RAIL SAFETY AND RAIL PRIVATISATION IN BRITAIN

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Summary

British Rail (BR), the former unified main line railway operator in Great Britain, was divided into about 100 separate organisations and privatised from April 1994. There was concern in the run-up to privatisation that the fragmentation of the system and the entry of new operators might compromise safety. This paper investigates what has happened to safety by analysing data on almost all fatal railway accidents, together with the most important non-fatal train accidents, from 1967 to 2003, with additional brief analyses back to 1946. BR had achieved downward trends in the mean numbers of accidents per train-kilometre for all the main classes of accident in the 27 years up to 1993, and the paper takes the extrapolation of these favourable trends as the yardstick by which to judge the safety performance of the privatised railway. The paper finds that the privatised railway bettered this yardstick in all classes of accident. Only one indicator is adverse: the number of fatalities in train collisions and derailments is higher than expected, because of the severity of the accident at Ladbroke Grove in 1999. Notwithstanding the generally good record, many people believe that safety has deteriorated on the privatised railway. The paper discusses reasons why, contrary to the evidence, this belief persists.

Keywords

Railways, rail privatisation, safety, accidents, fatalities.

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1 INTRODUCTION

The main line railway system of Great Britain was divided into about 100 separate organisations and largely privatised under the Railways Act 1993. The first major step was implemented on 1 April 1994, when a new company, Railtrack, took over the railway infrastructure from British Rail (BR), which had been a nationalised industry providing and operating all the constituent parts of the railway. At the same time all British Rail's other activities, including train operation and track maintenance, were subdivided into a large number of separate freestanding units, and these were privatised one by one over the following three years. Railtrack was initially publicly owned, but was privatised in May 1996. Railtrack was placed in administration in October 2001, and the infrastructure was taken over by a new not-for-profit company, Network Rail, in October 2002.

It was clear from the start that privatisation could affect railway safety, and that safety would require careful management. The main concerns were that:

(a) The safety responsibilities of the different railway organisations might be ill-defined, particularly as infrastructure provision and train operation were to be separated for the first time in Britain.
(b) Safety critical information might be attenuated across organisational boundaries (the 'interface risk').
(c) New companies with little previous experience of safe railway operation might enter the industry
(d) Changes in working practices were likely.

In 1992 the Government asked the Health and Safety Commission (HSC) to consider how to ensure that the railways' safety performance could be maintained during and after privatisation. Their report *Ensuring safety on Britain's railways* (1993) proposed a 'Railway Safety Case' regime as the cornerstone of the safety management system. This was accepted by the Government. The safety case system remains in place, though changes have been made since 1994.

The eight years 1996-2003 saw five fatal train collisions and derailments on the main line railway system, at Watford Junction in 1996, Southall in 1997, Ladbroke Grove in 1999, Hatfield in 2000, and Potters Bar in 2002. They each received wide publicity.

Because of these accidents, many journalists, railway professionals, and many of the public believe that the objective of maintaining safety during privatisation has not been achieved, and that safety has got worse. For example, in a book about a railway privatisation, *Broken Rails*, a railway journalist wrote:

> "Safety has been compromised … and this is the most powerful argument for some measure of reintegration." (Wolmar, 2001, p249).

In the most recent of a series of book on railway safety, a former BR Safety Officer wrote:

> "Privatisation was an underlying factor in the five serious accidents." (Hall, 2003, p120)

The playwright Sir David Hare (2003) has written a successful documentary play, *The Permanent Way*, indicting rail privatisation, two thirds of which is devoted to the four serious railway accidents since 1997.

The aim of this paper is to examine the safety record of the privatised railway in the decade after privatisation, using railway accident data both before and after privatisation. The general approach is

(1) Assemble long-term accident data for the BR period.
(2) Use these data to project estimates of the numbers of accidents that would have occurred after 1993 if BR had continued – the 'counterfactuals'.
(3) Compare this expected performance with the accidents that actually have occurred in 1994-2003.

The paper continues as follows. Section 2 presents the railway accident data. Section 3 presents the analysis of these data, leading to the conclusion that railway safety trends have not deteriorated since privatisation. Section 4 discusses and responds to counter-arguments, and considers why it is widely believed that safety has become worse. Section 5 is a brief conclusion.

2 DATA

2.1 Railway Inspectorate data

Compared with most countries, Great Britain has exceptionally good long-term railway accident data. This is because of the existence of the independent Railway Inspectorate (RI), whose history goes back to 1840. The RI receive accident data from the railway operators through statutory reporting requirements, and they publish statistical data and key events of the year in annual reports (for example, Health and Safety Executive, 2002). In addition, the Railway Inspectorate investigates accidents and publishes reports on them: some 500 reports have been published since 1946[1]. The RI's annual reports and accident reports are the original sources of almost all the data in this paper.

The writer has extracted and assembled RI data in several past projects: the main recent project covers all fatal accidents and fatalities in the 57 years 1946-2002 (Evans, 2004). The principal analyses in this paper cover 1967 to 2003, though we also look at data back to 1946. We regard 1967 as the beginning of the modern era on the railways; for example, it coincides approximately with the end of steam traction. In 1991, the RI changed their reporting period from calendar years to fiscal years (1 April to 31 March). This makes analysis slightly awkward. Wherever possible, we continue to use calendar years in our analyses, but for some types of accidents, we have no alternative but to use the same mixture of periods as the RI.

The RI traditionally classify railway accidents into three types: train accidents, movement accidents, and non-movement accidents[2]. Train accidents are those in which a train is damaged and casualties may occur; movement accidents are those in which a person is killed or injured due to the movement of a train, but the train itself is not damaged; non-movement accidents are other fatalities or injuries on railway property.

The RI data cover all railways, including the London Underground, metros, industrial and heritage railways, but for the purpose of investigating the effect of rail privatisation, we want

[1] From 2005 the investigation of accidents will carried out by a new body: the Rail Accidents Investigation Branch.
[2] The RI currently describe these as 'incidents' rather than 'accidents'. This is in response to the view that unintended harmful events should not be described as 'accidents', because accidents are sometimes held to be outside human influence. In this paper we use 'accident' without intending that implication.

data for the main line railways alone. We can separate the much of the main line from the non-main line data, but not all. We indicate the coverage in what follows.

2.2 Accidents analysed

2.2.1 Fatal accidents

Table 1 gives shows the number of fatalities and fatal accidents on the main line railway system in the 36¼ years from 1967 to 2002/2003[3]. The table shows that there were 2,229 fatal accidents in that period, causing 2,607 fatalities. Movement and non-movement accidents accounted for 88% of the accidents and 77% of the fatalities. The high-profile fatal train collisions, derailments and overruns accounted for 4% of the accidents and 12% of the fatalities.

Table 1: Fatal accidents and fatalities: main line railways: 1967-2002/2003

	Number of Accidents	Number of Fatalities
Accidents included in analysis		
Movement and non-movement	1,956	2,014
Train accidents		
Train collisions, derailments, overruns	80	320
Train/road vehicle collisions	167	231
All accidents included	2,203	2,565
Accidents not included in analysis		
Train fires	4	16
Other train accidents	22	26
All accidents not included	26	42
All fatal accidents	2,229	2,607

Of these fatal accidents, we include three groups for analysis in this paper These are

(1) Fatal movement and non-movement accidents, taken together.
(2) Fatal train collisions, derailments and buffer overruns on running lines of the main line railway.
(3) Fatal collisions between trains and road vehicles, both at level crossings and elsewhere.

Table 1 shows that these accidents together account for 98.8% of the fatal accidents, and 98.4% of the fatalities. The excluded accidents are train fires (not following collisions) and a residual category of 'other train accidents'. Train fires are important, but are so infrequent that they cannot sensibly be statistically analysed on their own. 'Other train accidents' are a mixture of mostly single-fatality accidents, including trains running into obstructions, deliberate or accidental missiles striking strains, and collisions or derailments in yards, in sidings, and during

[3] A notable feature of the published data for the years 1968-1983 is that, although the national total numbers of single-fatality movement and non-movement accidents in Great Britain are known for each year (and the average was about 80 per year in that period), there are no extant records of the numbers on the main-line and non-main line railways separately. In order to complete the data in Table 1, we need to know the numbers on the main line railways alone, and we have assumed that in each year these are exactly 6 less than the corresponding national totals. This is reasonable in the light of the numbers before and afterwards, but it will not be strictly correct.

engineering work. The excluded accidents are so few that they would not alter the conclusions of this paper.

Table 2 gives the detailed annual data on each of these classes of accidents, going back to 1946. The table also gives train-kilometres, as a measure of the scale of railway activity. Table 3 identifies the 80 individual fatal collisions, derailments and overruns in 1967-2003 on running lines of the main line railway[4].

2.2.2 Non-fatal accidents

As with many hazardous systems, fatal accidents on the railways make up only a small proportion of all accidents; there are many more non-fatal accidents. The most important non-fatal railway accidents are non-fatal train collisions, derailments and overruns, which are two orders of magnitude more frequent than fatal train accidents of the same kind. Since 1971 the RI have assembled data on such accidents affecting passenger lines, and they label these 'significant' train accidents. Unfortunately, the early data do not separate main line from non-main line accidents, so our analysis in this paper covers not just the main line railways but all in Great Britain. Nevertheless, this is still a valuable series, because it amplifies the rather limited data on fatal accidents of this kind. Table 4 gives the numbers of significant train accidents and train-kilometres in Great Britain for 1971 to 2002/2003.

There are also many non-fatal movement and non-movement accidents. Unfortunately, the data on injuries are incomplete over the long term, and there have also been substantial changes in definitions of reportable injuries. So we omit these from analysis.

[4] It should be noted that the accident at Great Heck on 28 February 2001, in which a train struck an errant road vehicle from the M62 motorway and then collided with another train, with 10 fatalities, is not in Table 3, because it is classified in this analysis as a collision between a train and a road vehicle.

Table 2: Fatal railway accidents and fatalities: national system: 1946-2003

Year	Main line Train-km (million)	Collisions, derailments & overruns Accidents	Collisions, derailments & overruns Fatalities	Train/road vehicle collisions Accidents	Train/road vehicle collisions Fatalities	Movement and non-movement accidents Accidents	Movement and non-movement accidents Fatalities
2003	518	0	0	3	5		
2002	516	1	7	3	3	*32	*32
2001	508	0	0	4	13	*20	*20
2000	503	1	4	3	3	*18	*18
1999	505	1	31	2	2	*25	*25
1998	487	0	0	4	4	*31	*31
1997	463	1	7	1	1	*28	*31
1996	437	2	2	2	3	*16	*16
1995	423	1	1	2	3	*18	*18
1994	415	2	7	4	4	*20	*20
1993	425	0	0	4	4	*28	*29
1992	430	1	1	4	7	*29	*31
1991	439	2	6	6	6	†60	†62
1990	431	1	1	2	2	54	58
1989	436	4	10	4	6	48	49
1988	443	2	36	4	4	50	50
1987	397	1	4	6	8	56	61
1986	414	2	2	13	23	40	40
1985	418	0	0	5	6	59	62
1984	389	5	22	3	5	42	43
1983	401	2	2	7	7	50	53
1982	372	2	2	3	3	40	40
1981	417	2	5	2	2	63	63
1980	430	2	3	2	3	55	56
1979	426	3	13	3	6	76	79
1978	430	2	4	4	5	84	86
1977	425	1	2	8	9	63	66
1976	426	2	3	12	14	70	71
1975	436	5	11	2	3	62	64
1974	452	2	2	1	1	65	66
1973	433	3	16	1	1	73	73
1972	431	2	7	7	11	71	73
1971	444	7	11	3	3	101	106
1970	452	2	3	11	12	115	118
1969	447	7	17	6	6	102	106
1968	449	3	6	13	31	84	87
1967	459	6	72	5	6	108	111
1966	478	1	2	8	10	102	103
1965	500	5	7	9	11	133	134
1964	541	6	11	11	14	123	128
1963	560	5	9	13	14	151	154
1962	578	2	21	8	11	160	165
1961	600	8	17	11	22	205	206
1960	603	5	10	7	17	183	184
1959	597	3	4	7	7	202	204
1958	605	5	18	9	13	169	169
1957	615	4	94	11	15	224	224
1956	605	4	4	11	12	228	228
1955	584	8	48	11	11	246	246
1954	608	1	1	10	11	215	217
1953	610	6	18	12	19	278	286
1952	605	7	120	12	13	249	254
1951	605	7	47	7	8	231	233
1950	618	5	13	14	19	247	250
1949	613	4	5	5	5	278	281
1948	589	10	48	11	20	273	273
1947	571	10	99	9	20	298	304
1946	600	9	38	7	16	370	378

†Fifteen months 1 January 1991 to 31 March 1992.
*Fiscal year: 3 months later than calendar year.

Table 3: Fatal collisions, derailments and overruns: national system: 1967-2003

Date	Location	Nature of accident	Immediate cause	Fatalities
10 May 2002	Potters Bar	Passenger train derailment	Defective points	7
17 Oct 2000	Hatfield	Passenger train derailment	Broken rail	4
5 Oct 1999	Ladbroke Grove	Two passenger train collision, fire	Conflicting movement SPAD	31
19 Sep 1997	Southall	Passenger/freight train collision	Conflicting movement SPAD	7
8 Aug 1996	Watford Junction	Passenger/ECS train collision	Conflicting movement SPAD	1
8 Mar 1996	Rickerscote	Two freight train collision	Broken axle on wagon	1
31 Jan 1995	Aisgill	Two passenger train collision	Landslip, derailment, collision	1
15 Oct 1994	Cowden	Two passenger train collision	Conflicting movement SPAD	5
25 Jun 1994	Branchton	Passenger train derailment	Obstruction placed on track	2
13 Nov 1992	Morpeth	Two freight train collision	Miscommunication	1
21 Jul 1991	Newton	Two passenger train collision	Conflicting movement SPAD	4
8 Jan 1991	Cannon Street	Passenger train/buffer collision	Overrun	2
4 Aug 1990	Stafford	Passenger/ECS train collision	Driver misjudgement	1
20 Apr 1989	Holton Heath	Freight train/LE collision	Miscommunication	1
6 Mar 1989	Bellgrove Junction	Two passenger train collision	Conflicting movement SPAD	2
4 Mar 1989	Purley	Two passenger train collision	Conflicting movement SPAD	5
27 Feb 1989	Warrington	Two freight train collision	Permissive working	2
12 Dec 1988	Clapham Junction	Two passenger/ECS train collision	Signal wiring error	35
11 Nov 1988	St Helens	Passenger train derailment	Train defect	1
19 Oct 1987	Glanrhyd Bridge	Bridge collapse, pass train fell	Bridge scour	4
19 Sep 1986	Colwich	Two passenger train collision	Conflicting movement SPAD	1
9 Mar 1986	Chinley	Passenger train/LE collision	Signalling error	1
4 Dec 1984	Eccles	Pass/freight train collision, fire	Plain line SPAD	3
3 Dec 1984	Longsight	ECS/freight train collision	Signalling error	1
11 Oct 1984	Wembley Central	Passenger/freight train collision	Conflicting movement SPAD	3
30 Jul 1984	Polmont	Passenger train derailment	Train hit cow on line	13
3 Feb 1984	Wigan	Two freight train collision	Permissive working	2
9 Dec 1983	Wrawby Junction	Passenger/freight train collision	Signalling error	1
3 Feb 1983	Elgin	Passenger train derailment	Track defect	1
9 Dec 1982	Linslade	Passenger train derailment	Displaced load	1
27 May 1982	Alvechurch	Passenger/freight train collision	Four runaway wagons	1
11 Dec 1981	Seer Green	Passenger/ECS train collision	Signalling error	4
8 Dec 1981	Ulleskelf	Passenger train derailment	Track defect	1
7 Nov 1980	Crewe	Two freight train collision	Excess speed	2
14 Mar 1980	Appledore, Kent	ECS train derailment	Excess speed	1
22 Oct 1979	Invergowrie	Two passenger train collision	Plain line SPAD	5
16 Apr 1979	Paisley Gilmour Str	Two passenger train collision	Conflicting movement SPAD	7
25 Feb 1979	Fratton	Passenger train/crane collision	Miscommunication	1
22 Dec 1978	Milford LC	Passenger train/car collision	Conflicting movement SPAD	1
19 Dec 1978	Hassocks	Two passenger train collision	Plain line SPAD	3
5 Sep 1977	Farnley Junction	Two passenger train collision	Signal defect	2
9 Nov 1976	Newton-on Ayr	Freight train/LE collision	Conflicting movement SPAD	1
3 Jan 1976	Worcester Tunnel Jc	Freight train/LE collision	Driver misjudgement	2
26 Oct 1975	Lunan Bay	Passenger train/LE collision	Excess speed	1
11 Jul 1975	Corby	Two freight train collision	Runaway wagons	1
24 Aug 1975	Carstairs	Freight train/LE collision	Signal bulb failure	2
6 Jun 1975	Nuneaton	Passenger train derailment	Excess speed	6
23 Jan 1975	Watford Junction	Derailment, then pass collision	Displaced load	1
23 Oct 1974	Bridgwater	Two freight train collision	Plain line SPAD	1
11 Jun 1974	Pollokshields East Jc	Two passenger train collision	Conflicting movement SPAD	1
19 Dec 1973	West Ealing	Passenger train derailment	Loco defect	10
30 Aug 1973	Shields Jc, Glasgow	Two passenger train collision, fire	Plain line SPAD	5
27 Apr 1973	Kidsgrove	Two freight train collision	Plain line SPAD	1
6 Sep 1972	Leicester	Two freight train collision	Miscommunication	1
11 Jun 1972	Eltham Well Hall	Passenger train derailment	Excess speed	6
16 Dec 1971	Nottingham	Two freight train collision	Conflicting movement SPAD	3
6 Oct 1971	Beattock	Two freight train collision	Train runaway	1
2 Jul 1971	Tattenhall Junction	Passenger train derailment	Track defect	2
21 May 1971	Cheadle	Two freight train collision	Wagons derail, then collision	1
18 May 1971	Middlesbrough	Two freight train collision	Permissive working	2
15 Apr 1971	Finsbury Park	ECS/freight train collision	Permissive working	1
26 Feb 1971	Sheerness	Passenger train/buffer collision	Overrun	1

Table 3 (cont): Fatal collisions, derailments and overruns: national system: 1967-2003

Date	Location	Nature of accident	Immediate cause	Fatalities
17 Jul 1970	Kirkstall	ECS/freight train collision	Permissive working	1
20 May 1970	Guide Bridge	Passenger train derailment	Signalling error	2
31 Dec 1969	Roade Junction	Passenger/freight train collision	Freight wagon defect	1
30 Dec 1969	Streatham Hill	ECS/crane collision	Miscommunication	1
18 May 1969	Beattock	Two passenger train collision	Driver misjudgement	1
7 May 1969	Morpeth	Passenger train derailment	Excess speed	6
8 Apr 1969	Monmore Green	Pass/freight train collision, fire	Conflicting movement SPAD	2
8 Mar 1969	Ashchurch	Passenger/freight train collision	Excess speed	2
4 Jan 1969	Paddock Wd-Marden	Passenger/freight train collision	Plain line SPAD	4
9 Sep 1968	Castlecary, Scotland	Passenger train/LE collision	Miscommunication	2
23 Mar 1968	Hatfield	Freight train overrun	Excess speed	2
11 Mar 1968	Peterborough North	Two freight train collision	Permissive working	2
5 Nov 1967	Hither Green	Passenger train derailment	Track defect	49
27 Sep 1967	Didcot	Passenger train derailment	Excess speed	1
15 Aug 1967	Copy Pit	Freight train/LE collision	Plain line SPAD	1
31 Jul 1967	Thirsk	Derailment, then pass collision	Freight wagon defect	7
5 Mar 1967	Connington South	Passenger train derailment	Signalling error	5
28 Feb 1967	Stechford	Passenger train/LE collision	Miscommunication	9

Table 4: Train-kilometres and significant train accidents: Great Britain: 1971-2002/2003

Year	Train-km (million)	Number of Accidents		Year	Train-km (million)	Number of Accidents
2002/2003	615	75		1986	467	200
2001/2002	607	92		1985	473	194
2000/2001	591	98		1984	444	201
1999/2000	592	97		1983	454	192
1998/1999	573	104		1982	423	184
1997/1998	552	89		1981	470	216
1996/1997	523	105		1980	478	190
1995/1996	496	104		1979	473	244
1994/1995	484	151		1978	478	220
1993/1994	489	142		1977	473	256
1992/1993	500	133		1976	475	263
1991/1992	504	131		1975	484	304
1990	486	161		1974	496	330
1989	488	177		1973	481	353
1988	504	226		1972	481	374
1987	455	201		1971	494	387

2.3 Train kilometres

As noted above, we use train-kilometres as a measure of the scale of railway activity. Table 2 gives the data for the main line railways alone, and Table 4 gives the data for all railways in Great Britain. Figure 1 plots the annual data for 1946 to 2002/2003.

Figure 1 shows that the majority of train-kilometres are on the main line railways, though those on the non-mainline railways have grown substantially since 1980, because of an increase on the London Underground, and because new metros and LRT systems have been built in major cities outside London. The number of train-kilometres on the main line system was remarkably steady throughout BR period from 1967 at 400-450 million per year. (The dip in 1982 was because of rail strikes.) However, train-kilometres declined from about 600 to 450 per year in the early 1960s, partly because of line closures in the 'Beeching era', and partly because of the loss of freight to the roads. The latter half of the 1990s saw a revival of rail activity to more than 500 train-kilometres per year.

Figure 1: Train-kilometres per year: 1946-2002/03

3 ANALYSIS OF ACCIDENT DATA

3.1 Form of analysis

As noted in section 1, the general approach to assessing the effect of privatisation on safety is to estimate the numbers of accidents and fatalities that could be expected to have occurred if BR had continued, and compare these with the actual numbers. Given the data above, we can now be more precise about how to do this. For data based on calendar years, we take end of the BR era as the end of 1993; for data based on fiscal years, we take the end of the BR era as the end of 1993/1994, because this was when Railtrack assumed control of the infrastructure.

The steps in the analysis of each class of accident are the following.

(1) Calculate and plot the observed annual or quinquennial accident rates per train-kilometre for the BR era 1967 to 1993 or 1967 to 1993/1994.
(2) Fit an exponential trend to the BR-era data, assuming that accidents occur as a Poisson process with a time-dependent mean proportional to (a) train-kilometres and (b) an exponential function of time.
(3) Extrapolate the trend to 2003 or 2002/2003
(4) Calculate the expected numbers of accidents and fatalities under a continuation of BR from the extrapolated trend.
(5) Compare expected numbers accidents and fatalities with the numbers that have actually occurred.
(6) Repeat the calculation taking 1946 instead of 1967 as the starting year to see whether this alters the conclusions.

3.2 Fatal movement and non-movement accidents

We now go through the steps above for the main line fatal movement and non-movement accidents, using the data in Table 2. The 27 solid points in Figure 2 plot fatal movement and non-movement accidents per million train-kilometres for the 27¼ BR years 1967 to 1993/94. It is clear by observation that the mean rate was falling over this period, though the scatter among the individual points is somewhat greater than would be expected of Poisson variables. The solid line is the exponential trend fitted through the points: its slope is –3.6% per year with a standard error of 0.3% per year. The dashed line is the extrapolation of the trend to 2002/03. The open points plot the observed values of accidents per million train-kilometres for the 9 post-privatisation years 1994/95 to 2002/03. It can be seen that every one of the post-privatisation points is below the trend established by BR. Thus the performance of the privatised railway has been better than the extrapolation of the BR trend. Figure 3 shows the corresponding results for data starting at 1946 rather than 1967. The fitted trend and the conclusions are very similar.

Figure 2: Fatal movement and non-movement accidents: 1967-2002/03

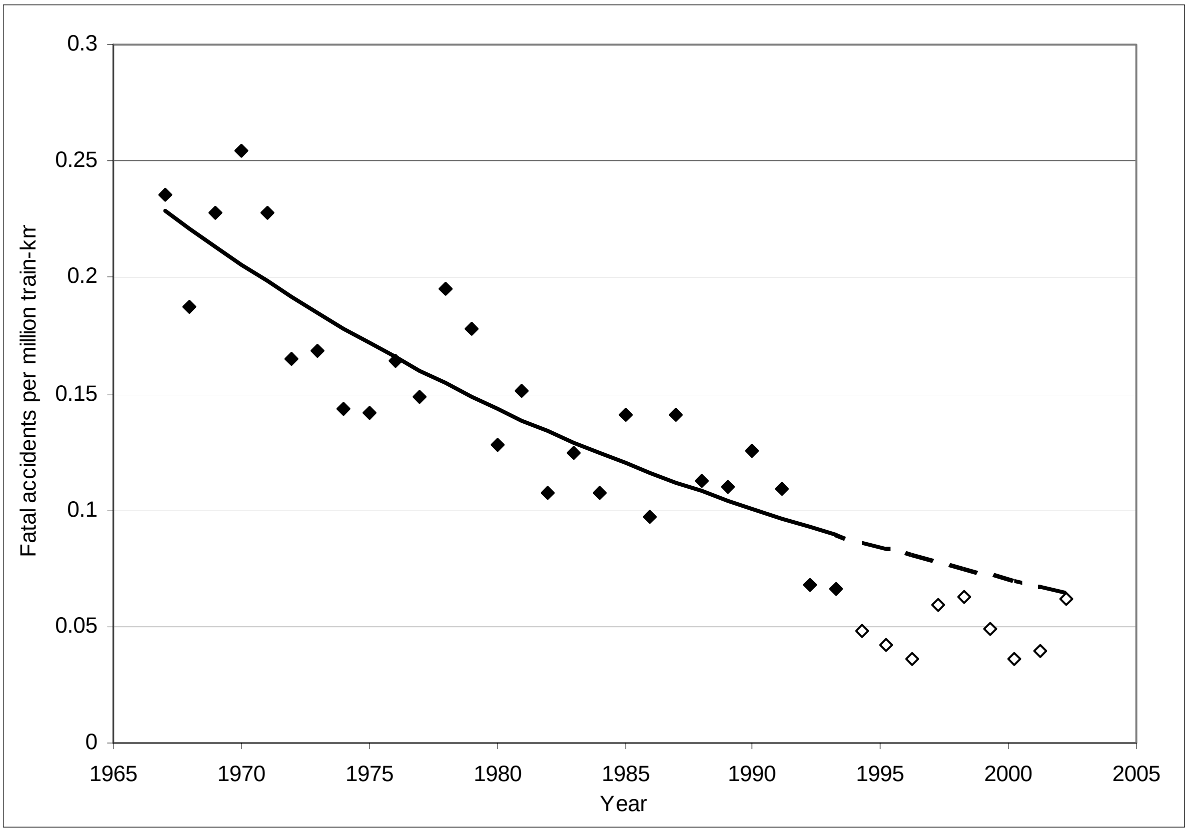


Figure 3: Fatal movement and non-movement accidents: 1946-2002/03

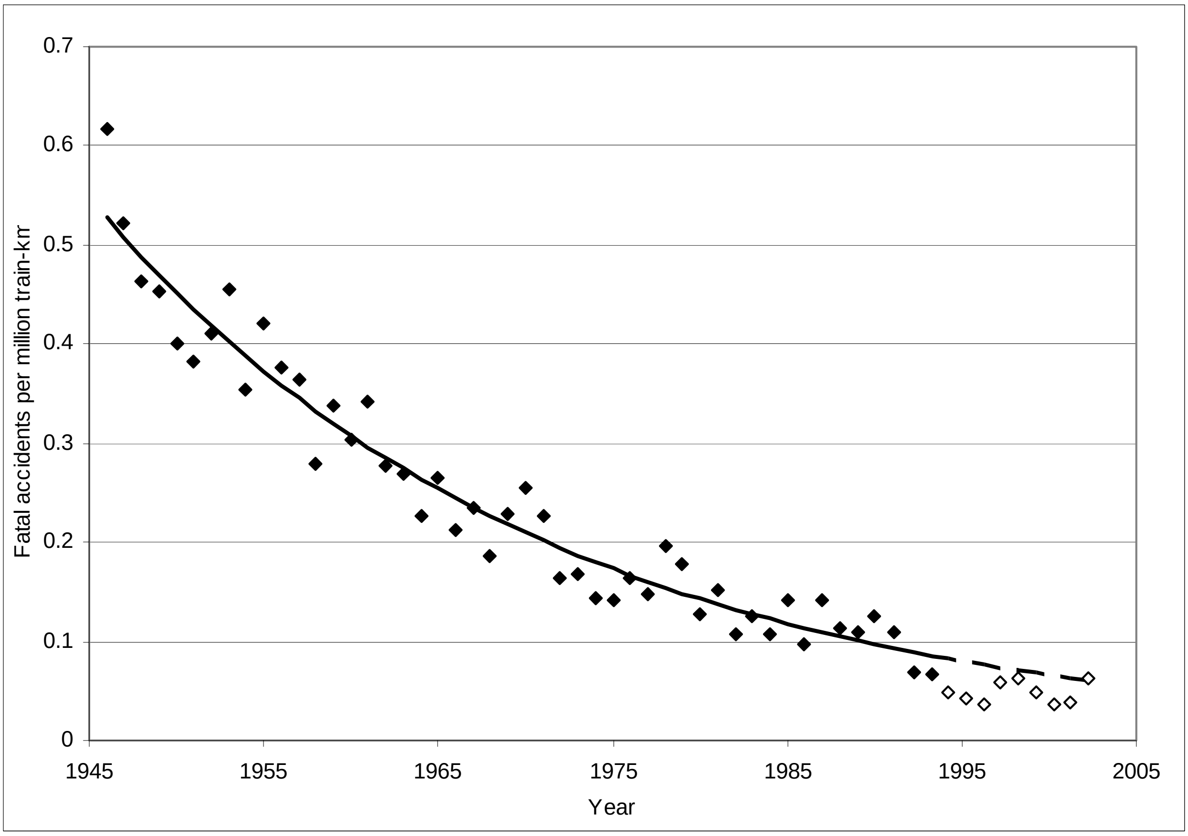


Table 5 gives the numbers of accidents and fatalities represented in Figure 2. The solid data points between them represent 1,748 fatal accidents. The product of the accident rates given by the extrapolated trend and the actual train-kilometres in 1994/95 to 2002/03 gives 319 expected accidents in that 9-year period. From Table 2, the actual number was 208. Thus there were 111 fewer fatal movement and non-movement accidents on the privatised railway in 1994/95 to 2002/03 than would have been expected from extrapolating the trend established by BR.

Table 5: Fatal movement and non-movement accidents: 1967-2002/03

	Trend in Accident rate	Number of accidents	Number of fatalities
1967 to 1993/94	−3.6% pa	1,748	1,803
1994/95 to 2002/03			
Expected		319	330
Observed		208	211
Observed − Expected		−111	−119

The number of fatalities in 1967 to 1993/94 was 1,803, that is about 3% greater than the number of fatal accidents. This is because a small proportion of the fatal movement and non-movement accidents had more than one fatality: the three worst accidents each caused four fatalities to staff working on the track. There is no significant upward or downward trend in the number of fatalities per accident in the period, so it is reasonable to assume that BR's mean ratio of fatalities to accidents would have been the same in 1994/95 onwards as it was in 1967 to 1993/94. With this assumption, the expected number of fatalities in 1994/95 to 2003/03 is 330. The actual number was 211, so that there were 119 fewer fatalities than expected.

3.3 Fatal train collisions, derailments and overruns

The starting point for the analysis of fatal train collisions, derailments and overruns is the set of data on individual accidents in Table 3. These accidents are much less frequent than fatal movement and non-movement accidents, but they are generally more serious, and they command much greater attention. There were 71 such accidents in 1967-1993, and 9 in 1994-2003.

Figure 4 plots the observed numbers of fatal accidents per billion train-kilometres, as Figure 2 did for fatal movement and non-movement accidents. It can be seen that data points are much more scattered than those in Figure 2. The greater scatter in Figure 4 can be attributed entirely to the random variation in small numbers of accidents. It is just possible to detect by eye from Figure 4 that the mean accident rate declined in 1967-1993, but the pattern becomes much clearer if the data are aggregated into five-year rather than one-year periods, as shown in Figure 5. Henceforward we work with five-year periods (with one 7-year period 1987-1993 to complete the 27-year pre-privatisation period). Table 6 shows the observed data for these periods.

Figure 4: Fatal train collisions, derailments and overruns per train-km: 1967-2003

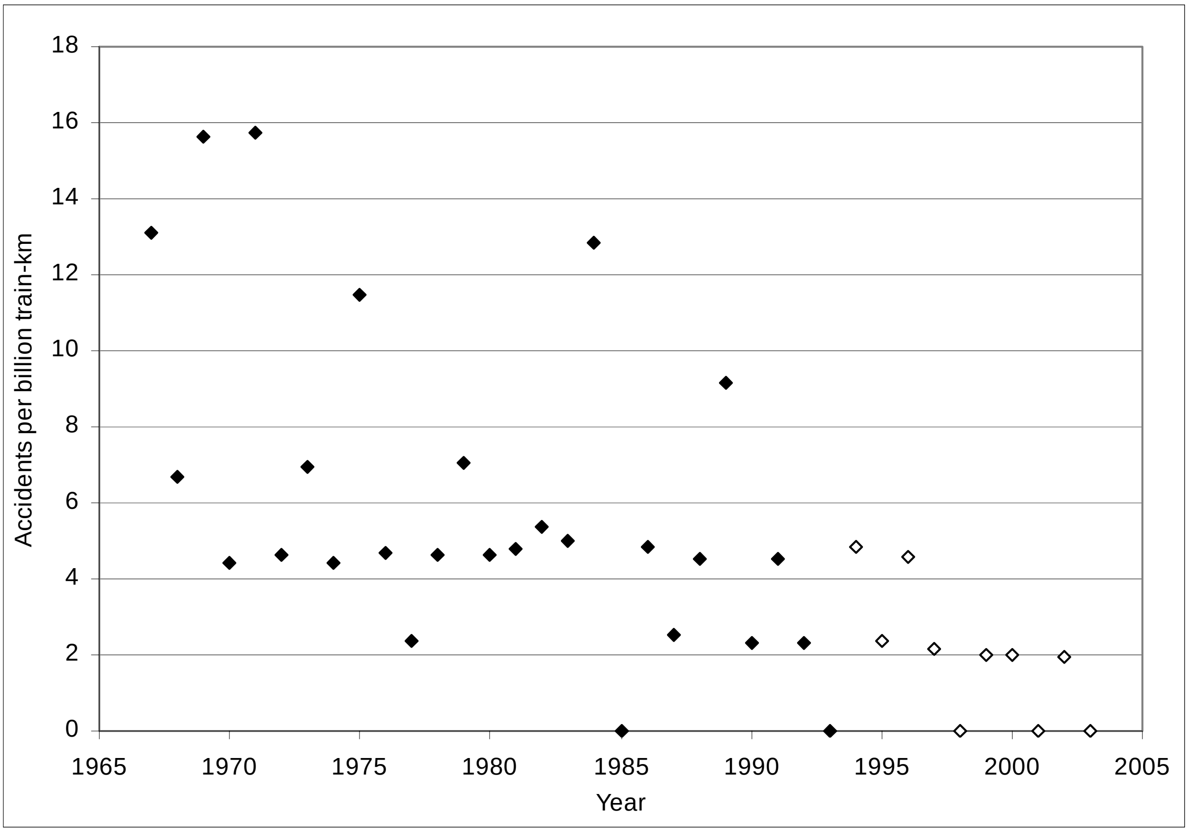


Figure 5: Fatal train collisions, derailments and overruns per train-km: 1967-2003

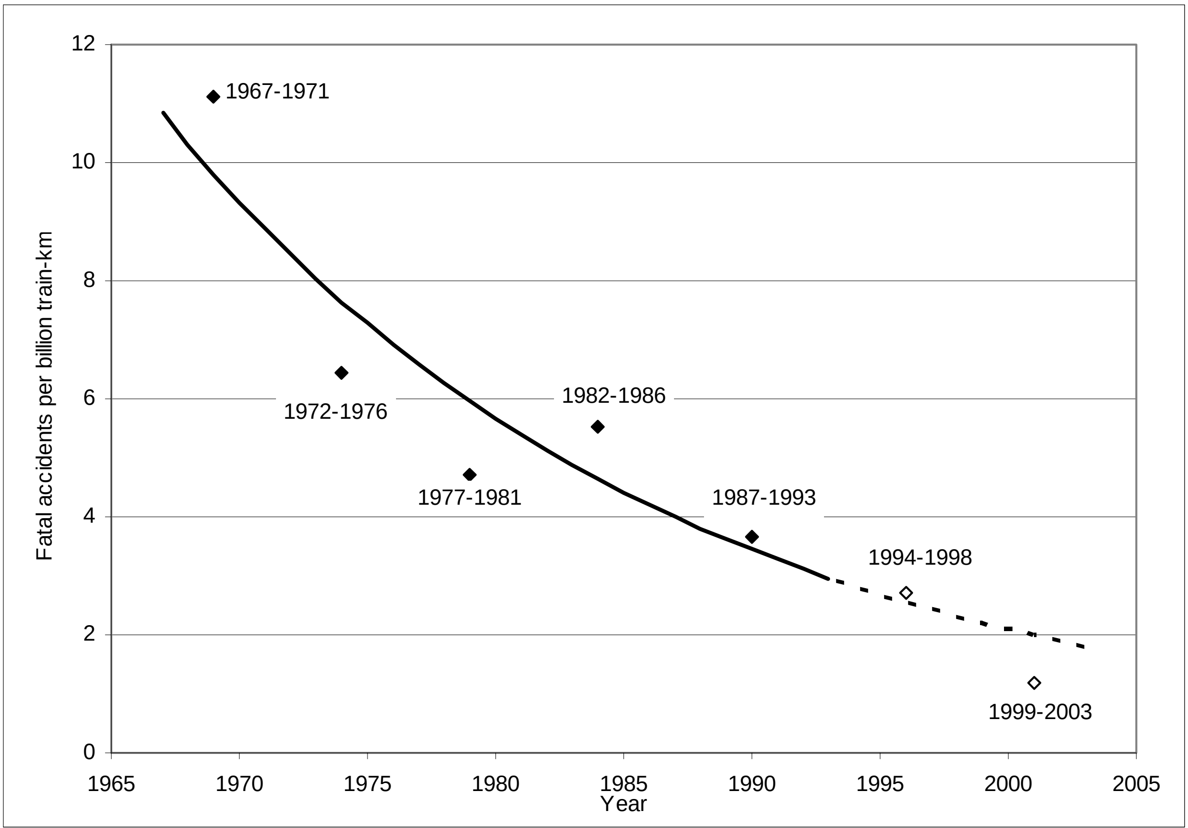


Table 6: Fatal train collisions, derailments and overruns: observed data 1967-2003

Period	Years	Train-km (billions)	Accidents	Accidents per billion train-km	Fatalities	Fatalities per Accident
1967-1971	5	2.25	25	11.1	109	4.4
1972-1976	5	2.18	14	6.4	39	2.8
1977-1981	5	2.13	10	4.7	27	2.7
1982-1986	5	1.99	11	5.5	28	2.5
1987-1993	7	3.00	11	3.7	58	5.3
1967-1993	27	11.55	71	6.1	261	3.7
1994-1998	5	2.22	6	2.7	17	2.8
1999-2003	5	2.55	3	1.2	42	14.0
1994-2003	10	4.77	9	1.9	59	6.6

The solid line in Figure 5 is the exponential trend fitted through the five data points for 1967-1993: its slope is –5.0% per year with a standard error of 1.6% per year. The scatter of the points about the trend is about what would be expected of Poisson variables. (The slope and standard error are much the same if fitted to the annual data.) The dashed line is the extrapolation of the trend to 2003. The open points plot the observed values of accidents per million train-kilometres for the two post-privatisation quinquennia 1994-1998 and 1999-2003. The first point is about on trend; the second is below the trend, so that in all there have been somewhat fewer fatal accidents than would be expected by extrapolating the favourable BR trend. Table 6 shows these results numerically: the expected number of fatal accidents in 1994-2003 is 10.8; the actual number was 9.

Table 7: Fatal train collisions, derailments and overruns: 1967-2003

	Trend in accident rate	Number of accidents	Number of fatalities
1967 to 1993	−5.0% pa	71	261
1994 to 2003			
Expected		10.8	39.5
Observed		9	59
Observed − Expected		−1.8	+19.5

The data in Table 3 show that the number of fatalities in individual train accidents has a skew distribution: most accidents have a small number of fatalities, but a few have large numbers. The three worst accidents in 1967-2003 were at Hither Green in 1967 with 49 fatalities, Clapham Junction in 1988 with 35 fatalities, and Ladbroke Grove in 1999 with 31 fatalities. Figure 6 plots the numbers of fatalities in individual accidents, and shows how these three accidents stand out. There is no significant upward or downward trend over time in the mean number of fatalities per accident in either 1967-1993 or 1967-2003. However, the observed numbers of fatalities or fatalities per accident are strongly influenced by the occurrence of such severe accidents, even when the averages are taken over 5-year periods. Table 6 thus shows that the periods in which the three severe accidents occurred all had higher than average fatalities per accident. This was especially so for 1999-2003, in which there were only two other accidents besides Ladbroke Grove.

Figure 6: Fatalities in fatal train collision, derailments and overruns: 1967-2003

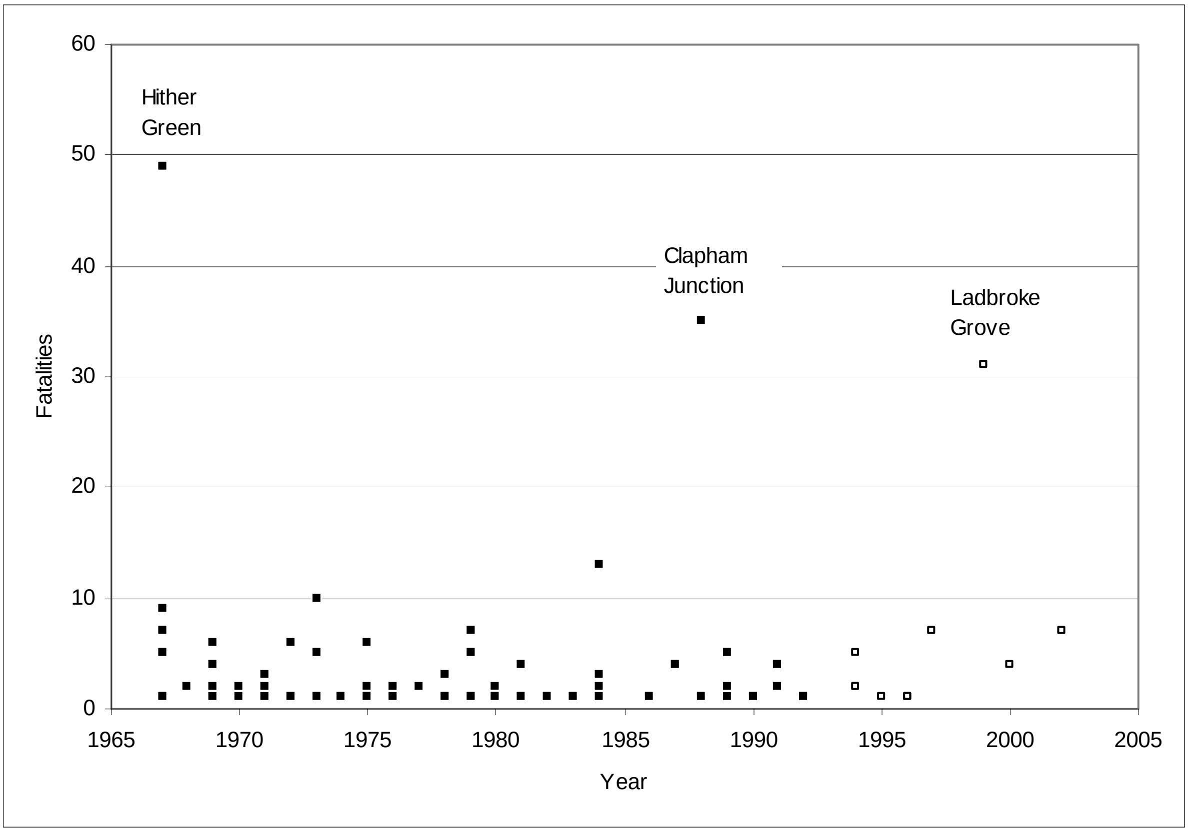


Figure 7: Fatal train collisions, derailments and overruns per train-km: 1946-2003

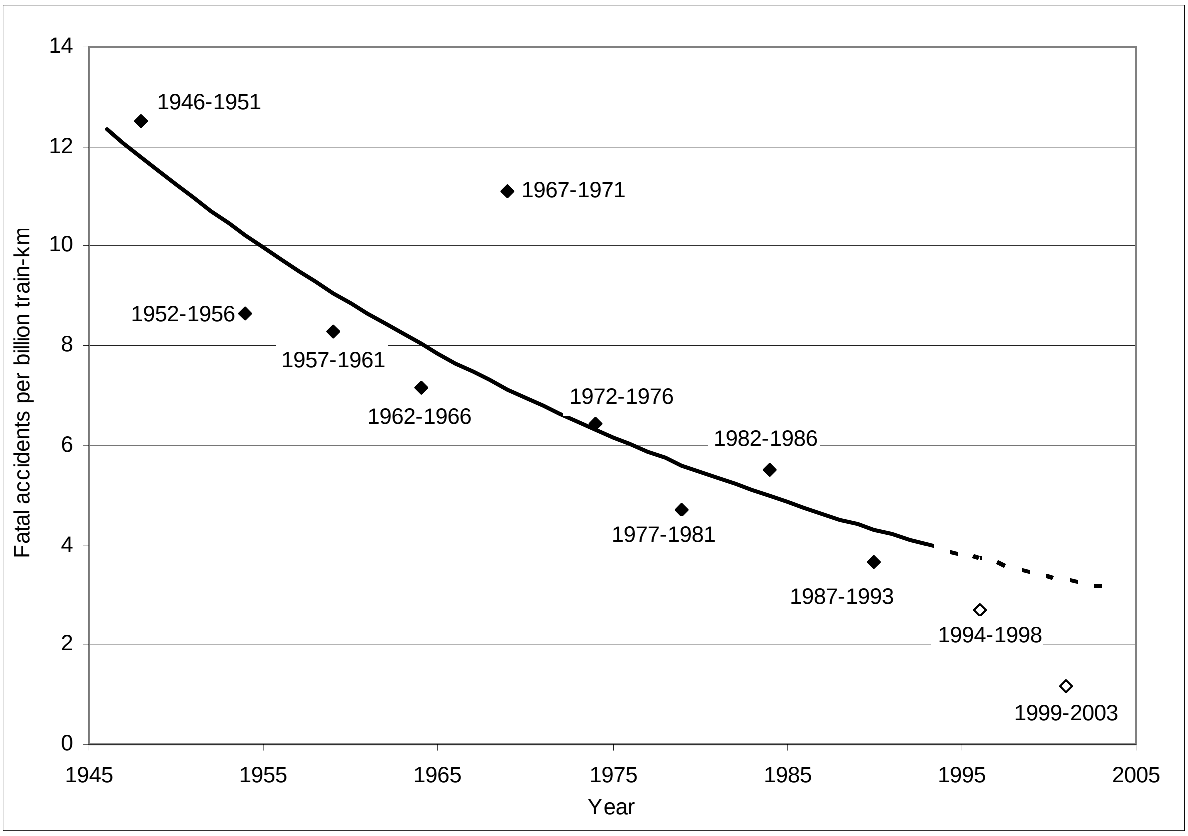


Table 6 shows that the overall mean number of fatalities per accident in 1967-1993 was 3.7. Since there was no significant trend over time, it is reasonable to assume that BR's mean number of fatalities per accident would have continued to be 3.7, even though we could expect substantial departures from this mean in individual accidents. With this assumption, the expected number of fatalities in 1994 to 2003 is 39.5, as shown in Table 7. The actual number was 59, so that there were 19.5 more fatalities than expected. This adverse result is due to the severity of the Ladbroke Grove accident. Given the known variability of the numbers of fatalities in accidents, there is no reason to interpret the high number of fatalities post-privatisation as a systematic effect.

To conclude this section, it is interesting to look at accident rates back to 1946. Figure 7 shows fatal accidents per billion train-kilometres in (mostly) five-year periods over the 58 years 1946 to 2003. The solid line is the exponential trend fitted to the data for 1946 to 1993. The slope is −2.4% per year, with a standard error of 0.6%. This trend is materially flatter than that fitted to the 1967-1993 data alone. The reason is that the observed accident rate in the 1967-1971 quinquennium is seen to be a high outlier when compared with the preceding quinquennia. The post-privatisation performance appears even better against the flatter trend than it did against the steeper trend, but in this paper we keep to the post-1967 data and trend. It is worth noting that if the observed fatal accident rate had increased in the late 1990s in the same way as it did in the late 1960s, that would have been a cause for concern.

3.4 Fatal collisions between trains and road motor vehicles

Collisions between trains and road motor vehicles occur mainly at level crossings, where roads cross railway lines, but a few occur at other places, such as bridges, from which road vehicles can reach railway tracks. There were 141 such fatal accidents in 1967-1993, with 194 fatalities. Most of the fatalities are road vehicle occupants, but there have been a small number of accidents causing multiple fatalities to train occupants.

Figure 8 plots the numbers of fatal accidents per billion train-kilometres for the same 5-year periods as adopted above. The figure shows that even when the data are aggregated into five year periods, there is much scatter, and the trend is not clear. The solid line is the exponential trend fitted to the 1967-1993 data: its slope is −1.5% per year, with a standard error of 1.1% per year. This standard error implies that the slope is not significantly different from zero, but we treat the slope as non-zero in this analysis, because if the analysis is extended to earlier periods there is a significant downward slope. The dotted line extrapolates the downward trend, and it can be seen that the observed accident rates in 1994-2003 were well below the trend. Table 8 gives the corresponding numerical results: the expected number of accidents in 1994-2003 is 43.4; the actual number was 28.

Table 8: Fatal collisions between road motor vehicles: 1967-2003

	Trend in accident rate	Number of accidents	Number of fatalities
1967 to 1993	−1.5% pa	141	194
1994 to 2003			
Expected		43.4	59.8
Observed		28	41
Observed − Expected		−15.4	−18.8

Figure 8: Fatal collisions between trains and road vehicles: 1967-2003

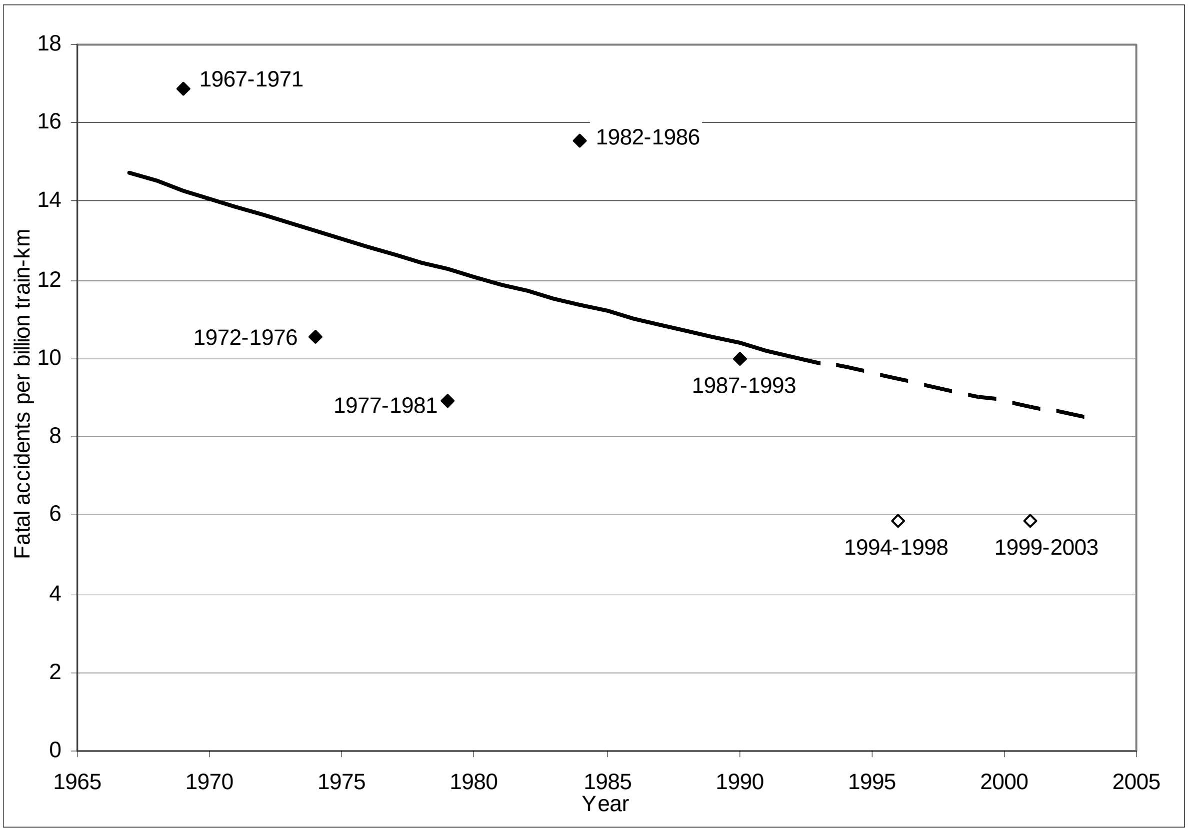
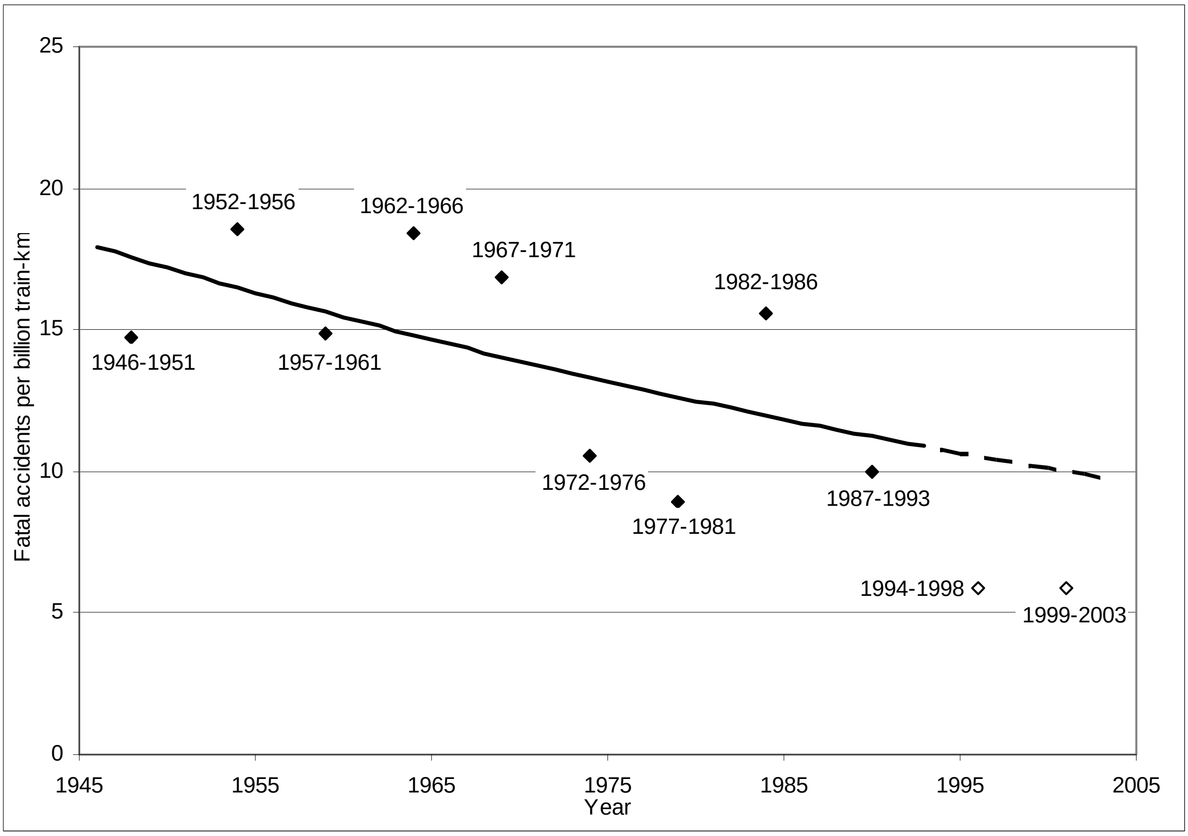


Figure 9: Fatal collisions between trains and road vehicles: 1946-2003



The number of fatalities in individual train/road vehicle collisions also has a skew distribution, though not as skew as that in train collisions and derailments. Most fatal accidents have small numbers of fatalities, but there were three severe accidents in 1967-2003: Hixon level crossing in 1968 with 11 train occupant fatalities, Great Heck in 2001 with 10 train occupant fatalities, and Lockington level crossing in 1986 with one road vehicle occupant and 8 train occupant fatalities. The observed mean number of fatalities per accident in 1967-1993 was 1.38, with no significant trend over time. It is reasonable to assume that this mean number of fatalities per accident would have continued after 1993 under BR. With this assumption, the expected number of fatalities in 1994 to 2003 is 59.8, as shown in Table 8. The actual number was 41 (which includes the 10 fatalities at Great Heck in 2001). Therefore there were 18.8 fewer fatalities than expected.

Figure 9 shows the data back to 1946, and the exponential trend fitted over the period 1946 to 1993. The trend is now significantly different from zero. The conclusions for the post-privatisation period are not very different, and again we keep to the post-1967 analysis.

3.5 Significant train accidents

As noted in section 2.2.2, 'significant' train accidents are defined as train collisions, derailments and overruns affecting passenger lines. They include the fatal accidents analysed in section 3.3, but most such accidents are non-fatal, so the non-fatal accidents dominate the analysis. The data are presented in Table 4. As also noted in section 2.2.2, the series begins in 1971, and in the early years it is not possible to separate accidents on the main line from the non-main-line railways. Our analysis therefore covers all accidents in Great Britain.

Figure 10: Significant train accidents per million train-km: 1971-2002/03

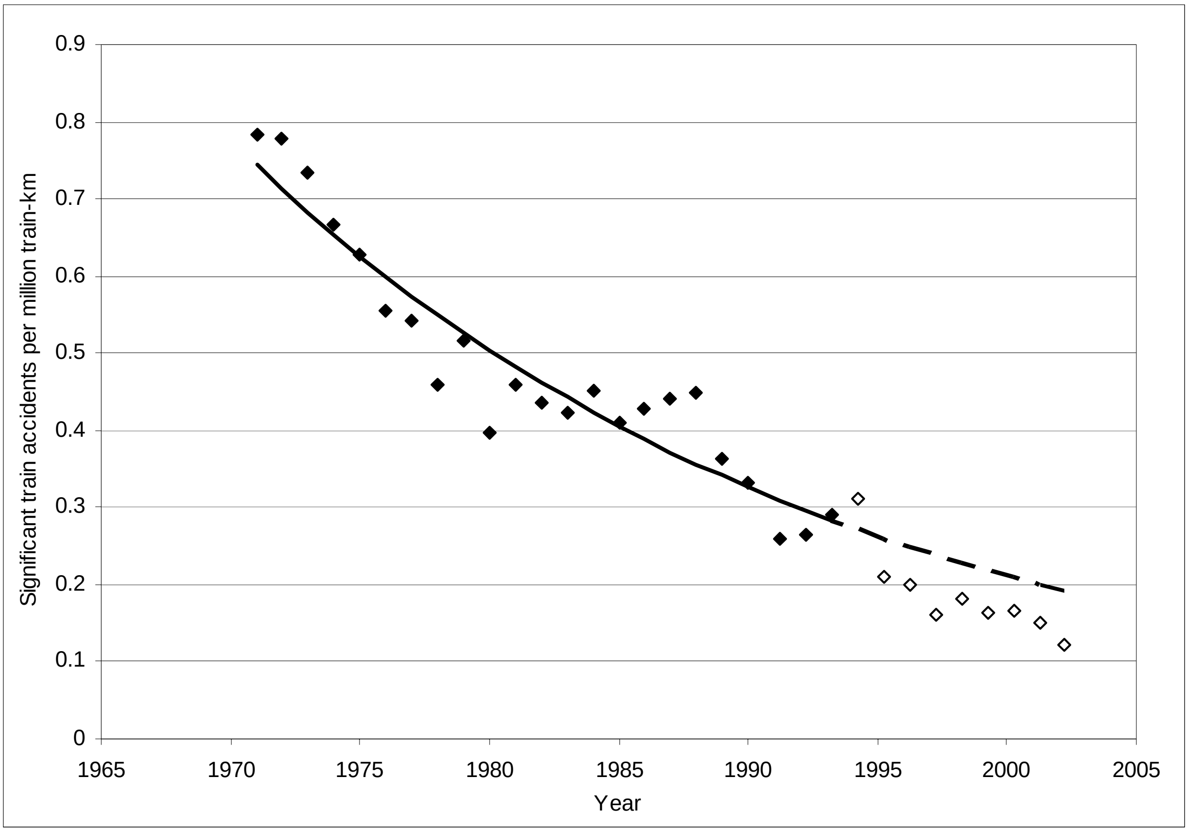


Figure 10 plots significant train accidents per million train-km by year from 1971 to 2002/03. It is clear that the accident rate was falling in 1967-1993/94. The solid line shows the fitted exponential trend over this period, which falls at 4.3% per year, with a standard error of 0.2% per year. The dotted line shows the extrapolation of this trend to 2002/03, and the 9 open points are the observed accident rates for the years 1994/95 to 2003/03. It can be seen that, with the exception of 1994/95, all the observed rates are below the trend. In numerical terms, the expected number of significant train accidents in 1994/95 to 2002/03 is 1,146; the actual number was 915. Therefore again the performance of the privatised railway appears to be good.

3.6 Summary of statistical results

Table 9 brings together the results for the four classes of accident analysed in the previous sections. The table shows that BR had achieved a downward trend in the accident rates from 1967 in all four classes of accident. However, the last column shows that the privatised railway since 1994 has bettered the favourable trends to varying degrees in all four classes of accident. The results for the significant train accidents, which are largely non-fatal, reinforce the results for the fatal collisions, derailments and overruns, which are based on relatively little data.

Table 9: Expected and observed fatal accidents: 1994 to 2003 or 1994/5 to 2002/03

Type of accident	Pre-privatisation trend in accidents per train-km	Expected accidents	Observed accidents	Observed − expected accidents
Fatal movement and non-movement accidents 1994/95 to 2002/03	−3.6% pa	319	208	−111
Fatal train collisions, derailments and overruns 1994 to 2003	−5.0% pa	10.8	9	−1.8
Fatal collisions between trains and road vehicles 1994 to 2003	−1.5% pa	43.4	28	−15.4
Significant train accidents (GB) 1994/95 to 2002/03	−4.3% pa	1,146	915	−231

Table 10 brings together the results on fatalities for the three classes of fatal accidents. For two out of the three classes, the actual number of fatalities is less than the number expected from the BR trends. For train collisions, derailments and overruns, the actual number of fatalities is greater than the expected number. As noted in section 3.3, the reason for the high number of fatalities is the severity of the 1999 Ladbroke Grove accident. However, given the known variability in the numbers of fatalities in individual accidents, there is no reason to interpret this as a systematic effect.

Table 10: Expected and observed fatalities: 1994 to 2003 or 1994/5 to 2002/03

Type of accident	Expected fatalities	Observed fatalities	Observed − expected fatalities
Fatal movement and non-movement accidents 1994/95 to 2002/03	330	211	−119
Fatal train collisions, derailments and overruns 1994 to 2003	39.5	59	+19.5
Fatal collisions between trains and road vehicles 1994 to 2003	59.8	41	−18.8

3.7 Conclusion of the statistical analysis

The general conclusion from the statistical analysis is that railway safety, as measured by accidents, has not become worse since privatisation. Moreover, as noted in Table 1 of section 2, the accidents included in the analysis together cover almost all the fatal accidents and fatalities since 1967, so there are no major omissions that could change the general conclusion. The analysis also includes significant train accidents, which are the most important class of non-fatal accidents, the results of which reinforce those for fatal train accidents. The conclusion is therefore remarkably consistent across types of accident.

4 COUNTER ARGUMENTS

If the statistical results are so unambiguous, why is it widely believed that railway safety has deteriorated since privatisation?

4.1 Accounts of train accidents

The principal argument that safety has deteriorated is based on an examination of the serious train accidents that have occurred in recent years (Watford Junction, Southall, Ladbroke Grove, Hatfield, Potters Bar). For each accident, the steps in the argument are the following.

(1) The question is asked "Would this accident have happened under British Rail?" Thus the counterfactual is again the continuation of BR.
(2) In most cases, the answer offered is "No, it would not".
(3) The inference is that there would have been fewer fatal train accidents without privatisation.

Thus, on the Southall train collision in 1997, Wolmar (2001) and Hall (2003) conclude:

> "The evidence is unequivocal … on the role of privatisation in causing the accident." (Wolmar, p135).
>
> "Whilst one cannot say for certain that the accident would not have happened in BR days, it is very likely that the easier and more reliable arrangements for passing messages … would have … avoided the HST [high speed train] running … without the driver having the assistance of AWS [automatic warning system]." (Hall, p118).

On the Ladbroke Grove train collision in 1999, they conclude:

> "To suggest that the same set of circumstances would have come about under BR is fanciful. It is inconceivable that the whole fatal sequence of mistakes would have occurred under the unified structure…" (Wolmar, p154).
>
> "All in all, there are grounds for believing that a number of beneficial changes would have taken place if BR had still been in control…" (Hall, p118).

On the Hatfield derailment in 2000, they conclude:

> "… At Hatfield, the main elements were the very structure of Railtrack, which meant it was far too weak on engineering, and the way it was forced to contract out maintenance through very badly drafted contracts." (Wolmar, p185).
>
> "It is inconceivable that a BR civil engineer would have allowed the track to deteriorate into such a dangerous state without taking some action …" (Hall, p118).

These writers then conclude that because some or all of the fatal train accidents since 1994 would not have occurred under BR, there would have been fewer such accidents if BR had continued. Therefore privatisation has made the main line railway less safe.

4.2 Response

The arguments that these accidents (and others) would not have happened under BR are by their nature not provable, but they are plausible.

However, to accept that specific accidents would not have happened in other circumstances is not to accept very much, because most accidents would not have happened in different circumstances. Most accidents are the outcome of a chain of events involving several people, and different actions by any one of a number of people would normally be enough to prevent them. People's actions are conditioned by the organisations in which they work, and therefore changing the organisational structure (such as privatising the railways) may well affect the occurrence of accidents.

However, this argument works in both directions. It is possible that the change in the organisational structure associated with privatisation has had positive as well as negative effects. For example, it is possible that the Railway Safety Case regime has been beneficial. Thus it is possible that the change in the organisational structure has led people to take actions that have prevented accidents that would otherwise have occurred. Furthermore, if that were so, we would not necessarily know about them from accounts of specific accidents, because prevented accidents may be non-events, and not recorded. Some prevented accidents may be recorded as 'near-misses', but accidents prevented early in a potential sequence of events might not be noted at all. Not even those who had prevented accidents would necessarily know that they had done so. Therefore accounts of specific accidents are biased in the direction of leading to the conclusion that changes are for the worse: we know about the accidents that occur, but we do not necessarily know about the accidents that are prevented.

Therefore we cannot assess the effect of privatisation on safety without some means of estimating the numbers of accidents and fatalities that would have occurred without privatisation. Section 3 offers one way of estimating these numbers: by extrapolating the trends established by BR. We do not claim that is the only possible way, but some such estimates are needed.

4.3 The power of stories over statistics

Another reason why it is widely believed that safety has got worse since privatisation is what Newman (2003) labels “the power of stories over statistics”. Most of us comprehend stories more easily than statistics, and accounts of railway accidents make exceptionally compelling and tragic stories.

Newman notes that accounts of accidents are particularly persuasive when they come from those who were directly involved; these include not only the bereaved and injured, but also others such as staff and rescue workers. Hare’s play *The Permanent Way* (2003) is powerful because it includes many such first-hand accounts. The stories are given added power by the fact that they sometimes do indeed demonstrate mistakes or incompetence by railway organisations.

The ease with which the high-profile accidents are recalled, and the frequency with which they are publicly revisited, leads people to overestimate their probabilities. The original accounts of the major accidents remain in people’s minds, and these are amplified by the fact that many of the accidents are the subject of several inquiries and legal proceedings stretching over several years. On each occasion, the story of the accident is recounted, and it then seems almost as if yet another accident has occurred.

The fatal train accidents have also provided a focus for more general dissatisfaction about railway privatisation. They are the public events that have come to encapsulate a wider range of concerns than safety, and in doing so have made the safety performance seem worse that it was.

5 CONCLUSIONS

The principal conclusions of this paper are the following.

(1) Railway accident data do not support the contention that rail privatisation has made the railways less safe. The data are remarkably consistent.

(2) It follows that safety is not now a compelling reason for restructuring the railway.

(3) The government, the railway industry, and statisticians have a duty to ensure that the debate on railway safety is well informed, but in doing so they have to contend with the power of stories over statistics.

LIST OF ABBREVIATIONS

AWS	Automatic warning system
BR	British Rail or British Railways
BRB	British Railways Board
ECS	Empty coaching stock
GB	Great Britain
HSC	Health and Safety Commission
HSE	Health and Safety Executive
HST	High speed train
LC	Level crossing
LE	Light engine (locomotive on its own)
LRT	Light rapid transit
RI	Railway Inspectorate
RSSB	Rail Safety and Standards Board
SPAD	Signal passed at danger

ACKNOWLEDGEMENTS

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