario (although the analysis there was not based on econometric methods). However, Figure 1 shows that total industry costs, like operating costs, were lower during the early period after privatisation (covering the period from 1993/94, but before 1999/00). The fact that this effect does not show up as statistically significant in the econometric

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[57] Calculated as EXP(0.3324) and EXP(0.2933)-1 for the two models.

Table 7
Total Factor Productivity Indices[a]

	Econometric Models			
	Model 1	*Model 2*	*Model 3*	*Tornqvist*[b] *Index*
Start of sample: 1963	100.0	100.0	100.0	100.0
Previous track renewal peak: 1975	116.2	106.5	100.5	129.7
End of BR era: 1992/93	149.3	120.4	104.4	156.6
Last pre-Hatfield year: 1999/00	168.2	129.1	108.0	188.2
Post-Hatfield: 2001/02	125.0	98.3	86.2	139.8

[a] 1963 = 100 for all indices.
[b] See Section 3 for description of this index. Uses TTM as the single output, to maintain consistency with the other results.

results may reflect the relatively small number of post-privatisation, pre-Hatfield data points and the large number of variables included in the cost function. Of course, the results in Table 7 do show faster TFP growth after privatisation, although this increase reflects a gradual increase in productivity growth over the sample, rather than a clear privatisation effect.[58]

The results from the renewals model (Model 3) are similar to those of Models 1 and 2, although the magnitudes of the Hatfield effects and time trends differ (see Table 5), with Model 3 suggesting a much lower time trend coefficient (which is also statistically insignificant). This finding suggests that part of the (time-trend) productivity gains reported in Model 2 can be explained by the decline in track renewal volumes from the mid 1980s onwards. Likewise, the Hatfield effect is smaller than under Model 2 since part of the cost increase post-Hatfield can be explained by increased renewal volumes over the period. In this case, a privatisation dummy variable shows up as just significant at the 5 per cent level (negative sign), although its inclusion produces some large standard errors and changes to the other coefficients.

Taking account of Hatfield and time-trend effects, Table 7 compares post-Hatfield productivity levels for the econometric models (Models 1 to 3) and the Tornqvist approach against four earlier periods. These are: 1963; the previous track renewal boom in the 1970s (represented by 1975);[59] the end of the BR period (1992/93);[60] and the last year before Hatfield (1999/00). Not surprisingly, given the different coefficients on

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[58] The inclusion of the $LnP_L.T$ and $LnP_F.T$ terms in the cost function allows the time trend to vary over the sample.

[59] 1975 is not only the mid-point of the 1970s, but also the peak of the 1970s track renewal boom.

[60] 1992/93 is the last year unaffected by privatisation. See Pollitt and Smith (2002).

the time-trend variable (see Table 5), Model 1 indicates significantly higher TFP growth over the period 1963 to 1999/00 than Model 2. Furthermore, since Model 1 implies broadly constant returns to scale, the Tornqvist productivity results are closer to those of Model 1 than Model 2. Appendix 3 shows a comparison of the results with previous studies.[61]

Based on the preferred model (Model 2), Table 7 shows that the TFP gains achieved over the period up to the Hatfield accident (1999/00) have been more than wiped out by post-Hatfield falls; leaving TFP in 2001/02 just below 1963 levels. Model 2 also shows that post-Hatfield productivity levels are lower than during the last period of major track renewal in Britain, in the 1970s, by about 8 per cent, and considerably lower than in the last year of the BR period, by around 18 per cent. Including track renewals in the regression equation (Model 3) produces the same overall conclusion (though the magnitudes of the effects differ).

Meanwhile, Model 1 paints a similar story to that of Models 2 and 3, although the end result is that post-Hatfield TFP levels remain higher than at the beginning of the sample, putting a slightly more favourable interpretation on productivity performance post-Hatfield. This finding is replicated by the Tornqvist index results. Nevertheless, Model 1 still suggests that there has been no productivity growth over the last twenty years, with the implied post-Hatfield TFP performance equivalent to that achieved as long ago as 1980.[62]

To sum up, the above results show that the sharp cost increases following the Hatfield accident are unprecedented when compared against historical benchmarks set by British Rail and the early experience of the newly privatised industry (1963 to date). While railway costs are clearly influenced by the investment cycle, including periods of under-investment, the results show that costs have increased much more steeply over the post-Hatfield period than during previous investment peaks in the sample (for example, the track renewal boom in the 1970s).

Taking into account both the Hatfield effects on costs and longer-term TFP trends, the preferred models in Table 7 (Models 2 and 3) show that post-Hatfield total factor productivity is now lower than at any time over the last four decades. These results suggest that it is not possible to justify post-Hatfield cost and productivity levels by reference to historical precedents, even when fluctuations in track renewal volumes are taken into account.[63] The final part of this section (5.3) considers whether

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[61] Studies that have reported TFP indices for comparable periods. See Appendix 3 for further details.

[62] And as long ago as 1983 under the Tornqvist approach.

[63] As noted earlier, this result is not materially affected if the post-Hatfield increase in rolling stock capital investment is excluded from the cost series.

improvements in key safety and quality measures can provide part of the explanation/justification for higher costs in the post-Hatfield environment. However, we first take a brief detour to consider the impact of the 2002/03 Interim Review on the above findings.

5.2.3 Relationship with the 2002/03 Interim Review

The previous analysis has shown that productivity levels deteriorated sharply following the Hatfield accident and are now (in 2001/02) lower than at any time over the four decades covered by this paper. The analysis therefore suggests that the industry should be able to reduce costs/improve productivity in future years. In this regard, in its 2002/03 Interim Review conclusions the ORR has recently tasked Network Rail with achieving efficiency savings of between 30 and 35 per cent over the five-year period from 2004/05 to 2008/09 (see ORR, 2003). At the overall level, the ORR's conclusions mean that total infrastructure cash costs will fall by 36 per cent over the period.

While these savings are significant, it should be noted that they start from a 2003/04 infrastructure cost base which is some 27 per cent higher (unit costs 24 per cent higher) than in 2001/02, the last year covered by the analysis in this paper. As a result, even if Network Rail delivers on the targets set by the ORR, unit infrastructure costs — that is, infrastructure costs per train kilometre — will not fall below 2001/02 levels until 2006/07 (assuming constant traffic levels). On this basis, unit infrastructure costs in 2008/09 are projected to be roughly 20 per cent below 2001/02 levels, but still 16 per cent higher than in the last year before Hatfield (1999/00). Furthermore, Table 4 shows that a large proportion of recent industry cost can be attributed to train operating costs. This finding therefore suggests that attention to cost trends is required across the whole industry — and not just infrastructure.

5.3 Quality, safety and productivity

Three measures have been selected for analysis, based on long-term data availability: train performance; broken rails (per train km); and passenger fatalities (per passenger km). Train performance represents a measure of output quality, while the other two are indirect or direct measures of safety (broken rails and passenger fatalities respectively). The train performance variable is a composite of the punctuality and reliability data published by British Rail and the SRA.[64] The other measures do

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[64] Punctuality measures the proportion of trains running on time, while reliability reflects the proportion of trains that are cancelled. See Section 4 and Appendix 2 for further details. See below for further discussion of the impact of changes in definition on the data.

Table 8
Quality/Safety Measures

	1960s	*1970s*	*1980s*	*1990s Pre-sale*	*1990s Post-sale Pre-HAT*[a]	*1990s Post-sale Post-HAT*
Train performance (per cent)	NA	89.4	87.9	87.7	91.0	81.5
Broken rails per train km (Index: 1969 = 100)	100	118.4	116.5	102.4	116.7	79.5
Passenger fatalities per pass. km (Index: 1963 = 100)	101.4	91.3	79.4	57.6	49.2	26.0

[a] *HAT* = Hatfield.
Train performance data from 1975.
Broken rails data available from 1969.
Sources: see Section 4 and Appendix 2.

not require further explanation. The data is summarised in Table 8.[65] To our knowledge, such a long-term series for two of the three measures (train performance and broken rails) has not previously been reported in the literature.

As noted in the introduction to this section, attempts to incorporate these measures directly into the total cost function did not produce sensible results, even when lagged relationships between the variables were explored.[66] As a result, the main analysis here is based on simple observation of the cost/quality/safety data over time. In addition, econometric estimation is conducted in order to explore the determinants of these key quality/safety variables over the period. The train performance and safety measures are discussed in turn below.

5.3.1 Train performance

The full time series for train performance is shown in Figure 3, covering the period for which data are available (1975 to 2001/02). It should be noted that the sharp increase in the train performance measure in 1996/97 does not result from definitional changes (the definitions were changed one

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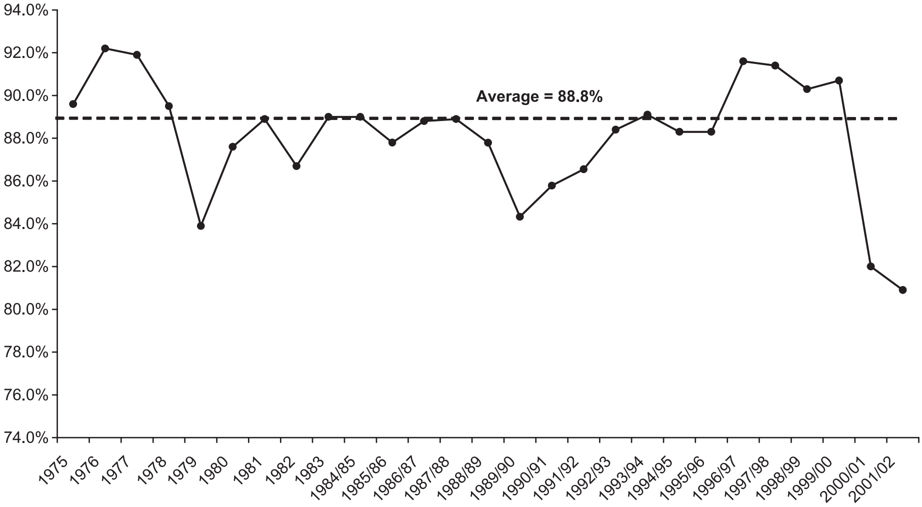
[65] Note that the last year before privatisation in Table 8 is taken to be 1995/96 — that is, before Railtrack and the train operators were privatised. In previous tables in this paper, the last year under British Rail is taken to be 1992/93, as some restructuring and sell-offs started from 1993/94.

[66] This may be the result of collinearity problems, the relatively small sample size and endogeneity problems (that is, the quality/safety measures might be considered as endogenous variables — and therefore, inclusion of these variables on the right hand side of a cost regression may introduce bias).

Figure 3
Train Performance[a]



[a] Composite measure of punctuality and cancellations. Sources: see Appendix 2.

year earlier in 1995/96).[67] This increase represents a genuine improvement, driven largely by reductions in Railtrack-caused delays (see Pollitt and Smith, 2002). Railtrack was given very strong incentives to improve performance under the incentive regimes put in place at the time of privatisation. Of course, the deterioration in post-Hatfield train performance likewise represents a genuine deterioration and is not driven by definition changes.[68]

With the definitional points dealt with, it is clear from Figure 3 and from Table 8 that improvements in train performance cannot be used to explain higher costs/lower productivity in the post-Hatfield environment. While costs have surged during the post-Hatfield period, train performance deteriorated sharply in 2000/01 and again in 2001/02, and has failed to mount a significant recovery since then. Furthermore, current performance levels are now lower than at any previous period in the sample.

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[67] From 1995/96, the punctuality definition changed, so that trains were defined as late if more than 4.59 late (and 9.59 for InterCity), rather than 5.59 (and 10.59 for InterCity) as before. However, this change does not appear to have a major impact on the data. Note also that the 1995/96 change actually made it harder for trains to be counted as on-time. There was also a change in definition in 1992/93, with data based on services covering Monday to Sunday, rather than Monday to Saturday as previously. However, this change does not appear to have impacted significantly on the data, with the composite performance measure continuing an upward trend established in earlier years.

[68] As noted in Section 4 and Appendix 2, the change in definition of services covered by the PPM — which would otherwise affect the comparison after 1999/00 — has been corrected for.

Table 9
Ordinary Least Squares
Dependent Variable: Ln(Train Performance)

	Model A		*Model B*	
	Coefficient	*t ratio*	*Coefficient*	*t ratio*
Constant	0.342	2.503	−0.185	−0.756
Ln(Passenger train km per track km)	−0.157	−3.134	0.023	0.266
Ln(Track Renewals per track km)	−0.036	−2.877	0.004	0.218
Hatfield effect dummy variable[a]			−0.093	−2.491
R^2 statistic	0.346		0.485	

[a] Takes the value unity in 2000/01 and 2001/02; zero elsewhere, since the main deterioration in performance took place in 2000/01.

There is little else that can be added regarding the cost-quality relationship. However, is there more that can be said about the reasons behind the recent sharp deterioration in train performance, based on the historical data? Two possible explanations are explored here. First of all, it is clear that track renewal activity over the post-Hatfield period has been at very high levels compared with the period immediately prior to Hatfield. The disruption caused by increased work on the track may be a driver of recent performance falls. Second, traffic density (measured as passenger train kilometres per track kilometre) was also higher in 2001/02 than at any point during the period 1975 to 2001/02, and this factor would again be expected to impact negatively on train performance.

Table 9 presents the results of regressing train performance on both traffic density and track renewals per track kilometre (all in logs). The results for Model A show that the coefficients on the density and track renewals variables take the expected negative signs, and that these variables are also statistically significant.[69] However, Model B shows that these effects cease to be significant once a Hatfield dummy variable is included. Overall, the econometric results therefore suggest that recent performance falls are dominated by unexplained Hatfield effects, and that changes in traffic density and track renewal volumes do not have a statistically significant impact on performance when modelled alongside a Hatfield dummy variable.

Of course, as discussed further below, the recent deterioration in train performance may have been caused, in part, by a shift in the industry's priorities in favour of asset condition and safety measures, at the expense of keeping the trains running on time. In this regard it should be noted

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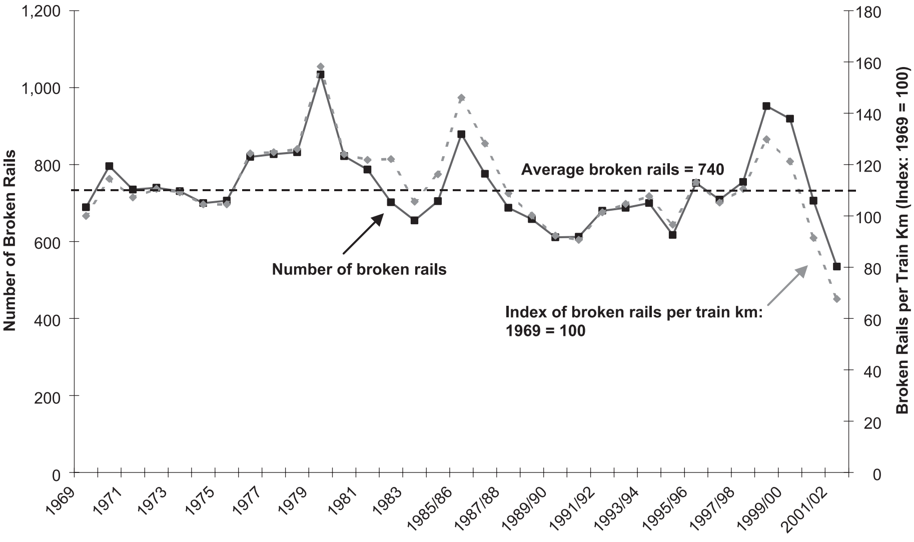
[69] The results in Table 9 are based on a log-linear model. The linear equivalent gives similar results.

Figure 4

Number of Broken Rails and Broken Rails per Train Kilometre (Index: 1969 = 100)



Sources: Network Rail and Transport Trends. 2002 Edition. Department for Transport.

that the number of temporary speed restrictions on the network has remained high throughout the post-Hatfield period, relative to previous years (averaging 537 in 2002/03, compared with between 250 and 300 during the early years after privatisation).[70]

5.3.2 Safety measures

While post-Hatfield cost increases cannot be justified based on train performance data, which has deteriorated, the analysis now turns to consider whether the recent cost rises can be explained by improvements in rail safety? One measure of rail safety is the number of broken rails. Over the last thirty or so years this measure has fluctuated around an average of roughly 740 per year (see Figure 4). However, in 1998/99 and 1999/00, broken rails started to rise considerably, and this increase prompted the ORR to set new targets for Railtrack. The Hatfield accident — itself caused by a broken rail — further heightened concerns over the condition of the network, and the number of broken rails subsequently improved sharply over the next two years, with further improvements continuing under Network Rail.

The reduction in the number of broken rails was achieved alongside improvements in other asset condition measures (for example, track

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[70] See Booz-Allen & Hamilton (1999) and Network Rail (2003).

Table 10

Ordinary Least Squares

Dependent Variable: Ln(Broken Rails per Track Kilometre)

	Coefficient	*t ratio*
Constant	−0.191	−0.468
Ln(Passenger train density)[a]	0.484	2.456
Ln(Freight tonne density)[a]	0.221	1.194
Hatfield effect dummy variable[b]	−0.425	−3.086
R^2 statistic	0.265	

[a] Expressed per track km.

[b] Takes the value 0.5 in 2000/01 and unity in 2001/02, as in the cost function estimation described above.

geometry). The data therefore do appear to suggest a link between improved asset condition and increased cost over the post-Hatfield period. The number of broken rails has now been reduced way below the long-term average. Indeed, the econometric results presented in Table 10[71] suggest that there is a clear, negative Hatfield effect on the number of broken rails (although broken rails had started to fall prior to Hatfield — see Figure 4).

It should be noted that broken rails and other asset condition measures are indirect measures of rail safety. Improvements in the quality of track should, over time, be reflected in reduced numbers of accidents and fatalities. However, the historical data show that few serious rail accidents in Britain have been caused by rail breaks. As a result, the reduction in broken rails seen in recent years may not have achieved much in terms of reduced accident risk, although it may have improved perceptions about safety on the railways. Of course, improved asset condition may be desirable in its own right, apart from its impact on safety, although it is questionable whether the recent improvements — so far in excess of long-term average levels — are really required.

Before turning to look at actual data on passenger fatalities, it is informative to consider an alternative indicator of accident risk on Britain's railways — namely SPADs (signals passed at danger). Although it has not been possible to obtain comparable data over the longer-term, recent trends suggest that this measure has also improved substantially in recent years. SPADs per train kilometre fell by 55 per cent between 1994/95 and 2001/02, with the majority of this improvement achieved over the period 1998/99 to 2001/02. Here again, the data suggest a link between increased

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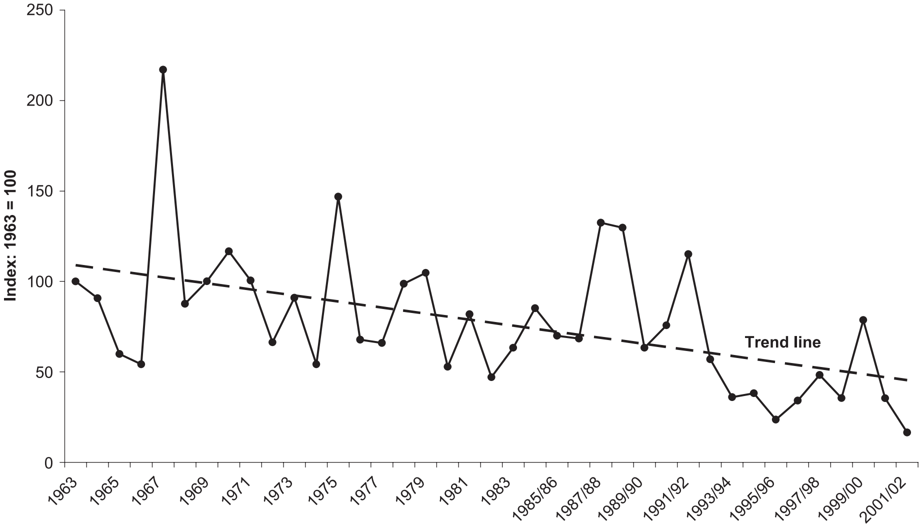
[71] The results in Table 10 are based on a log-linear model. The linear model produces similar results.

Figure 5

Passenger Fatalities per Passenger Kilometre (Index: 1963 = 100)



Sources: see Appendix 2.

spending and reduced accident risk, as the recent improvements reflect, in part, substantial investment in TPWS (the Train Protection and Warning System);[72] although it should be noted that SPADs were falling prior to the installation of TPWS.

Figure 5 charts the number of passenger fatalities per passenger kilometre over the period 1963 to 2001/02. The data show that the number of passenger fatalities (in absolute terms, and per passenger kilometre) has declined since the Hatfield accident. It is therefore possible that the recent attention to safety and asset condition measures, and the associated increase in expenditure, may already have led to reduced numbers of passenger fatalities — although it is too early to draw firm conclusions based on just two years' data. Econometric analysis of the determinants of passenger fatalities produced little of interest in this regard.[73] Of course, Evans (2000 and 2002) has separately argued that, based on the data available so far, the reduction in fatal train accidents since

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[72] This was fully implemented by the end of 2003, as required by the 1999 Railway Safety Regulations.

[73] Given the sharp annual fluctuations in passenger fatality data, the econometric work was carried out based on five year moving average data, thus precluding analysis of Hatfield effects, which relate only to two years. The results suggested that variations in passenger fatalities over this period have been dominated by time trend effects, as Evans (2000 and 2002) also suggests.

privatisation (and extending beyond Hatfield) should be viewed as a continuation of a long-term downward trend in accidents.[74]

To sum up, the above data and discussion suggest that the sharp cost increases observed during the post-Hatfield period have been associated with improved safety on Britain's railways. Broken rails fell sharply between 1999/00 and 2001/02, and the econometric results show that this can clearly be identified as a Hatfield effect (see Table 10; although some progress in bringing broken rails down was being made prior to Hatfield as noted above). Meanwhile SPADs have fallen substantially, driven, in part, by the rolling out of TPWS across the network. Finally, the number of passenger fatalities has also fallen, although more data are required to determine whether this represents a Hatfield effect, or merely a continuation of previous long-term trends.

Of course, if recent cost increases have indeed led to improvements in rail safety, it is important to ask whether these safety improvements are worth it from a cost-benefit perspective. The analysis now turns to consider this question.

5.3.3 Cost–benefit analysis of post-Hatfield safety gains

In order to compute the benefits of any safety improvements resulting from Hatfield, some measure of the associated reduction in passenger fatalities is needed. One option would be to base the calculation on the reduction in passenger fatalities between 1999/00 and 2001/02. However, such a calculation would be distorted by peaks in the data caused by individual incidents (for example, the Ladbroke Grove disaster in 1999/00, in which 31 people died). Table 11 therefore considers two comparisons.

First, the average number of fatalities over the post-Hatfield years (2000/01 and 2001/02) is compared with the average over the previous ten years (1990/91 to 1999/00). This reduction in fatalities is translated into a value to society using the VPF[75] figures published by the Rail Safety and Standards Board (RSSB). The RSSB puts the value of a rail fatality (or multiple fatalities) at £3.35m per equivalent fatality.[76] Of course this comparison suffers from the problem that it is based on only two years of post-Hatfield data. To supplement the first calculation, Table 11 therefore also shows the value to society of eliminating passenger

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[74] Although Evans does note a possible increase in the number of fatalities per accident in recent years. Evans argues that it is reasonable to put this increase down to chance, until further data becomes available. It may also reflect increased numbers of passengers per train, as train crowding has worsened in recent years.

[75] Value of preventing a fatality.

[76] See Railway Group Safety Plan 2001/02, published by Railway Safety.

Table 11

Societal Value of Reducing Passenger Fatalities[a]

Base data	
Average annual number of passenger fatalities: 1990/91 to 1999/00 (pre-Hatfield)	28.0
Average annual number of passenger fatalities: 2000/01 to 2001/02 (post-Hatfield)	15.5
Societal values of reducing passenger fatalities (2001/02 prices)	
Post-Hatfield reduction in annual fatalities (28 per year to 15.5 per year)	£42m
Reducing annual fatalities to zero (28 per year to zero per year)	£94m
Costs	
Hatfield effect on annual industry cash costs	£2,122m[b]

[a] Based on a value of preventing a fatality (VPF) of £3.35m per equivalent fatality (multiple or rail fatality).

[b] Based on applying the Hatfield effect (Model 2) of 34% to the cost base in 1999/00 (see Table 4).

fatalities altogether, based on the average number of fatalities over the ten years from 1990/91 to 1999/00.

Table 11 shows that the social welfare benefit of the post-Hatfield reduction in passenger fatalities (£42m) is dwarfed by the Hatfield effect on industry costs (£2.1bn),[77] with the data implying a cost per life saved of approximately £168m. Furthermore, even if passenger fatalities were cut to zero, the resulting improvement in social welfare (£94m) would still be well short of the £2.1bn increase in cost. The data in Table 11 therefore suggest that if recent cost increases have been driven predominantly by safety improvements — rather than straightforward reductions in productivity — the cost of these improvements far outweighs the benefits. It also implies that the extra money being pumped into railways would be better spent on road safety improvements, or possibly other areas of the public sector, such as the National Health Service (NHS).

To complete this section, it should also be noted that the preceding discussion highlights the stark contrast between performance and safety trends in the post-Hatfield era. It could be argued that the regulatory, political, and legal environment in which the railways currently operate has created a culture of risk aversion that produces 'too much' safety, at the expense of performance. Rail accidents make headline news and senior executives face lengthy follow-up enquiries, as well as the threat of manslaughter charges, which may have a greater impact on management incentives than the financial payments underpinning the performance

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[77] See note (b) to Table 11. This figure is lower than the £2.9bn increase in costs shown in Table 4, since part of the cost rises are explained by the variables in the cost function regression analysis presented in section 5.2 above (such as traffic growth).

regimes — particularly following the loss of Railtrack equity incentives after October 2001.[78]

A key question facing policy makers is whether there is a case for refocusing effort and resources away from safety towards dealing with performance issues, and if so, how the framework of incentives should be set to encourage delivery of this change in priorities. Of course, since improved rail performance would have the effect of taking passengers off the roads — which are less safe — such a change in policy should actually reduce fatalities on the two modes overall (although this effect might be offset, to some extent, by the diversion of traffic to the even safer mode of air transport).

6.0 Conclusions

The privatisation of British Rail has been the source of much controversy over the eight years of private sector ownership, particularly after the sharp increase in costs following the Hatfield accident. The objective of this paper was to construct total rail industry costs over the post-privatisation period, and then assess post-Hatfield cost and productivity levels against the historical precedents set by British Rail and also the early experience of the newly privatised industry (1963 to date). Rail industry productivity levels and trends for the post-Hatfield period have not previously been reported in the literature.

The paper reports a number of interesting findings. First of all, the data show that annual industry cash costs have risen by £2.9bn in real terms since the Hatfield accident, an increase of 47 per cent (or a unit cost rise of 40 per cent). Perhaps more surprisingly, the data also show that TOC costs account for 38 per cent of the total industry cost rise since Hatfield, of which about half comes from increases in the basic cost of running passenger train services. Taken together, passenger and freight operator costs account for 42 per cent of the industry cost rise over the post-Hatfield period.

The econometric results show that the sharp cost rises following the Hatfield accident are unprecedented when compared against historical benchmarks. While railway costs are clearly influenced by the investment cycle, including periods of under-investment, the results show that costs have risen much more steeply over the post-Hatfield period than during previous investment peaks — including the track renewal boom in the 1970s. In terms of comparative productivity levels, the indices for the

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[78] After the company was placed into administration.

preferred models show that post-Hatfield cost rises have more than wiped out the TFP gains achieved over the previous four decades (though slightly more favourable results are given by some of the other models). It is therefore not possible to justify post-Hatfield cost and productivity levels by reference to historical precedents, even when fluctuations in the investment cycle are taken into account.

Furthermore, preliminary data for 2002/03 and 2003/04 indicate that industry costs have continued to rise sharply since the last year of the sample used in the analysis (2001/02). In other words, the true picture of post-Hatfield cost and productivity performance may be even worse than suggested by the results presented in this paper. However, a lack of external benchmark information means that the industry's regulators have so far struggled to challenge these cost rises successfully.

The paper has also considered whether improvements in quality/safety might be used to explain recent cost increases. Unfortunately, higher costs after Hatfield have not resulted in better train performance relative to historic data — quite the reverse. On the other hand, it would appear that the post-Hatfield environment has been associated with improvements in direct and indirect measures of rail safety. However, to the extent that improved safety is the cause of higher railway costs, it is clear that the implied investment in safety easily fails the cost–benefit test. This finding suggests that the current regulatory, legal and political environment may have led to an excessive focus on safety, without due regard to cost considerations or the implications for punctuality.

Of course, while safety considerations appear to have played a role in driving up costs in recent years, there may be other factors impacting on recent cost and productivity trends. The decision to place Railtrack into administration, and replace it with a not-for-dividend company, may have weakened incentives for cost control at a critical time for the industry. Alternatively, part of the explanation may lie in higher maintenance and renewal contractor profits, although this is considered unlikely for the reasons outlined earlier.[79] On the train operation side, incentives to contain costs may have been impacted by the franchise renewal process (delays and changes in policy), as well as by the SRA's approach to bailing out failing TOCs. The impact of the new, more tightly-defined franchise agreements on TOC incentives remains to be seen. Further research is required in this area.

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[79] Even if contractor profits have increased, driven perhaps by capacity constraints and insufficient competition between companies, the associated rise in Railtrack/Network Rail costs, and ultimately government subsidies, is unlikely to represent good value for money for taxpayers. Note that in 2003, Network Rail announced its decision to bring all maintenance activities in-house.

Whatever the causes of the recent deterioration in rail productivity, the results suggest that the industry should be able to achieve significant productivity gains in the future. While the ORR has tasked Network Rail with achieving substantial efficiency savings over the period 2004/05 to 2008/09, these reductions start from an infrastructure cost base (2003/04) that is 27 per cent higher than in 2001/02 (the last year covered by the analysis in this paper). This means that, even if Network Rail delivers on these targets, infrastructure costs per train kilometre will not fall below 2001/02 levels until 2006/07; and the projections show that costs are not projected to return to pre-Hatfield levels over the period of Network Rail's Business Plan (to 2013/14).

It should also be noted that the ORR's expenditure allowances have been prepared on the assumption that Network Rail continues to improve key asset condition and safety measures further. The level of infrastructure cost savings could therefore be higher were this not the case. Furthermore, given that the costs of train operation have also increased sharply post-Hatfield, it is clear that pressure needs to be brought to bear on costs across the whole industry and not just infrastructure. It remains to be seen what impact the current government review of the rail industry will have on the industry's priorities as between cost, safety and punctuality.

We suggest three key areas for future research. First, it is important to obtain a greater understanding of the costs and benefits of the safety requirements and practices on Britain's railways. This proposed work is likely to require analysis at a considerably more disaggregated level than has been attempted in the present discussion. Second, one of the key issues facing policy makers is the fact that we still do not know where Britain's railways stand relative to international comparators. The development of a robust international benchmarking framework should therefore be a priority, particularly given the fact that overseas comparisons offer (potentially) the only way of justifying current cost levels. Finally, further work is required to understand the reasons behind recent sharp increases in train operating costs (as TOC costs have received considerably less attention than infrastructure costs in the recent rail policy debate).

Appendix 1

From 1978, the BR accounts show that capital grants received from the government were reflected as revenue in the profit and loss account (P&L), with an equal and offsetting charge reflected in costs (so that the capital grant had a neutral impact on the P&L). The capital grant was

Comparison of British Rail Depreciation Data:
BR Accounts vs. UIC

£m (current prices)	*89/90*	*90/91*	*91/92*	*91/92 Re-stated*	*92/93*	*93/94*
BR accounts						
Depreciation charge	130	150	179	287	270	292
Capital grant charge to P&L	79	95	209	−161	−172	−192
Sum of the above	**209**	**245**	**388**	**126**	**98**	**100**
UIC data						
Depreciation charge	209	245	179	NA	98	100

Sources: BR Annual Report and Accounts; UIC International Railway Statistics.

then added to the capital reserve in the balance sheet. In the UIC accounts the capital grant is (incorrectly) added to the depreciation charge, and the UIC data therefore overstates the level of depreciation. From 1991/92, the accounting policy changed, with the capital grant no longer shown in turnover (only the revenue grant was included in turnover). Instead, the capital grant was added to reserves in the balance sheet and then released to the P&L as a negative cost over the lives of the assets. Once again the UIC (incorrectly) includes this negative figure in the depreciation charge for Britain and therefore understates the level of depreciation from 1991/92 onwards.

Appendix 2

Supplementary Information on Data Sources and Assumptions

Data	*Source*	*Assumptions*
Post-Hatfield cost adjustments	Annual reports of privatised companies[a] (1996/97 to 2001/02); ATOC Press Release (February 2001); SRA Annual Report (2001/02).	As noted in Section 4, a number of adjustments were made to the post-Hatfield cost data to reflect the large intra-industry payments over this period. For some of these items, and for some TOCs, the accounting treatment is not explicitly identified in the relevant TOC accounts. In these cases assumptions were made based on the practice of other TOCs and also access charge revenue data provided by Network Rail. Where not stated explicitly in the TOC accounts, compensation from Railtrack to TOCs is assumed to be included in TOC accounts as a negative cost,[b] while TOC penalty payments, Clause 18.1, and passenger compensation are assumed to be included as negative revenue. These assumptions were verified following discussions with National Express Group. Section 4 also made reference to a figure of £590m provided for in the Railtrack accounts in 2000/01, in respect of compensation to train operators. Note, however, that not all of the £590m was actually paid. The amount actually paid is used in the analysis here. As part of the 2000 Periodic Review, track access charges were reduced. Clause 18.1 of the TOC Franchise Agreements mean that TOCs are held neutral in respect of such changes, and therefore in aggregate TOCs were required to make payments to the SRA (Clause 18.1 payments referred to in Section 4).
Volume and quality measures	British Rail Annual Reports; National Rail Trends (SRA); Transport Statistics Great Britain; Network Rail; Health and Safety Executive.	The composite train performance measure referred to in Table 3 is calculated as punctuality less (1-reliability). For the period after 1999/00 — when punctuality and reliability reporting was replaced by the SRA's own combined measure (the Public Performance Measure, or PPM) — the composite measure used in this paper is constructed based on the change in the SRA's PPM measure. This is possible because the PPM is published alongside punctuality/reliability (1997/98 to 1999/00).

[a] TOCs, EWS, Freightliner, three rolling stock companies and Railtrack/Network Rail.

[b] With the exception of Charter compensation and compensation for disruption resulting from large projects (e.g. West Coast Mainline), which is generally shown as other income in TOC accounts.

Appendix 3

Comparison with Results of Previous Studies

	Annual average TFP growth rates (per cent)					
	Present study				*Previous studies*[a]	
	Model 1	*Model 2*	*Model 3*	*Tornqvist*	*Bishop and Thompson (1992)*	*Cowie (2002)*
1970s	1.3	0.6	0.1	0.7	−1.7	−0.2
1980s	1.5	0.7	0.2	2.3	1.2	3.8
1970 to 1990	1.4	0.7	0.2	1.5	−0.3	1.8

[a] Note that in the case of Cowie (2002), the 1970s TFP growth rate covers the period 1972 to 1980.

The results in the above table show some differences between the findings reported in this paper and those reported for the previous studies shown (these are the only studies from Tables 1 and 2 that explicitly report TFP growth rates for comparable periods). However, as noted in Section 2, the previous approaches shown above use track kilometres to represent the capital input and are therefore not suited to addressing the problems under consideration in this paper, which is concerned, *inter alia*, with track investment and condition. Furthermore, it is not clear that these studies have adequately dealt with the accounting problems discussed in Section 2. In any case, neither of the studies shown above report (total system) railway productivity measures beyond 1990, and therefore do not shed light on questions concerning post-Hatfield productivity levels.

In particular, it should be noted that the differing results for the 1970s are probably caused by the change in accounting policy in 1975, referred to in Section 2. From 1975, track renewals were charged to the P&L (previously they were capitalised). TFP measures based on labour inputs, other costs and track mileage — as used in Bishop and Thompson (1992) and Cowie (2002) — will therefore record this change as a deterioration in TFP, since the rise in other costs will not be offset by any change in the capital input. However, the approach in this paper would not observe any change in TFP, since the total cost measure used is invariant to changes in accounting policy. As noted in Pollitt and Smith (2002), previous studies may have overstated productivity growth during the 1980s due to the substantial asset sales undertaken during that period.[80]

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[80] See page 481.

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