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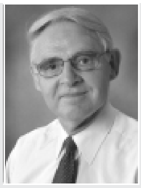

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Railway risks, safety values and safety costs

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This paper has two principal sections. The first reviews railway risks since 1967, focusing on fatal collisions, derailments and overruns on running lines of the national railway system. Risks for most types of accident have declined substantially, but until the recent completion of the train protection and warning system, fatal accidents due to trains passing signals at danger at conflicting junctions persisted at about one accident per billion train-kilometres. The second main section discusses the valuation and costs of preventing rail fatalities, contrasting these with the valuation and costs of preventing road fatalities. The paper concludes by noting that society could prevent more fatalities at the same cost by devoting relatively more resources to road safety and less to rail safety, but is apparently content not to do so.

1. INTRODUCTION

This paper has two main sections, each addressing an important issue in railway safety. The first part of the paper is concerned with the level of risk on the national system, and the long-term trends in the risk over the period from 1967 to 2003. The paper focuses particularly on fatal train collisions, derailments and overruns, because these are particularly important, even though they account for only a minority of fatalities. The paper shows that railway safety has greatly improved over the long term, and contrary to popular belief, safety trends did not deteriorate after privatisation in 1994.

The second part of the paper is concerned with criteria for the adoption of railway safety measures, particularly the principle that risks should be 'as low as reasonably practicable' (ALARP), and the interpretation of the ALARP principle as requiring a balance between the marginal costs and benefits of safety measures. The estimation of the benefits of safety measures requires the valuation in monetary terms of the prevention of casualties. Such valuations have a long history in the context of road safety, and were introduced to the railway context in the early 1990s. The paper finds that in practice the costs of some adopted railway safety measures such as the train protection and warning system (TPWS) exceed the benefits, whereas the benefits of many non-adopted road schemes exceed the costs. It follows that society could prevent more fatalities at the same cost by devoting relatively more resources to road safety and less to rail safety. Nevertheless, the TPWS has been widely welcomed, and society seems to be content with the present allocation of resources.

The paper is a revised and updated version of a presentation made to the Railway Civil Engineers' Association at the Institution of Civil Engineers in November 2002.

2. RAILWAY ACCIDENTS AND FATALITIES

2.1. Railway fatalities in Great Britain: 1967–2002

Railway accidents are traditionally classified as train accidents, movement accidents or non-movement accidents. Train accidents are those in which a train is damaged and casualties may occur; movement accidents are those in which a person is injured due to the movement of a train, but the train itself is not damaged; non-movement accidents are other injuries on railway property.

The number of accidental fatalities in the 36 years from 1967 to 2002 on all railways of Great Britain was 2903, excluding trespassers and suicides. Of these, 642 were in train accidents, including collisions between trains and road vehicles; 1887 were in movement accidents, and 374 were in non-movement accidents. Of the 642 fatalities in train accidents, 592 were on the national railway system, and 50 were on other railways. Of the 592 on the national system, 320 were in train collisions derailments and overruns on running lines, 230 were in collisions between trains and road vehicles (of which 36 were train occupants), and 42 were in other train accidents such as train fires. This paper focuses on the mainline collisions, derailments and overruns, because these are important and high profile, but readers should be aware that these account for only about 11% of all railway fatalities, even when trespasser fatalities and suicides are excluded. The data in this paragraph are taken from a report by Evans,[1] which is in turn derived principally from HM Railway Inspectorate annual reports.

2.2. Fatal mainline collisions, derailments and overruns in Great Britain: 1967–2003

This section presents data and analyses of trends in fatal train collisions, derailments and overruns on running lines of the main line railway system in the 37 years from 1967 to 2003. The year 1967 is taken as the first year for the analysis, because it may be regarded as the start of the modern era of British railways. Further details are given by Evans.[2]

Period	Years	Train-km (billion)	Number of accidents					Accidents per billion train-km				
			ATP-preventable			Non-ATP-preventable	All	ATP-preventable			Non-ATP-preventable	All
			Conf. SPAD	Plain SPAD	Other			Conf. SPAD	Plain SPAD	Other		
1967–1971	5	2·25	2	2	5	16	25	0·9	0·9	2·2	7·1	11·1
1972–1976	5	2·18	2	3	2	7	14	0·9	1·4	0·9	3·2	6·4
1977–1981	5	2·13	2	2	1	5	10	0·9	0·9	0·5	2·4	4·7
1982–1986	5	1·99	2	1	0	8	11	1·0	0·5	0	4·0	5·5
1987–1991	5	2·15	3	0	1	6	10	1·4	0	0·5	2·8	4·7
1992–1996	5	2·13	2	0	0	4	6	0·9	0	0	1·9	2·8
1997–2001	5	2·46	2	0	0	1	3	0·8	0	0	0·4	1·2
2002–2003	2	1·03	0	0	0	1	1	0	0	0	1·0	1·0
1967–2003	37	16·33	15	8	9	48	80	0·9	0·5	0·6	2·9	4·9

Table 1. Train-km, fatal train accidents and accident rates: national railway system: 1967–2003

There were 80 fatal train collisions, derailments and overruns on running lines of Great Britain's mainline railway system from 1967 to 2003. Table 1 summarises these, together with the numbers of train-km and the calculated numbers of accidents per train-km. The accidents are subdivided into those that would have been preventable by automatic train protection (ATP) and those that would not. The ATP-preventable accidents are further subdivided into those due to signals passed at danger (SPADs), and those due to overspeeding or buffer overruns. The SPAD accidents are subdivided into those involving a train passing a signal protecting a conflicting movement, and those involving trains proceeding in the same direction on the same track, a 'plain-line' SPAD. Of the 80 accidents, 15 were due to conflicting movement SPADs, eight were due to plain-line SPADs, nine were due to ATP-preventable excess speeds or buffer overruns, and 48 were non-ATP-preventable.

Table 1 gives the numbers of fatal accidents in each of these four categories in seven five-year periods from 1967 and one two-year period from 2002 to 2003. The table shows that the overall fatal accident rate per train-km has greatly declined over the long term, and that there have been falls in the rates of plain-line SPADs, other ATP-preventable, and non-ATP-preventable accidents. On the other hand, fatal accidents due to conflicting movement SPADs persisted until recently at a roughly constant rate of one fatal accident per billion train-km. At the historical level of railway activity of about 0·4 billion train-km per year, this was equivalent to an average of two fatal accidents in five years. However, there were no fatal ATP-preventable accidents between 2002 and 2003, and at the time of writing, the most recent such accident was at Ladbroke Grove on 5 October 1999.

The author has fitted trends to the numbers of fatal accidents per train-km, described in more detail by Evans.[2] Fig. 1 presents the fitted trend for the sum of all four categories of accident, together with the data points from Table 1. The trend line bifurcates at the right-hand end: the upper fork represents the continuation of present trends; the lower fork represents the estimated effect of the TPWS discussed in section 2.3 below.

The number of fatalities in collisions and derailments is very variable, depending on the circumstances. At one end of the

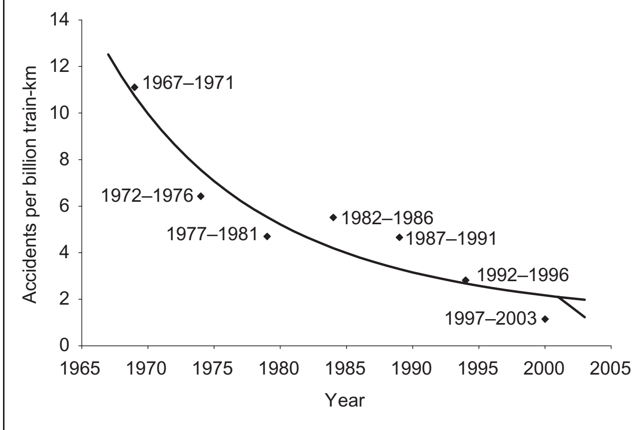

Fig. 1. Fatal train accidents per billion train-km, 1967–2003

scale, 36 out of the 80 fatal accidents in the period 1967 to 2003 had a single fatality. At the other end, the worst three had 31 fatalities (Ladbroke Grove, 1999), 35 fatalities (Clapham Junction, 1988) and 49 fatalities (Hither Green, 1967). The average number of fatalities was 320/80 = 4·0, with no apparent trend over time. For that reason, the author assumes that the mean number of fatalities is proportional to the number of accidents, with a constant proportionality of 4.

2.3. The train protection and warning system (TPWS)

It was largely in response to the persistent problem of conflicting-movement SPADs that the train protection and warning system (TPWS) was developed in the late 1990s as an alternative to full ATP in order to reduce the frequency of ATP-preventable accidents. TPWS was installed quickly and had been completed by the end of 2003.[3] It became effective largely during 2002 and 2003. TPWS is expected to make a step reduction in ATP-preventable risk. Before installation, it was estimated to be capable of reducing ATP-preventable accidents and casualties by about 70%.[4] In early 2003, Railway Safety made another estimate of its effectiveness using the Safety Risk Model, and came to much the same conclusion.[5] This author at present has no independent method of estimating the post-TPWS ATP-preventable risk, so adopts the pre-installation estimate that it reduces ATP-preventable accidents and casualties by 70%. The lower fork at the right-hand end of Fig. 1 shows the effect of this on the trend in fatal accidents per train-km.

2.4. Estimated mean accidents and fatalities for 2003

Table 2 gives estimates of the mean numbers of accidents and fatalities per year in 2003. The estimates of accidents without TPWS are obtained by multiplying the mean numbers of accidents per train-km in 2003 from the fitted trends by the estimated number of train-km in 2003 (0·518 billion). The estimates of accidents with TPWS are obtained by reducing the ATP-preventable accidents by 70%. The estimates of fatalities are then obtained by multiplying the mean numbers of accidents by 4·0.

Table 2 shows that the estimated mean number of fatal train accidents in 2003 would have been 1·02 per year without TPWS, which is reduced to 0·64 with TPWS. The corresponding estimated mean number of fatalities per year would have been 4·10 without TPWS and 2·55 with TPWS. The pre-TPWS accident rates are 84% less than in 1967, which represents an average reduction of 5·1% per year over the 37-year period. The post-TPWS accident rates are about 90% less than in 1967.

	Without TPWS	With full TPWS	Reduction due to TPWS
Accidents:			
Conflicting movement SPADs	0·52	0·16	0·37
Plain line SPADs	0·02	0·01	0·02
Other ATP-preventable	0·01	0·00	0·01
Non-ATP-preventable	0·47	0·47	0·00
Sum of all types	1·02	0·64	0·39
Fatalities:			
Conflicting movement SPADs	2·09	0·63	1·46
Plain line SPADs	0·09	0·03	0·06
Other ATP-preventable	0·03	0·01	0·02
Non-ATP-preventable	1·88	1·88	0·00
Sum of all types	4·10	2·55	1·55

Table 2. Estimates of mean train accidents and fatalities per year in 2003

2.5. Rail privatisation and safety

Because of the severe train accidents at Southall, Ladbroke Grove, Hatfield and Potters Bar, it is widely believed that rail privatisation had an adverse impact on safety. The data on train accidents do not support this belief.

Two analyses are presented here. The first analysis uses the same data on mainline fatal accidents for the period 1967 to 2003 as discussed above, but it analyses the data in a slightly different way. The results are shown in Fig. 2. The steps are as follows.

(*a*) Divide the accidents into those that occurred in the 27 years from 1967 to 1993 and those that occurred in 1994 to 2003.
(*b*) Imagine we are back at the end of 1993 (the last complete pre-privatisation year), and fit an exponential trend to the fatal accident rates over the period 1967 to 1993. This is the solid curve in Fig. 2. The fatal accident rate falls at 5·0% per year.
(*c*) Extrapolate the trend above to 2003 to provide an estimate of the accident rates expected on the basis of a continuation of British Rail's performance.
(*d*) Compare the expected performance with the accidents that actually occurred in 1994 to 2003. The expected number of fatal accidents is 10·8; the actual number was 9.

It follows that the fatal accidents that have actually occurred since privatisation have been slightly fewer than those expected on the basis of the favourable trend established by British Rail. Thus there is no evidence that the post-privatisation performance is worse than British Rail might be expected to have achieved.

The second analysis is similar in nature, but based on HM Railway Inspectorate's series of 'significant train accidents', which is available from 1971 to 2002/03. Significant train accidents are train collisions, derailments and overruns affecting passenger trains or passenger lines. These accidents had the potential to be serious, even though most of them were not. The benefit of analysing this class of accident is that they are much more numerous than fatal train accidents (by a factor of the order of 100), and therefore the results are less subject to statistical fluctuation. They include the fatal accidents analysed above, but they are dominated by numerous non-fatal accidents. The data cover the non-national as well as the national railways.

The pattern in Fig. 3 is similar to that in Fig. 2. The significant train accident rate was falling at 4·3% per year

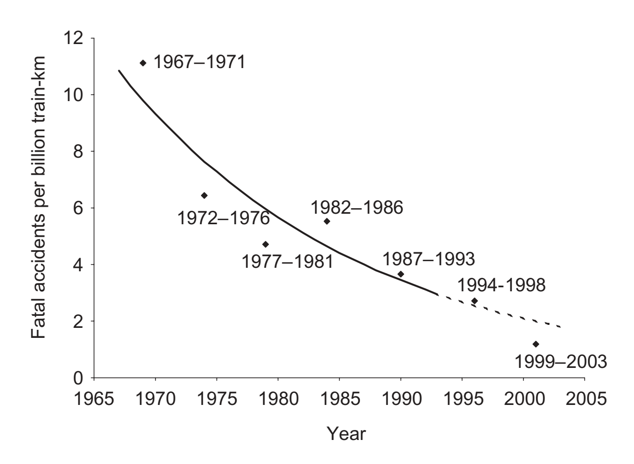

Fig. 2. Fatal train accidents 1967–2003: Great Britain national system

between 1971 and 1993/94, but with the exception of 1994/95 all the later annual data points are better than that favourable trend. The expected number of significant train accidents in 1994/95 to 2002/03 based on an extrapolation of the pre-privatisation trend is 1146; the actual number was 915.

3. SAFETY VALUES AND SAFETY COSTS

3.1. The 'tolerability of risk' framework

The standard framework for appraising risks and safety measures on the railways is the 'tolerability of risk' (ToR) framework, first propounded by the Health and Safety Executive (HSE) in the context of nuclear power stations in 1988, and revised in 1992.[6] The ToR framework was re-presented by HSE in their policy document *Reducing Risks, Protecting People*,[7] and is now widely accepted as applicable to other risks besides nuclear. The framework came to be applied to the railways because from the early 1990s there was a need for systematic appraisal of safety measures (notably ATP), and HSE had then become the railway safety regulator. There is widespread agreement that although appraisal frameworks such as ToR are an essential input to good decisions, they should be regarded as informative rather than compelling. This is because almost all specific safety decisions require ethical and political judgements that may be crucial, but which are outside the scope of such frameworks.

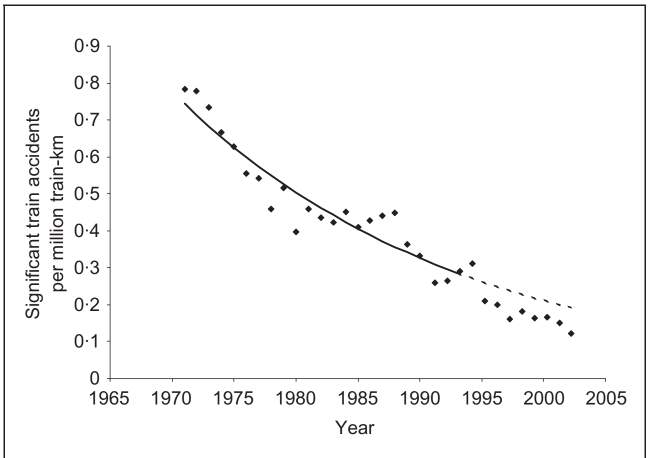

Fig. 3. Significant train accidents 1971–2002/03: Great Britain

The ToR framework combines a near-prohibition on relatively high levels of individual risk with a considered trade-off between risks and safety benefits at lower levels of risk. The trade-off is generally described as the principle that risks should be 'as low as reasonably practicable' (ALARP). For many risks, the requirement that they should be ALARP is met by adopting good practice. However, where analysis is required, the ALARP principle has come to be interpreted as a requirement that the benefits and costs of safety measures should be compared, normally in monetary units. Because the principal benefits of many safety measures are the prevention of fatalities and injuries, this requires valuing the prevention of casualties. The value of preventing fatalities (VPF) is discussed in section 3.2.

The simplest interpretation of the benefit/cost comparison is that if the benefits of a safety measure are greater than or equal to its costs, the safety measure should be implemented. On the other hand, if the benefits of a safety measure are less than its costs, the safety measure should not necessarily be implemented. This is broadly the interpretation placed on it both by the railway industry in the *Railway Group Safety Plan*[8] and by HSE in *Reducing Risks, Protecting People*,[7] although both sources emphasise that there are circumstances in which safety measures should be implemented even though the valued benefits may be less than the costs. HSE also refers to the *Edwards* v. *National Coal Board* court case,[9] which states that a safety duty holder must implement safety measures up to the point at which the costs are not merely equal to the value of the risks, but 'grossly disproportionate' to them. However, the VPFs currently used in ALARP calculations are much greater than the typical compensation awarded for fatalities by courts, so it could be argued that the current VPFs already incorporate a factor for 'gross disproportion'.

The quantitative application of the ToR framework thus in principle requires two sets of parameters. The first set is the boundary or boundaries between tolerable and intolerable levels of individual risks. The second set is the values of preventing casualties, mentioned above and further discussed in section 3·2.

The boundary between tolerable and intolerable individual risks is widely accepted as being an ethical judgement. In their original presentation HSE proposed that the upper limit to the tolerable risk of death for employees should be 1 in 1000 per year and that for third parties should be 1 in 10 000 per year. These values have stood the test of time and are the same in HSE's most recent policy document *Reducing Risks, Protecting People*.[7] However, these values are not critical for railways, because even the highest individual risks on the railways are generally well below these limits.

3.2. Valuations of preventing fatalities

3.2.1. Road fatalities. The second set of parameters are the values of preventing casualties. The Department for Transport (DfT) and its predecessors have estimated such values for some

50 years for use in the appraisal of road investment and road safety projects. Their methods have evolved over time.

The widely accepted principle for valuing the effects of public policies or projects is that these should be valued according to the preferences of those who are affected. In safety, these preferences are now measured by estimates of people's 'willingness to pay' for risk reductions in specified contexts. The DfT's VPF is based on the total amount that a large group of people would be willing to pay for small reductions in risk to each person that could be expected on average to save one fatality among them. From time to time the DfT commissions surveys to provide data to estimate these values; the most recent was by a consortium of universities in 1998.[10] In years without surveys, the DfT updates the previous year's VPF by increasing it in proportion to the index of gross domestic product (GDP) per head. As the country gradually becomes wealthier, this index rises faster than inflation, so that the VPF has gradually risen in real terms. The DfT's most recent published VPF for roads is £1·25 million for 2002.[11] This figure also includes the public costs of fatalities such as medical costs.

The DfT also uses 'willingness to pay' evidence, together with data on medical costs, to estimate the valuations of preventing injuries on the road, but for reasons of space these are not discussed in this paper.

3.2.2. Rail fatalities. When British Rail adopted the ToR framework in the early 1990s, they needed a VPF for railway fatalities. After substantial internal debate, but no public surveys, they adopted the current roads VPF for fatalities in movement and non-movement accidents, but a higher VPF for fatalities in train accidents. This was because British Rail judged that people would be willing to pay more to prevent fatalities in train accidents, primarily because passengers have no control over the risks. At that time, the latest roads VPF was £715 000 at 1992 prices. British Rail adopted a round-figure VPF of £2 million for fatalities in train accidents at the same price level, which was 2·8 times greater than the roads/movement/non-movement VPF. As the roads VPF has been increased in the following years, the national railway operators have maintained the ratio of 2·8, so for example, the road/basic rail VPF in 2002 to 2003 was £1·25 million, and the VPF for fatalities in train accidents was £3·46 million.[12]

There have been two major empirical research studies on the rail VPF.[13,14] They were both commissioned by HSE, and were linked to Chilton *et al.*'s 1998 study of the roads VPF mentioned above.[10] Both studies aimed to estimate the rail VPF relative to the roads value. (The studies also considered VPFs for fatalities due to fires in the home and in public places, but those are not discussed here.) The surveys for the first study were carried out in four towns spread over Britain in the autumn of 1998, which was about a year after the train collision at Southall on 19 September 1997 and a year before the train collision at Ladbroke Grove on 5 October 1999. The Ladbroke Grove collision caused such public concern about railway safety that, to their credit, HSE commissioned a second set of surveys in early 2000 to investigate whether people's valuations had changed. The second surveys were similar to the first, except that they were carried out in towns in south-east England where rail use is higher than the national average.

The results of the rail surveys were surprising. Contrary to expectation, people in the first survey had a slightly smaller, not a larger, mean VPF for rail than road fatalities: the average ratio of rail to road was 0·83. In the second survey, conducted when the Ladbroke Grove accident was fresh in respondents' minds, the average ratio had moved somewhat towards a higher rail VPF, but was still only 1·00. Even for regular rail users, the ratio was only 1·17. Although the ratios of 0·83 and 1·17 were statistically significantly different from 1·00 in different directions, the numerical differences are modest. Therefore the broad conclusion is that the public, including regular rail users after a major accident, appear to place much the same value on the prevention of rail fatalities as they do on preventing road fatalities. The authors concluded: 'If we focus on those who are regular rail users, it would appear that their preferences and attitudes to risk *per se* provide no justification for Railtrack's higher VPF . . . of some 2·8 times the DETR roads figure. The results therefore suggest that if a justification for Railtrack's higher figure *is* to be found, then it will almost certainly need to be sought in considerations other than the preferences of the travelling public.'[14]

The railways' formal collective position in May 2004 expressed in the *Railway Group Safety Plan 2003/2004* is to maintain the differential VPF between fatalities in train accidents and other fatalities,[8] although the Rail Safety and Standards Board have a research project to review this question. The UK Government's formal position is that the VPF for the prevention of fatalities in rail accidents should be the same as that in road accidents.[15]

3.3. Costs of preventing fatalities

3.3.1. Road fatalities. The costs of preventing fatalities depend on the safety measure being used. The number of safety measures for which these costs are estimated and published is relatively small, so the results presented in this section are illustrative rather than comprehensive.

For the prevention of fatalities on the road, the best-documented safety measures are local road-safety engineering projects. These are generally small in scale, but are numerous. The remarkable feature of such projects is their extremely high rates of return. A 1997 review of such schemes by the Department of Transport stated: 'The Department has monitored the introduction of recent local safety schemes and this is one of the few areas where expenditure is underpinned by a considerable amount of knowledge about costs and benefits. Clear benefits can be shown, with the first-year rate of return of these schemes typically in excess of 150%.'[16]

Such returns imply that, even if the average project produced benefits over a period of only six or seven years, the value of the accident savings would be ten times the cost; or equivalently, that the cost is only 10% of the value. This implies that the cost of preventing a road fatality by such schemes is only about £100 000. Other sources, such as local authority road-safety plans support that conclusion. Evans provides a brief review.[17] One might expect that the costs of saving road casualties would rise gradually as the 'easy' schemes were tackled first, but that does not appear to be happening. Because road-safety budgets and staff are constrained, highway authorities look to implement schemes with good returns. Schemes with more modest, but still positive, returns therefore tend not to be implemented.

3.3.2. Rail fatalities. The railway safety measures for which the costs of preventing fatalities have been best documented and published are those concerned with train protection. The British Railways Board[18] published a comprehensive review of the British Rail system of automatic train protection (labelled BR-ATP). Much more recently, reviews have been published of the cost per fatality prevented by the TPWS.[2, 19] We consider each of these.

British Rail committed itself to installing ATP on a large proportion of the system in November 1988, when it began technical development and pilot installations. In 1994 British Rail reviewed the costs and benefits of ATP. It estimated that the installation and maintenance costs of BR-ATP would be £825 million at (presumably) 1992 prices. Offsetting this would be reductions in damage and disruption valued at £66 million, leaving a net cost of £759 million attributable to casualty reduction. British Rail assumed that BR-ATP would be effective for a period of 20 years before it became obsolete, and estimated from past accident data that it could be expected to prevent 52 'equivalent fatalities' over this period, which in later discussion was amended to 65. (Equivalent fatalities are a combination of fatalities, major injuries and minor injuries with weights of 1, 0·1 and 0·005 respectively.) Dividing the net cost of £759 million by 65 gives a cost per prevented fatality of about £12 million at 1992 prices, or £15 million at 2002 prices. British Rail's review was considered by HSE and by the Secretary of State for Transport, who in the end 'agreed with the advice of British Rail and Railtrack, endorsed by the HSC, that the fitment of ATP throughout the network could not be justified because the costs far outweigh the benefits'.[20]

As noted in section 2·3 above, TPWS was developed to provide a more cost-effective though less comprehensive form of train protection than ATP, following the decision not to pursue BR-ATP. TWPS was made a legal requirement under the 1999 Railway Safety Regulations, and was installed by the end of 2003. As also noted above, TPWS is expected to prevent about 70% of ATP-preventable casualties. Evans estimated the cost of TPWS to be £550 million and the non-casualty savings in damage and disruption to £40 million,[2] giving a net cost of £510 million. Using the data discussed in section 2 of this paper, Evans estimated that TPWS would prevent 47 equivalent fatalities over a 20-year life, giving a cost of about £11 million per fatality prevented. The House of Commons Transport Committee refers to evidence from the chief executive of Network Rail implying a somewhat lower cost,[19] primarily because Network Rail assumes an effective life for TPWS of 25 rather than 20 years. However, the most interesting aspect of Network Rail's evidence was the estimate that about 90% of equivalent fatalities could be prevented for only one-third of the expenditure, and that the remaining 10% required two-thirds of the expenditure. This implies that the average cost per fatality prevented for the first 90% was about £4 million, but that the average cost per fatality prevented for the last 10% was about £70 million.

3.4. Summary and discussion

Table 3 summarises the information assembled in this section. It is notable that for the road-safety measures considered the values of preventing fatalities substantially exceed their costs, whereas for the rail protection measures considered the costs exceed the values.

We began this section with a discussion of the ToR framework, which in principle requires the implementation of all safety measures for which the value per prevented fatality exceeds the cost. It is clear from Table 3 that the ToR framework is not applied in practice to the road system, because there are many potential road-safety measures for which the value exceeds the cost, but which are not implemented. The reason for non-implementation is the constraint on resources, but in other fields resource constraints are not accepted as a valid reason for non-implementation of reasonably practicable safety measures.

On the other hand, railways go beyond the requirements of the ToR framework in the field of train protection. Although BR-ATP was not implemented across the network, the cost per fatality prevented by TPWS as implemented exceeds its value. Even with the more limited version of TPWS originally envisaged, the cost per fatality prevented appears to be slightly greater than the higher of the two VPFs used by the Railway Group, and that VPF is not supported by the 'willingness to pay' evidence discussed in section 3.2.2. Furthermore, the individual risks on the railways are relatively low, so there is no case for special safety measures to prevent the risks being intolerably high. Therefore TPWS as implemented is not justified within the ToR framework alone. Indeed, it was for that reason that specific regulations were made effectively to override the ToR framework.[21] Nevertheless, it is notable that TPWS has been almost universally welcomed, because it has substantially reduced a persistent and important source of railway risk.

It is clear from the preceding discussion that society could prevent more fatalities at the same cost by devoting relatively more resources to road safety and less to rail safety. It remains a puzzle that society chooses not to do so, and is apparently content with the present allocation of resources.

	Road: £m	Rail: £m
Values per prevented fatality:		
In road accidents/basic rail accidents	1·25	1·25
Fatalities in train accidents (industry value)		3·46
Costs per prevented fatality:		
In well-designed local road safety schemes	~0·1	
By BR-ATP (not implemented)		15
By TPWS (implemented)		
Overall		11
First 90% of fatalities		4
Last 10% of fatalities		70

Table 3. Values and costs of preventing fatalities (at 2002 prices)

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