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The economics of railway safety

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A B S T R A C T

This paper reviews the statistics and economics of railway safety in Great Britain, the European Union and the United States, together with some results for Finland and Japan. In these countries railway safety has improved over recent decades. That finding applies both to train accidents and to personal accidents such as persons struck by trains. Fatal train collisions and derailments command most attention even though they are infrequent and account for only a small minority of railway fatalities. Great Britain, the EU and the USA formally espouse conventional cost benefit analysis for the appraisal of railway safety measures, using the same valuations for the prevention of casualties as are used in road safety appraisal. However there are often strong institutional, legal and political pressures towards adopting railway safety measures with safety benefit: cost ratios well below 1. The best-documented examples of this are automatic train protection systems, which are discussed in the paper. Apart from trespassers, the largest group of railway fatalities occur at level crossings, which the paper also discusses. Level crossing safety measures would seem to be an appropriate subject for cost benefit analysis, but there are few case-studies in the literature. Over the last few decades, the railways in many countries have been privatised or deregulated with the aim of improving their economic performance. Such changes have the potential to affect safety. The paper reviews evidence of the effects on safety of railway restructuring in Great Britain, Japan and the United State, and finds no evidence that safety deteriorated.

1. Introduction

This paper reviews the statistics and economics of railway safety. The principal countries considered are Great Britain (GB), the European Union (EU) collectively, and the United states of America (USA). Some results are also given for Finland and Japan. These are the countries for which most information and analysis are available.

Section 2 looks at the railway risk profile in the 2000s, as measured by fatalities and fatality rates, and the medium term trends in the major classes of accident over periods of up to about three decades. Section 3 looks at the appraisal of railway safety measures and the use of cost benefit analysis. Section 4 considers the appraisal of an important and well-documented safety measure, automatic train protection. Section 5 considers level crossings, which are a major source of railway risk in almost all countries. Section 6 considers evidence of the effect on safety of rail privatisation and deregulation. Section 7 presents conclusions.

2. Railway risks and trends

This section reviews the safety risks on the railways and the medium term trends in these risks. The emphasis is on fatalities and fatal accidents, so as to avoid problems arising from different and changing definitions of non-fatal injuries, and from the underreporting and variable reporting of these. The main countries considered are GB, the EU and the United States (USA), with references also to Finland and Japan. Great Britain is included both on its own and as part of the EU, but it represents only about 12% of EU railway activity, as measured by train-kilometres.

Abbreviations: ALCRM, All Level Crossing Risk Model; ATP, Automatic Train Protection; BCR, Benefit cost ratio; BR, British Rail or British Railways; CBA, Cost benefit analysis; CSI, Common Safety Indicator [EU]; ERA, European Railway Agency; EU, European Union; FHWA, Federal Highway Administration [US]; FRA, Federal Railroad Administration [US]; GB, Great Britain; HEATCO, Harmonised European approaches for transport costing and project assessment; HSE, Health and Safety Executive [GB]; HSWA, Health and Safety at Work Act 1974 [GB]; ITF, International Transport Forum; JNR/JR, Japanese National Railway/Japanese Railways; LC, Level crossing; NTSB, National Transportation Safety Board [US]; ORR, Office of Rail Regulation [GB]; PTC, Positive train control; RI, Railway Inspectorate [GB]; RSIA08, Rail Safety Improvement Act 2008 [US]; RSSB, Rail Safety and Standards Board [GB]; SE, Standard error; SFAIRP, So far as is reasonably practicable; SMS, Safety Management System; SPAD, Signal passed at danger; TPWS, Train Protection and Warning System; UIC, International Union of Railways; VPF, Value of preventing a fatality; VPI, Value of preventing an injury; WTP, Willingness to pay.

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2.1. The risk profile of railways

The common image of a railway accident is of a multi-fatality train collision or derailment, but most railway casualties are more mundane. Table 1 gives data on railway fatalities per train-kilometre in the USA for 2000–2009, the EU for 2006–2009, and GB for 2000–2009, together with some general data about the three systems.

The top panel of Table 1 gives route-kilometres, the average number of level crossings, and train-kilometres per year for each system, from which are calculated average train-kilometres per day per route kilometre, which is a measure of the density of train movements on the system, and level crossings per route-kilometre. There are substantial differences between the systems, which partly account for their different risk profiles. The most striking safety-related difference is that the USA has about three times as many level crossings per route-kilometre as GB and about twice as many as the EU. The effect is that even though the fatality rate per crossing per year in the USA is low and close to that in GB, level crossings are responsible for a much greater proportion of railway fatalities in the USA than in GB. Another difference, not shown Table 1 but shown elsewhere (OECD/International Transport Forum, 2010, Table 2.2) is that railway operations are mainly of freight trains in the USA but of passenger trains in Europe and Great Britain. In 2002–2006, 88% of train-kilometres in the USA were of freight trains, but in Great Britain 89% were of passenger trains.

The second panel of Table 1 shows fatalities per 10^9 train-kilometres classified by person type: railway passengers, staff, public non-trespassers, trespassers, and suicides. The first three groups are people legitimately on the railway; trespassers are not. The fatalities that receive most attention are those to passengers and staff. The USA, EU and GB all had about 25 fatalities to passengers and staff per 10^9 train-kilometres, but in the USA the majority of these were staff whereas in the EU and GB the majority were passengers. This presumably reflects the high proportion of freight operation in the USA and of passenger operation in the EU and GB. Some of the passengers and staff fatalities occurred in train collisions and derailments, but the majority were in accidents to persons, such as staff working on the track or passengers struck by trains.

The numbers of passenger and staff fatalities were small compared with fatalities to the non-trespassing public, which are dominated by those to level crossing users. In the USA 89% of all non-trespasser fatalities were at level crossings (but see the footnote under Table 1) and in the EU 75% were. Only in GB is the proportion of level crossing fatalities low at 39%; as noted above, that reflects partly the relatively low density of crossings in GB, and partly a lower fatality rate per crossing than in the EU. Turning to trespassers and suicides, Table 1 shows that in each of the USA, EU and GB the numbers of accidental fatalities to trespassers per train-kilometre exceeded those to non-trespassers, and in the EU and GB the numbers of suicides were several times greater still. All these are tragic events, but they receive relatively little attention in the context of railway safety.

A problem with data on trespasser fatalities is that the reporting authorities often find it difficult to know whether specific deaths to persons on the track were accidents or suicides. Traditionally authorities reported fatalities as suicides only if a coroner had so determined. Open verdicts were treated as accidental and classified as trespassers. This led to overestimates of accidental trespasser fatalities and underestimates of suicides. In the last decade the RSSB in GB has used the so-called 'Ovenstone criteria' (RSSB, 2011, Appendix 4) to classify suspected suicides as suicides without a coroner's verdict. The effect has been to reduce the estimated number of trespassers and increase that of suicides. In the decade from 1991/2 to 2000/01 the Railway Inspectorate (RI) used the old reporting system to report a total of about 260 trespassers and suicides per year in GB, of which 49% were trespassers and 51% were suicides. In the 2000s the principal data come from the RSSB, who use the Ovenstone criteria. The RSSB data in Table 1 imply about the same total number of trespasser and suicide deaths per year in 2000–2009 as in the earlier decade, but only about 18% of these are trespassers. The RSSB data are likely to be closer to the truth than the pre-Ovenstone data, but the change in reporting means that there are no consistent long term data on trespassers in GB. In the USA, the railroads were not required to report suicides until mid-2011, but it is likely that the trespasser fatalities include some suicides. A study by George (2008) for the FRA covering 2002–2004 estimated that about 23% of reported trespassers were suicides. Savage (2007) presents an analysis of trespasser fatalities and injuries in the USA, covering both their nature and their trends.

As an indication of the absolute numbers of fatalities from which the fatality rates in Table 1 are derived, the average numbers of fatalities per year to passengers in the USA, EU and GB were 7, 28 and 9 respectively; the average numbers of fatalities per year to staff were 26, 14 and 5 respectively; the average numbers of fatalities per year to public non-trespassers were 362, 186 and 14 respectively; and the average numbers of fatalities per year to trespassers were 480, 358 and 45 respectively.

Table 1
Railway fatalities in the United States, the European Union and Great Britain: 2000–2009.

	United States	European Union	Great Britain
	2000–2009	2006–2009	2000–2009
System data			
Average railway route-kilometres	194,002	212,607	16,108
Average number of level crossings	239,126	129,221	7457
Train-kilometres per year (10^9)	1.2065	4.1495	0.5248
Train-kilometres per day per route-kilometre	17.0	53.5	89.3
Level crossings (LCs) per route-kilometre	1.23	0.61	0.46
Fatalities per 10^9 train-km by person type			
Railway passengers	5.8	16.9	17.1
Staff	22.0	8.6	9.0
Public non-trespassers	300.0	112.1	25.9
All accidental non-trespassers	327.8	137.5	52.0
Trespassers	397.6	215.6	85.8
All accidental including trespassers	725.4	353.1	137.8
Suicides		598.2	398.1
All including trespassers and suicides		935.3	535.9
Fatalities per 10^9 train-km for selected accident types			
In train collisions and derailments, not at level crossings	10.6	6.1	4.4
At level crossings	291.1	103.2	20.2
Fatalities at level crossings per year per 1000 crossings	1.47	3.31	1.42
Selected ratios			
Fatalities to passengers and staff as percent of all non-trespassers	8.5%	18.5%	50.2%
Fatalities in train collisions and derailments as percent of all non-trespassers	3.2%	4.5%	8.4%
Fatalities at level crossings as percent of all non-trespassers	88.8%	75.0%	38.8%
Fatalities to trespassers as multiple of all non-trespassers	1.21	1.57	1.65
Suicides as multiple of all non-trespassers		4.23	7.65

Sources: calculated by author from data in Federal Railroad Administration (FRA, 2011 and earlier); European Railway Agency (ERA, 2011); Rail Safety and Standards Board (2011 and earlier); International Union of Railways (2010 and earlier). The FRA classify some fatalities at level crossings caused by misuse of the crossing as trespassers, but in order to maintain comparability all fatalities to road users at LCs are here classified as public non-trespassers.