

Fatal Train accidents on Europe`s railways: 1980-2009

Prof. Andrew Evans from CTS, Imperial College London

Wednesday, 02 March 2011 - 16:00

Location: Room 610, Skempton (Civil Eng.) Bldg, Imperial College London

Abstract

The seminar presents an analysis of fatal train accident rates and trends on Europe's main line railways from 1980 to 2009. The analysis is based on a new set of data for the European Union together with Norway and Switzerland, assembled partly under the auspices of the European Railway Agency and partly on the author's own account. The estimated overall trend in the number of fatal train collisions and derailments per train-kilometre is -6.3% per year from 1990 to 2009, with a 95% confidence interval of -8.7% to 3.9% . The estimated accident rate in 2009 is 1.35 fatal collisions or derailments per billion train-kilometres, giving an estimated mean number of fatal accidents in 2009 of 6.0. The overall number of fatalities per fatal accident in 1990-2009 is 4.10, with no apparent long term change over time, giving an estimated mean of 24.6 fatalities per year in train collisions and derailments in 2009. There are statistically significant differences in the fatal train accident rates and trends between the different European countries, although the estimates of the rates and trends for many individual countries have wide confidence limits. The distribution of broad causes of accidents appears to have remained unchanged over the long term, so that safety improvements appear to have been across the board, and not focused on any specific cause. The most frequent cause of fatal train collisions and derailments is signals passed at danger. In contrast to fatal train collisions and derailments, the rate per train-kilometre of serious accidents at level crossings remained unchanged in 1990-2009. The immediate causes of most of the serious level crossing accidents are errors or violations by road users.

Biography

Andrew Evans is Emeritus Professor of Transport Risk Management at Imperial College London and Visiting Professor at University College London. He was previously Director of the Lloyds Register Educational Trust Transport Risk Management Centre at Imperial College and Professor of Transport Safety at UCL. He is a statistician and economist by background.

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Andrew Evans
Centre for Transport Studies
Imperial College London
University College London
a.evans@imperial.ac.uk

Further information

- A peer-reviewed paper on this work is published in the journal *Accident Analysis and Prevention*
 - Evans, A W (2011). Fatal Train Accidents on Europe's Railways: 1980-2009. *Accident Analysis and Prevention*, Vol 43(1), 391-401.
- If you do not have access to journals, the manuscript is online at
 - <http://www.cts.cv.ic.ac.uk/documents/publications/iccts01383.pdf>

Outline

- Background, objectives, project history
- Data sources
- Exposure: train-kilometres
- Fatal train collisions and derailments
 - Accident rates and trends for Europe as a whole
 - Accident rates and trends by country
 - Accident causes
- Serious level crossing accidents
- Accident consequences
- Conclusions

Background and Objectives

- Fatal train accidents are the most serious of railway accidents
- Major safety effort devoted to controlling them
- Important to monitor their frequency and consequences, but difficult because they are infrequent. Methods used include
 - Empirical analysis of accidents
 - Analysis of precursors
 - Risk models
- Relatively good data and models exist for some countries
- Little data and few models exist for all Europe
- The objectives of this project are to:
 - Assemble empirical data on serious train accidents in EU+NO+CH in 1980-2009
 - Analysis these data to estimate trends and levels of risk

Project history

- Data available for GB/UK, but not for Europe
- A 2006 IC/UCL MSc project investigated use of press sources (Simon Blainey)
- Proposal for data assembly put to ERA
- In 2007 IC/ LR won contract to assemble data for 1990-2007
- In 2009 ERA placed resulting data on web
- AE extended data forward to 2009 and back to 1980
- AE analysed data for 1980-2009

Data coverage

- Data for the ERA covered
 - (1) Fatal train collisions and derailments
 - (2) Level crossing accidents with ≥ 1 on-train fatality
 - (3) Fatal train fires
 - (4) All other accidents with ≥ 4 fatalities
 - (5) Train collisions and derailments without fatalities but ≥ 5 serious injuries
 - (6) Other high cost accidents ($\geq \text{€}2$ million)
 - (7) Other accidents in which dangerous goods were released
- This analysis...
 - Focuses mainly on fatal train accidents (1)
 - Presents some analysis of other fatal accidents (2) to (4)
 - Disregards the non-fatal accidents (5) to (7)

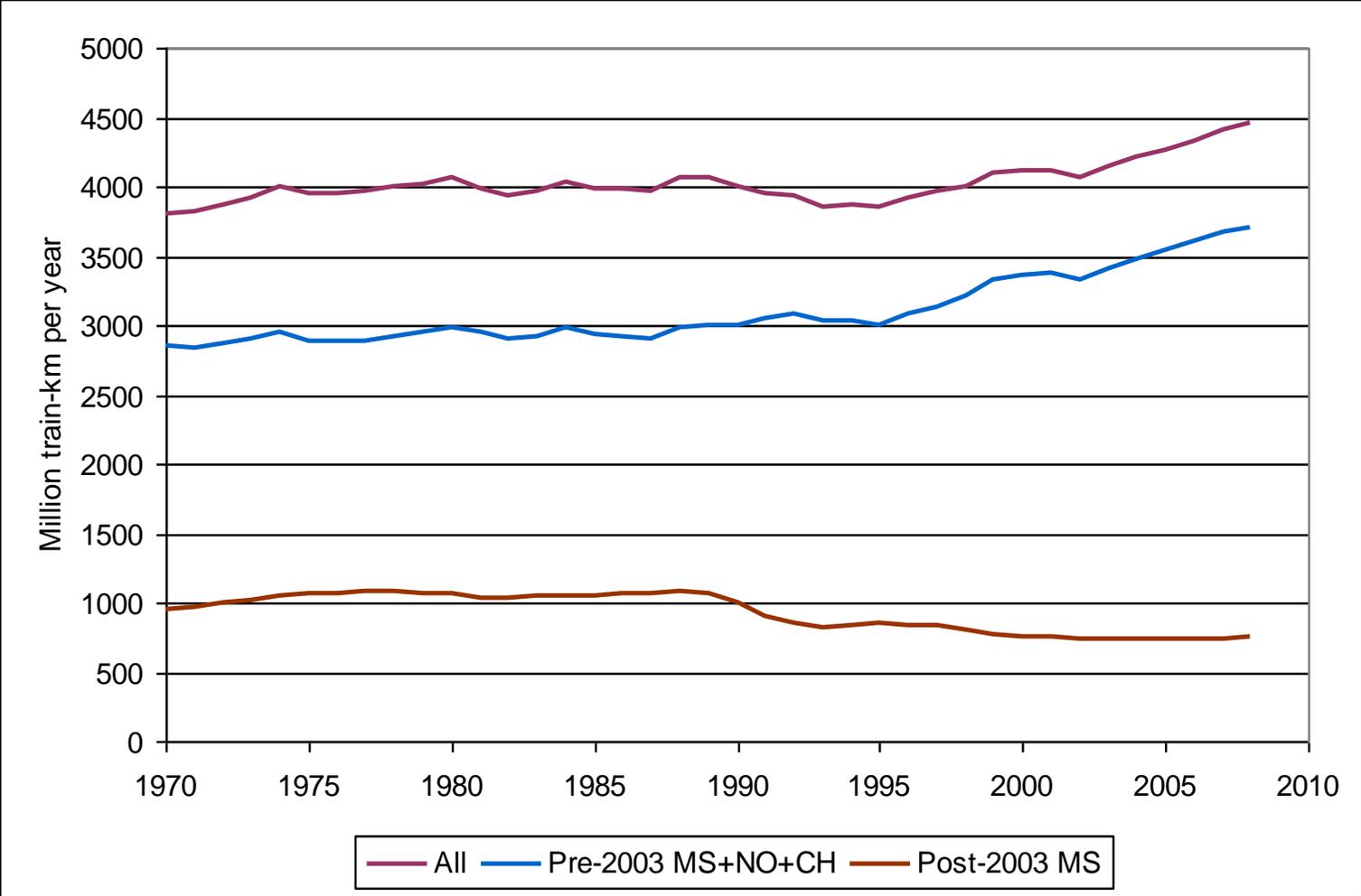
Data sources

- Main initial data sources were press reports
- Principal source of press reports was a commercial database entitled Nexis®
 - News agency reports more useful than newspaper reports
- Backed up by scrutiny of findings by the National Investigation Bodies (NIBs) for 1990-2007
- Many other sources used
- Data for 1990-2009 assumed complete
- Data for 1980-1989 incomplete, but assumed complete for...
 - DE, FR, UK, NL, SE, NO, IE,
 - and accidents with ≥ 4 fatalities

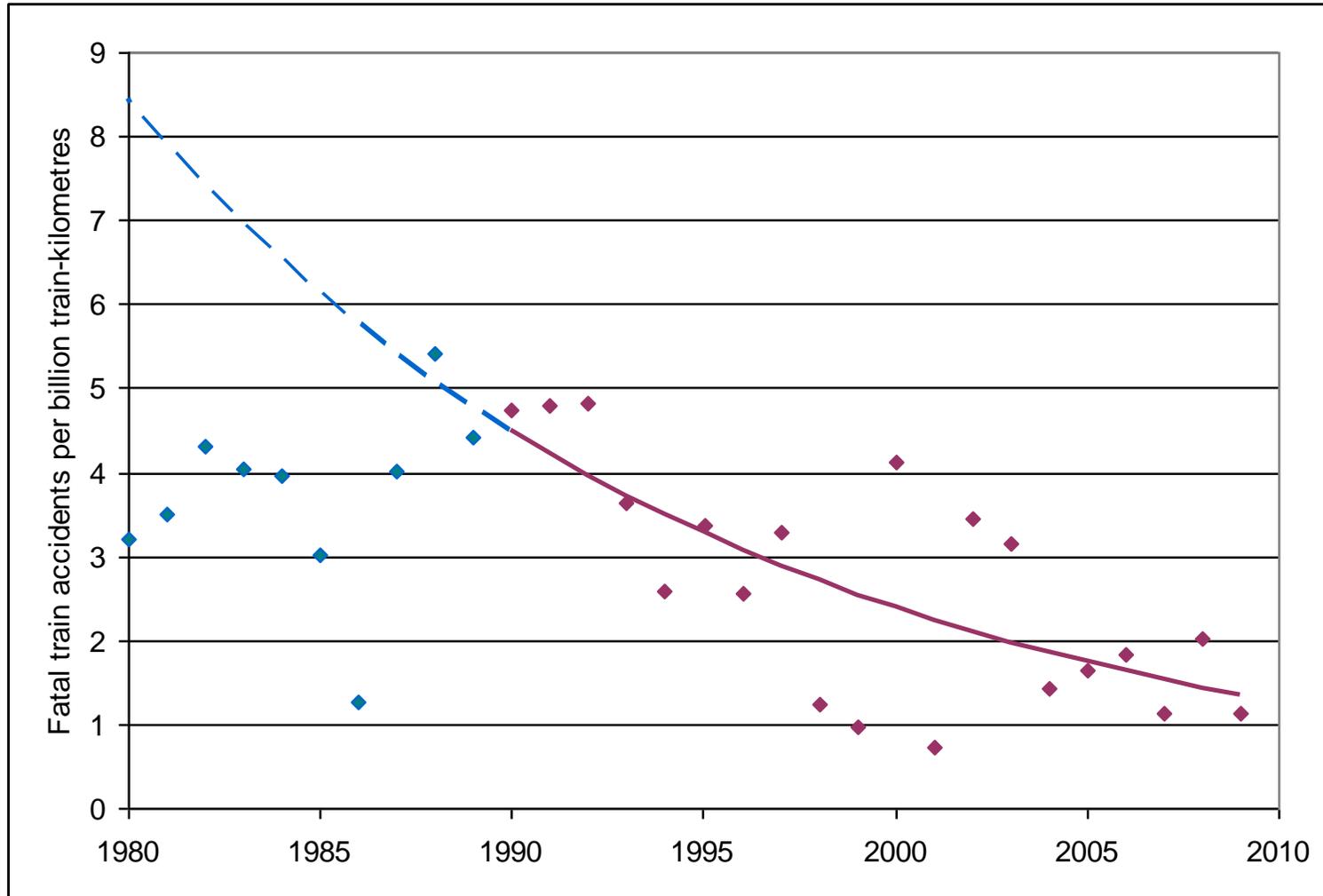
Fatal train collisions & derailments by data source: 1980-2009

Source	1980-1989	1990-1999	2000-2009	Total
Nexis®	137	111	79	327
Not Nexis but NIB	3	13	4	20
Not Nexis or NIB but other	9	2	4	15
All	149	126	87	362

Train-kilometres per year: EU+NO+CH: 1970-2008



Fatal train accidents per billion train-km: EU+NO+CH: 1980-2009



Fatal train collisions & derailments: EU+NO+CH

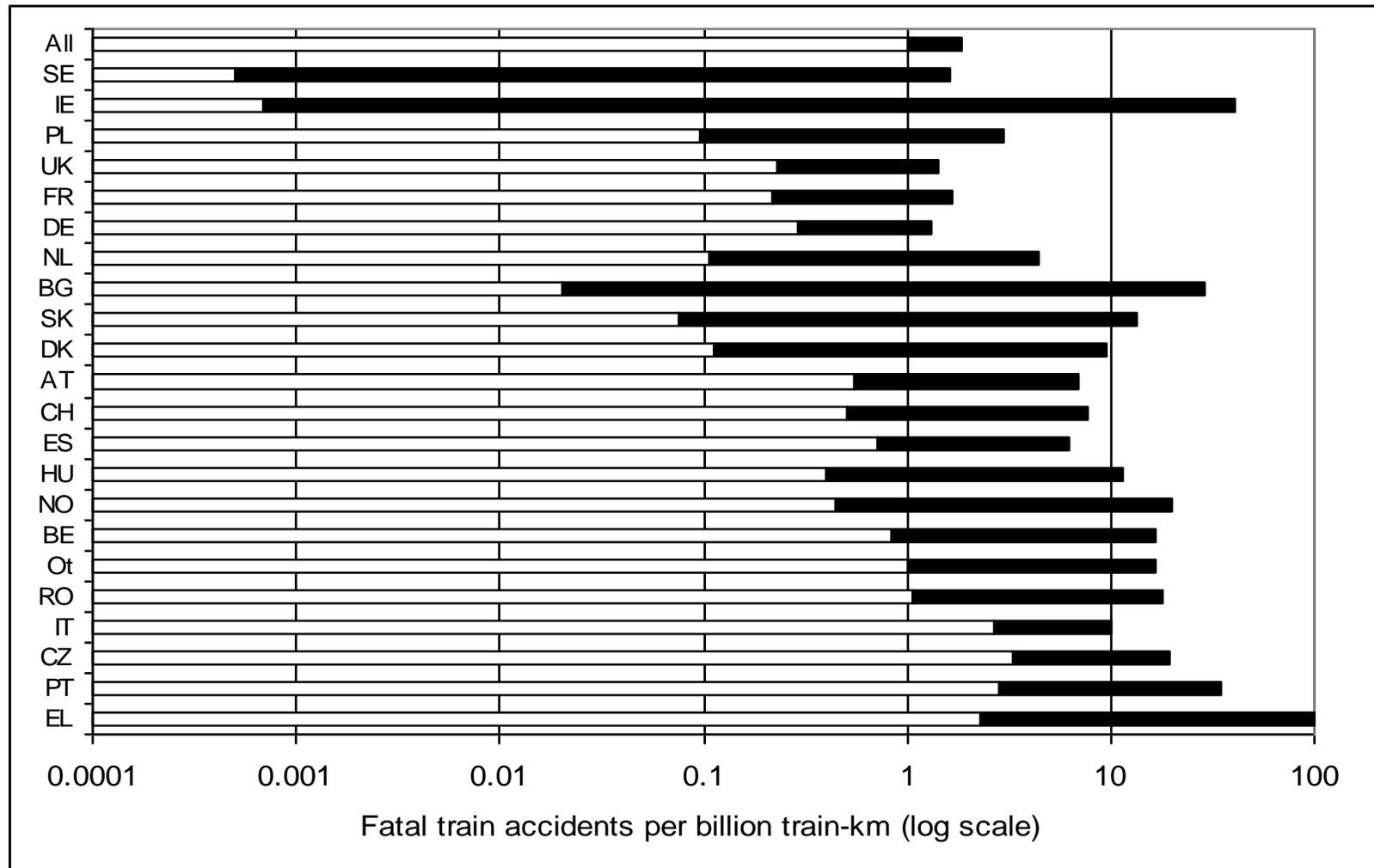
- Trend in accidents per billion train-km fitted to all-Europe data for 1990-2009 by “Poisson regression”
 - Fitted trend -6.3% per year (close to trends in UK and Japan)
 - Implies mean of 1.35 accidents per 10^9 train-km in 2009
 - Implies mean of 6 fatal accidents in 2009 (actual number in 2009 was 5, but there were 11 in 2010)
 - Somewhat more scatter than Poisson
- Back extrapolation of trend implies 259 accidents in 1980-1989
 - Observed number 149
 - Suggests ~ 100 missed accidents in 1980-1989

Fitted variants of exponential trend

$$\lambda_t = \alpha k_t \exp(\beta t) \text{ for different countries}$$

Model variant	Degrees of freedom	Scaled deviance
Common α ; $\beta = 0$	101	238.4
Common α ; common β	100	223.3
Different α 's; $\beta = 0$	80	157.8
Different α 's; common β	79	113.6
Different α 's; different β 's	58	78.8

95% confidence intervals for central estimate of train accidents per billion train-km by country: 2009



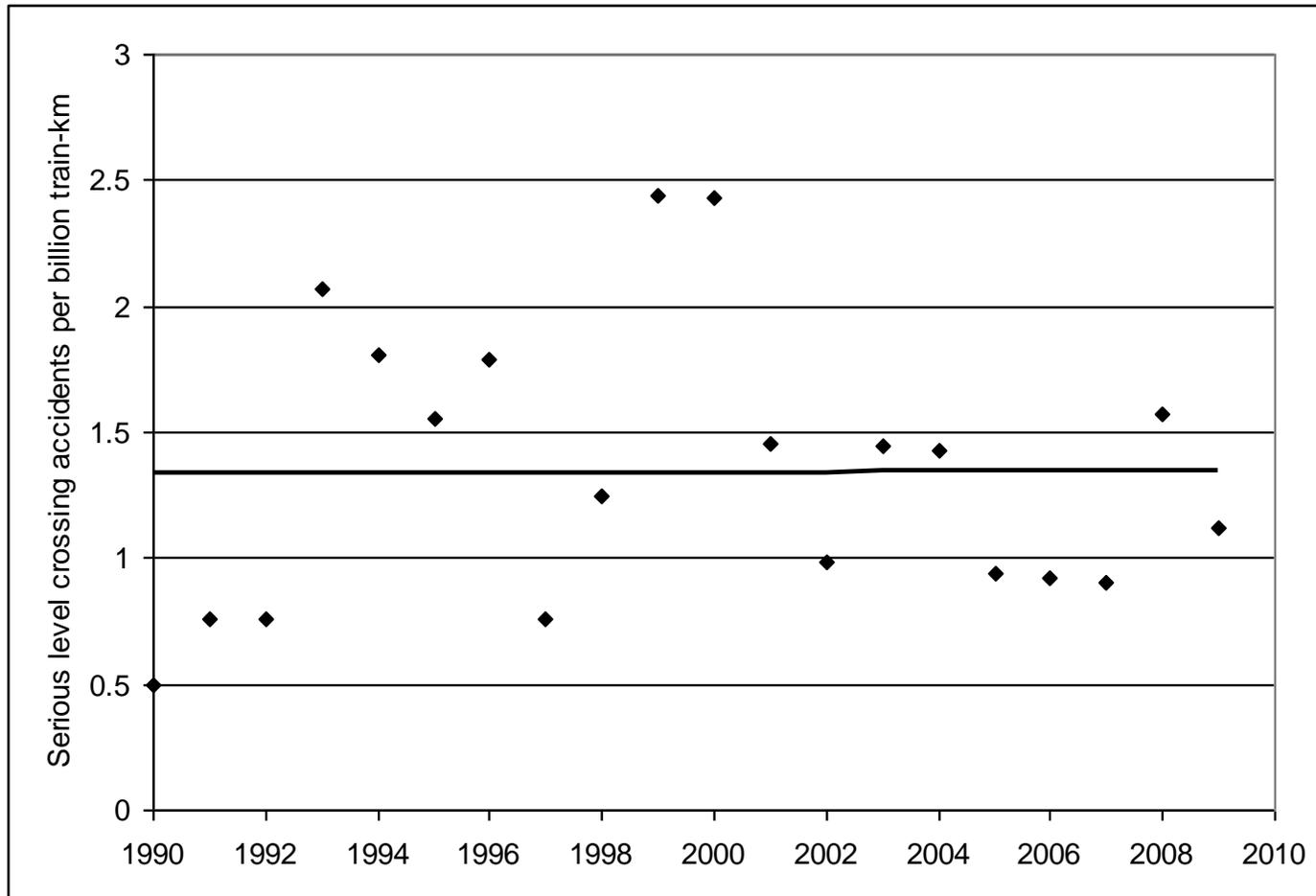
Fatal train collisions and derailments by country

- Limited data at country level, but not too limited
 - Data grouped into 5-year periods
 - Six periods for 7 countries, four periods for the rest
- Mean accident rates for 2009 have wide confidence intervals, but we can say the following
 - Differences in accident rates and trends between countries are statistically significant
 - Sweden, Ireland have lowest estimated mean rates in 2009
 - The three largest systems (DE, FR, UK) have similar mean rates in 2009 (0.6 per 10^9 train-km); these are well below the overall average of 1.35
 - Some countries have relatively high rates
- Nine of the 11 accidents in 2010 are in countries in the worse half of the graph
- Trends for most countries are downwards; none are statistically significantly upwards

Immediate causes of train accidents: 1990-2009

Immediate cause	1990-1999	2000-2009	Total
Signal passed at danger	35	24	59
Overspeeding	13	7	20
Signalling or dispatching error	12	12	24
Other operational error	8	3	11
Rolling stock failure	4	7	11
Infrastructure or track failure	9	13	22
External to railway	5	6	11
All known	86	72	158
Not known	40	15	55
All including not known	126	87	213

Serious level crossing accidents per billion train-km: EU+NO+CH: 1990-2009



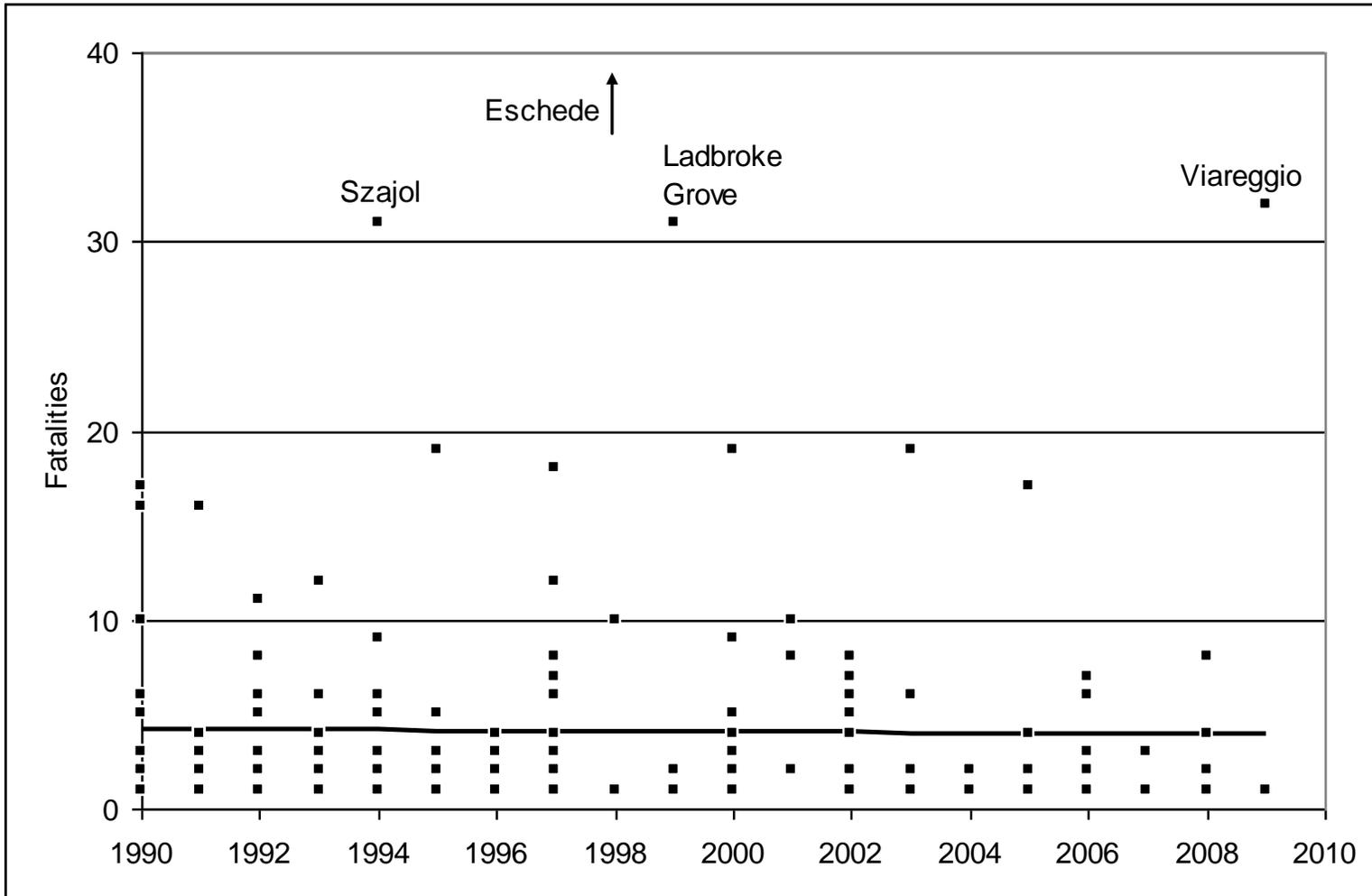
Number of train accidents by number of fatalities: 1980-2009

Fatalities	1980- 1989	1990- 2009	Total
1-3	83	153	236
4-9	44	42	86
≥ 10	22	18	40
All	149	213	362

Accidents with ≥ 30 fatalities: EU+NO+CH: 1980-2009

Date	Cou -ntry	Location	Brief description	Fatal- ities
19/08/80	PL	Otloczyn	Passenger/freight train collision	67
21/11/80	IT	Lamezia Terme	Three train collision	30
12/09/82	CH	Pfaffikon	Pass train/bus collision, fire, at LC	39
14/07/84	SI	Divača	Passenger/freight train collision	31
03/08/85	FR	Flaujac	Two passenger train collision	35
31/08/85	FR	Argenton-sur-Creuse	Pass train derailment, then collision	43
11/09/85	PT	Nelas-Alcafache	Two passenger train collision, fire	45
27/06/88	FR	Paris Gare de Lyon	Two passenger train collision	56
12/12/88	UK	Clapham Junction	Three passenger train collision	35
02/12/94	HU	Szajol	Passenger train derailment	31
03/06/98	DE	Eschede	Passenger train derailment	101
05/10/99	UK	Ladbroke Grove	Two passenger train collision, fire	31
08/05/03	HU	Siófok	Pass train/bus collision, fire, at LC	33
29/06/09	IT	Viareggio	Freight train derailment, fire	32

Fatalities in fatal train accidents: EU+NO+CH: 1990-2009



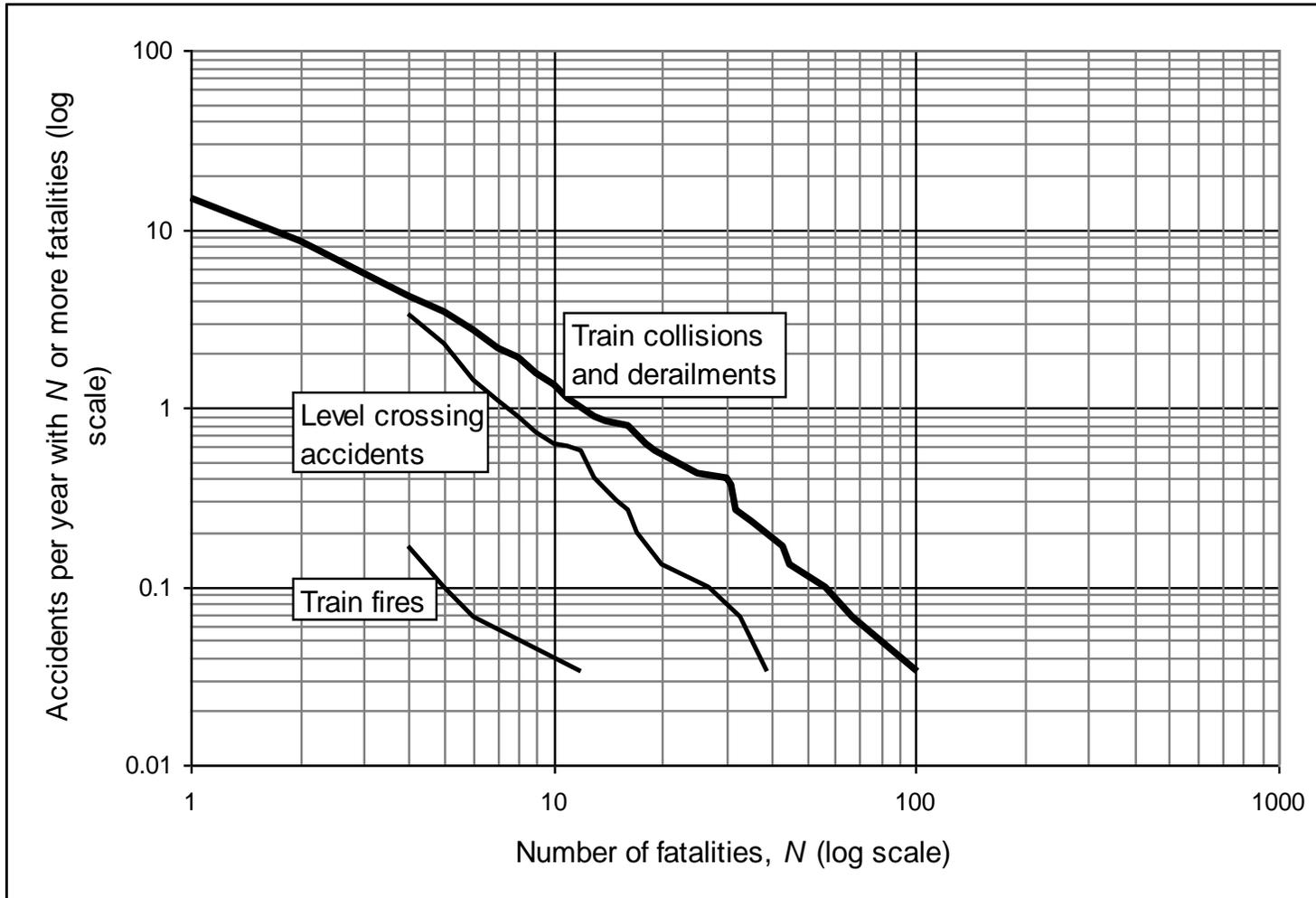
Accident consequences: train collisions & derailments

- Consequences measured by number of fatalities
- Relationship between larger and smaller recorded accidents again suggests ~100 collisions and derailments in 1980-1989 are missing
- Distribution of fatalities is very skew
 - Most accidents have a small number of fatalities
 - A few have a large number (worst in period had 101 fatalities)
- No evidence that the average number of fatalities per fatal accident is rising or falling over time in 1990-2009
- Average is 4.10; implies mean of 25 fatalities per year in train collisions and derailments in EU+NO+CH in 2009 (actual was 36; 41 in 2010)

High-fatality accidents

- Project assembled data on all accidents with ≥ 4 fatalities
- These are assumed to be complete for 1980-2009
- Besides train collisions & derailments, the following classes of accident have multiple fatalities
 - Level crossing collisions with multiple fatalities to
 - Train occupants (worst with 13 fatalities)
 - Road vehicle occupants (worst with 33 and 39 bus fatalities)
 - Train fires (worst with 12 fatalities)
 - Groups of people struck by trains (worst with 7 fatalities, but a 12-fatality accident occurred in 2010)
- FN-curves describe accident size distributions
- LC accidents gaining in importance

FN-curves for train accidents: EU+NO+CH: 1980-2009



Conclusions: 1

- Data sources
 - Press sources+NIBs+others successful for 1990-2009
 - Non-retrieval of ~100 accidents in 1980-1989
- Trends and rates of train fatal collisions & derailments
 - Overall trend in rate –6.3% per year to 1.35 fatal accidents per billion train-km in 2009
 - Statistically significant differences in rates and trends between countries
 - DE, FR and UK all had similar estimated accident rates in 2009 and of about 0.6 accidents per billion train-km
- Accident causes
 - Most common cause is signals passed at danger, followed by signalling or dispatching errors
 - Accident frequencies have fallen over time, but distribution of causes has shown no significant changes

Conclusions: 2

- Serious level crossing accidents
 - Overall trend in accident rate is flat
 - Trend in less serious LC accident rate might be similar
 - LC accidents gaining in importance relative to train collisions and derailments
- Accident consequences
 - Distribution of numbers of fatalities in fatal accidents is skew
 - The trend in mean fatalities per fatal collision or derailment is flat
 - Mean value 4.1 fatalities per fatal accident giving a mean of about 25 fatalities per year in 2009

Thank you

Andrew Evans
Centre for Transport Studies
Imperial College London
a.evans@imperial.ac.uk
www.imperial.ac.uk/cts