International Transport Forum

Updated Estimates of the Relationship Between the Business Cycle and Traffic Fatalities

Discussion Paper

Rune Elvik
The Institute of Transport Economics, Oslo

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The International Transport Forum

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Introduction

The global recession during 2008-10 was associated with an accelerated decline in the number of traffic fatalities in 14 countries belonging to the Organisation for Economic Co-operation and Development (OECD) (ITF, 2015). The countries included: Austria, Belgium, Denmark, Finland, France, Germany, The United Kingdom, Ireland, Japan, the Netherlands, Norway, Sweden, Switzerland, and the United States of America. A shorter version of the report, with some additional analyses, has been published in Accident Analysis and Prevention (Wegman et al., 2017).

The global recession has ended, and economic growth has returned to many OECD-countries. In some countries, for example the United States, the number of traffic fatalities has increased in recent years. It therefore is natural to ask whether a decline in unemployment rate is associated with a slowdown, or even reversal, of the long-term decline in the number of traffic fatalities. This paper presents an update of the analyses in the 2015 report and includes data up to 2016 for the same 14 countries that were included in the original study. The main questions asked are:

1. How are changes in unemployment related to changes in the number of traffic fatalities?
2. Is the relationship stable over time or has it become stronger or weaker in recent years?
3. Are traffic fatalities involving young people more sensitive to changes in the business cycle than traffic fatalities in general?

Changes over time in traffic fatalities and unemployment are analysed separately for each country, as countries differ greatly with respect to changes over time in both variables of principal interest in this study.

Data and methods

Description of data

The data used in the study were provided by the OECD. The data include the number of traffic fatalities up to and including 2016. Both the total number and the number of fatalities by age group were provided. Data were also provided on mean annual rates of unemployment, stated as the per cent of the labour force without work. In the original study, data was also obtained on gross domestic product (GDP) per capita and on vehicle-kilometres of travel. These data were not collected for the update, as experience shows that both GDP per capita and vehicle-kilometres of travel are almost perfectly correlated with time and cannot be included in a model that also includes year as a variable. The inclusion of all three variables (time, GDP, vehicle-kilometres) in the same model leads to unstable estimates of regression coefficients. For an illustration, see Elvik (2018). The data used in the update was therefore limited to unemployment rate and the number of traffic fatalities.

Figures 1-14 in this paper present the data for each country. These figures show the number of traffic fatalities each year from 1995 to 2016 and mean annual unemployment rate in the same period. In each figure, the number of traffic fatalities is shown on the left scale and by means of a solid line; unemployment is shown on the right scale and indicated by a dotted line.

In Austria (Figure 1), there has been a fairly constant decline in the number of traffic fatalities, with only a few years showing an increase. There is nevertheless a strong negative correlation between unemployment rate and traffic fatalities, mostly because the long-term trends are opposite: down for fatalities, up for unemployment. It remains to be seen whether annual changes also show a negative relationship between unemployment and traffic fatalities.

Figure 1: Traffic fatalities and unemployment in Austria 1995-2016

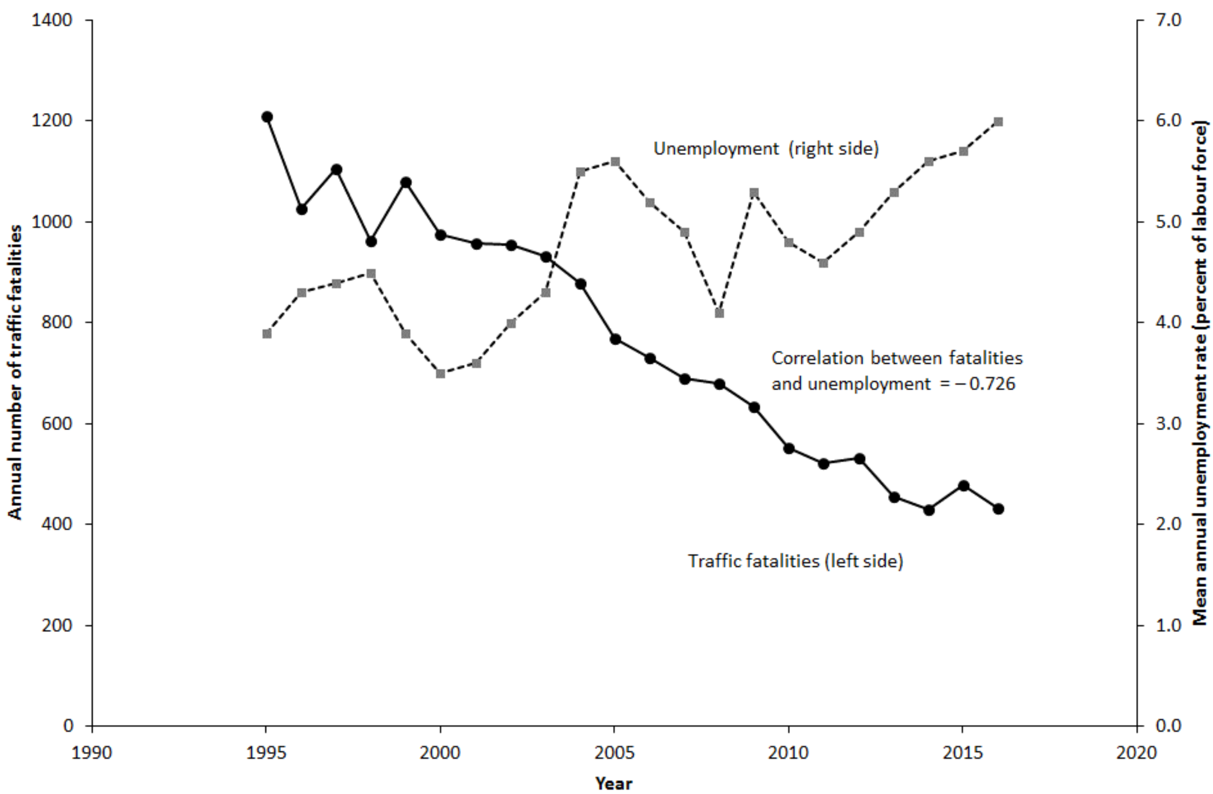


Figure 2 shows traffic fatalities and unemployment in Belgium during 1995-2016. The number of traffic fatalities was stable until 2001. After that, there has been a steady decline. Unemployment was at its highest at the beginning of the period and has fluctuated in a rather narrow range with no clear long-term trend after about 2001.

Figure 2: Traffic fatalities and unemployment in Belgium 1995-2016

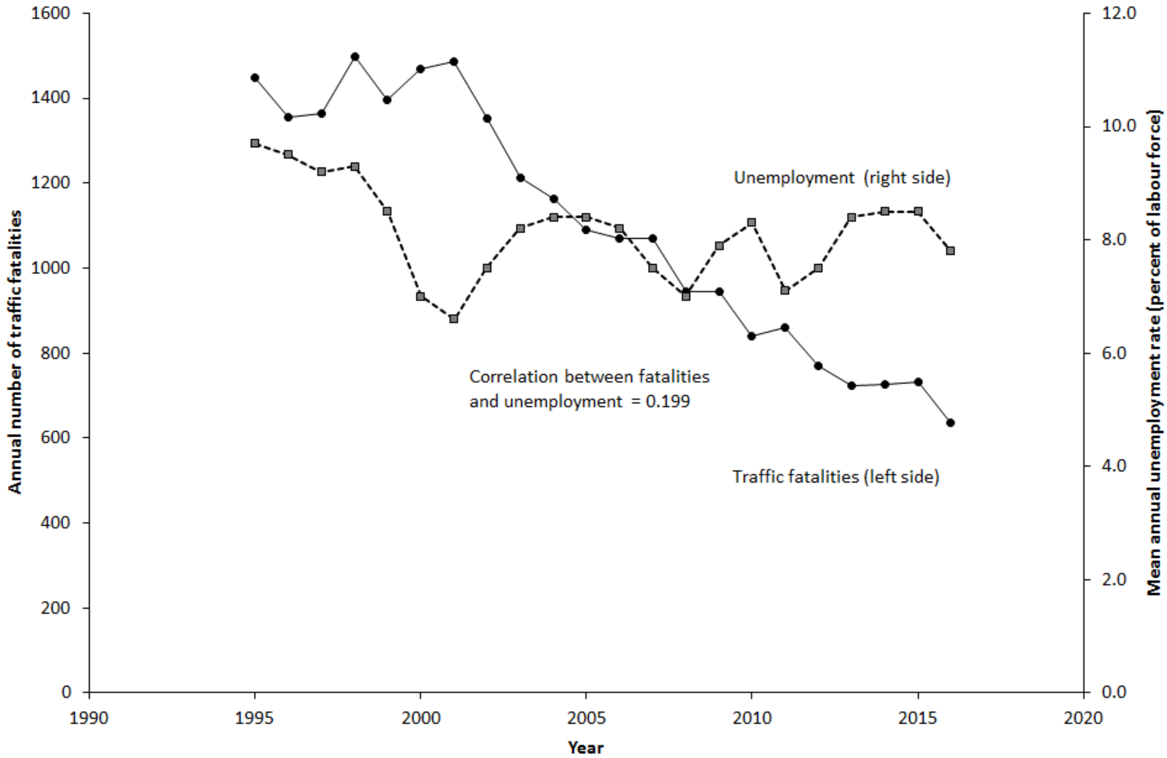
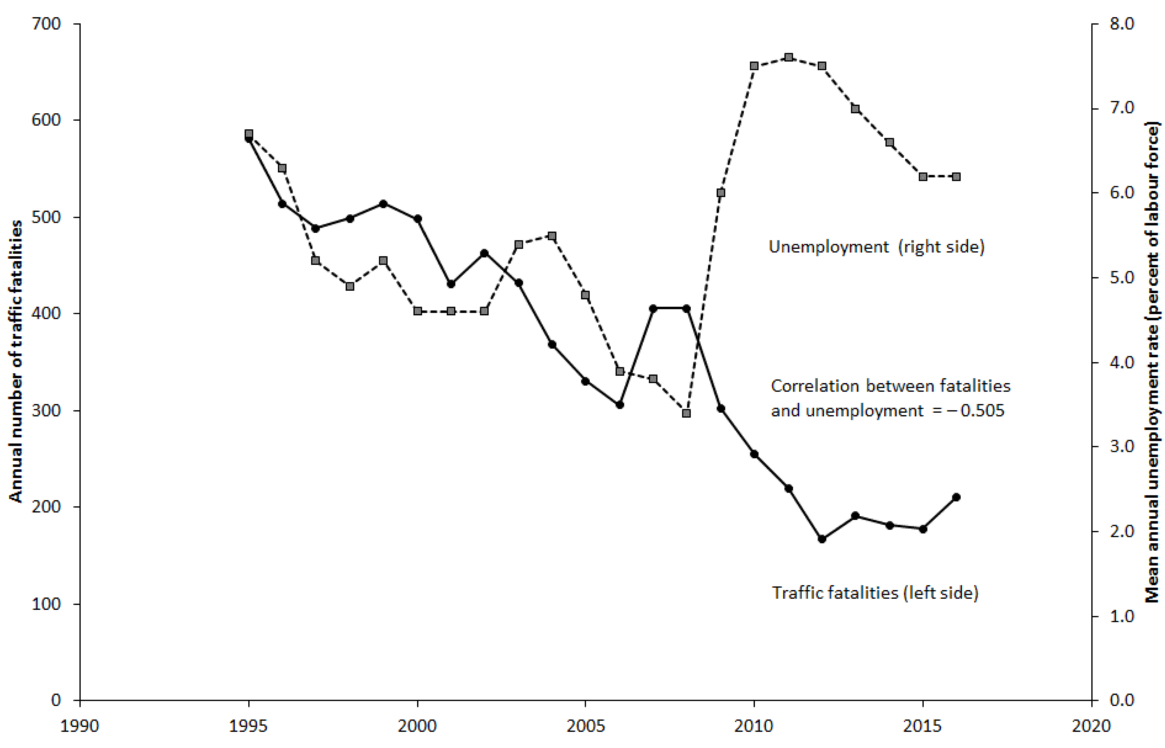
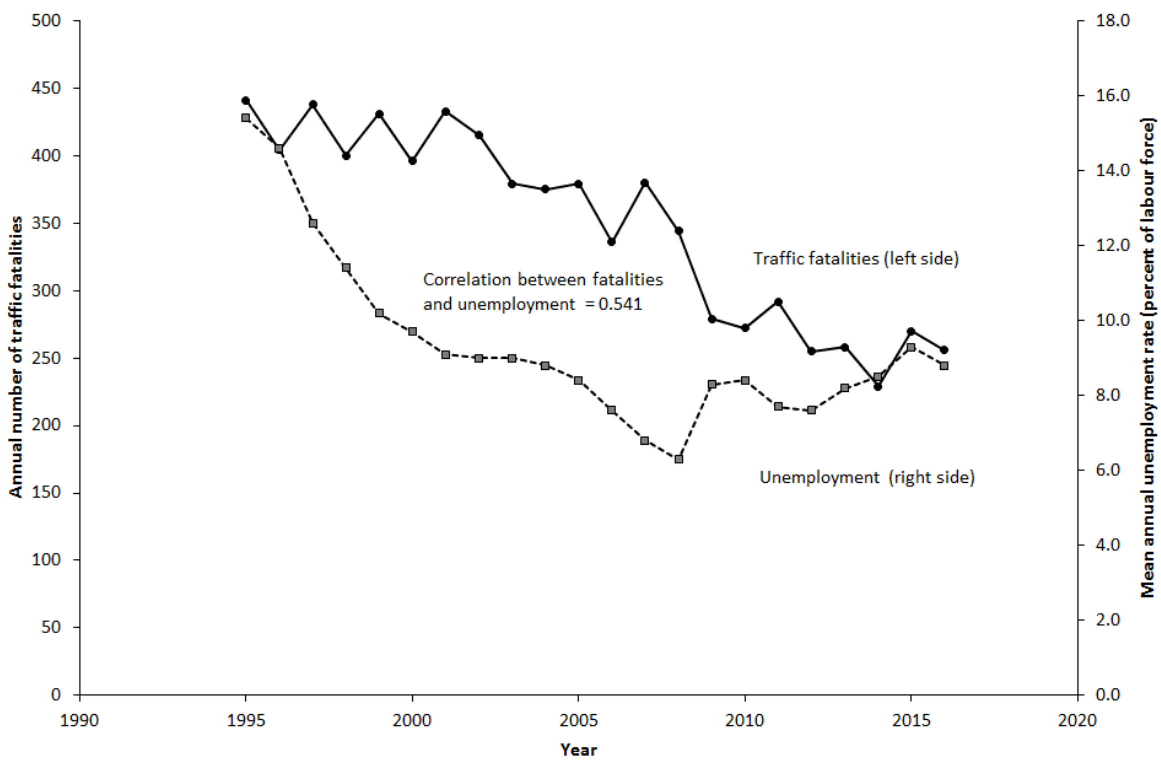


Figure 3: Traffic fatalities and unemployment in Denmark 1995-2016



Traffic fatalities in Denmark (Figure 3) show a large decline over time, but with considerable fluctuations around the long-term trend. There has not been any decline in the number of traffic fatalities after 2012. Unemployment rate appeared to develop almost in parallel with traffic fatalities up to 2006; after that year there seems to be a striking negative relationship between changes in unemployment and changes in the number of traffic fatalities. Note the sharp increase in unemployment rate between 2008 and 2011 and the steep decline in traffic fatalities in the same period. From 2012, unemployment rate has declined, but traffic fatalities have not declined.

Figure 4: Traffic fatalities and unemployment in Finland 1995-2016



In Finland (Figure 4), unemployment declined from a high level in 1995 until 2008, after which it has increased, but not to the same high level as in 1995. There is a long-term decline in the number of traffic fatalities, but with large irregularities. The decline has slowed down in recent years, while, at the same time, unemployment rate has increased. These trends are not consistent with the hypothesis that an increase in unemployment rate is associated with a reduction in the number of traffic fatalities, but an analysis of annual changes is needed before concluding anything.

Traffic fatalities in France (Figure 5) have declined fairly steadily, particularly after 2001. Unemployment, on the other hand, shows an irregular development, with an early peak in 1997, followed by a decline until 2008 and an increase in later years, almost reaching the same level as the peak in 1997. The visual impression from Figure 5 is that there is no clear relationship between changes in unemployment and changes in traffic fatalities.

There has been a steady decline in the number of traffic fatalities in Germany (Figure 6), with setbacks in only a few years. Unemployment reached a peak in 2005 and declined sharply in the following years, but so did the number of traffic fatalities. In recent years the decline in traffic fatalities appears to have slowed down, while unemployment keeps going down.

Figure 5: Traffic fatalities and unemployment in France 1995-2016

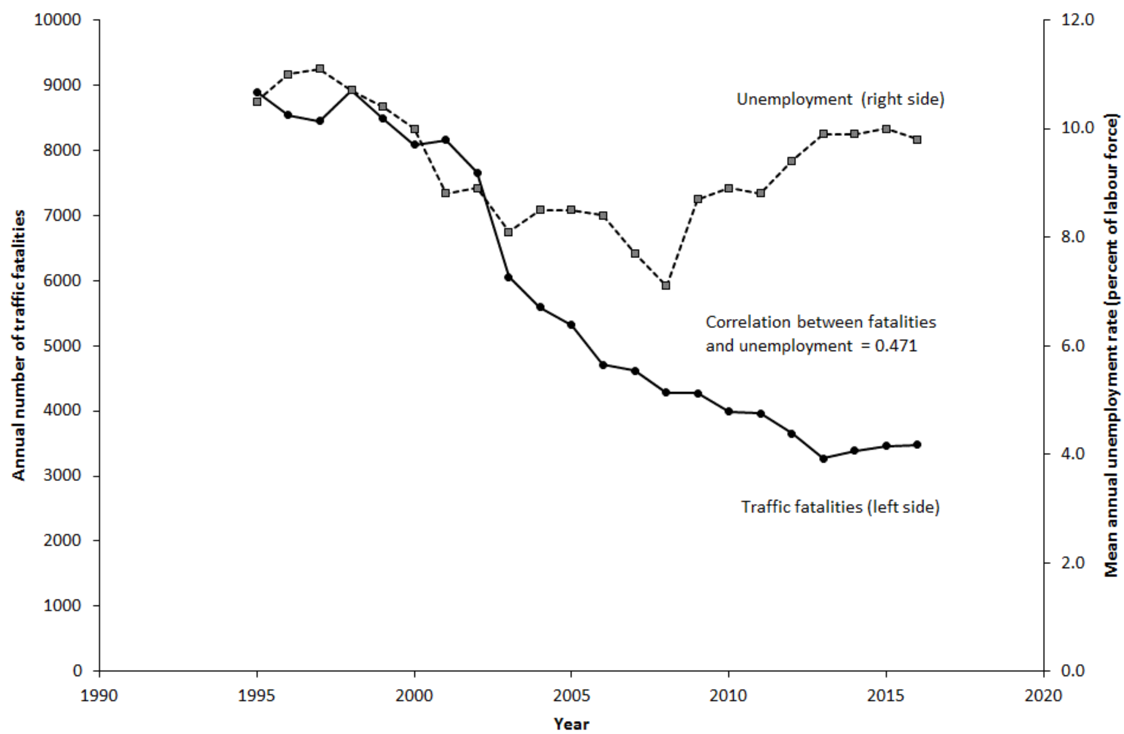
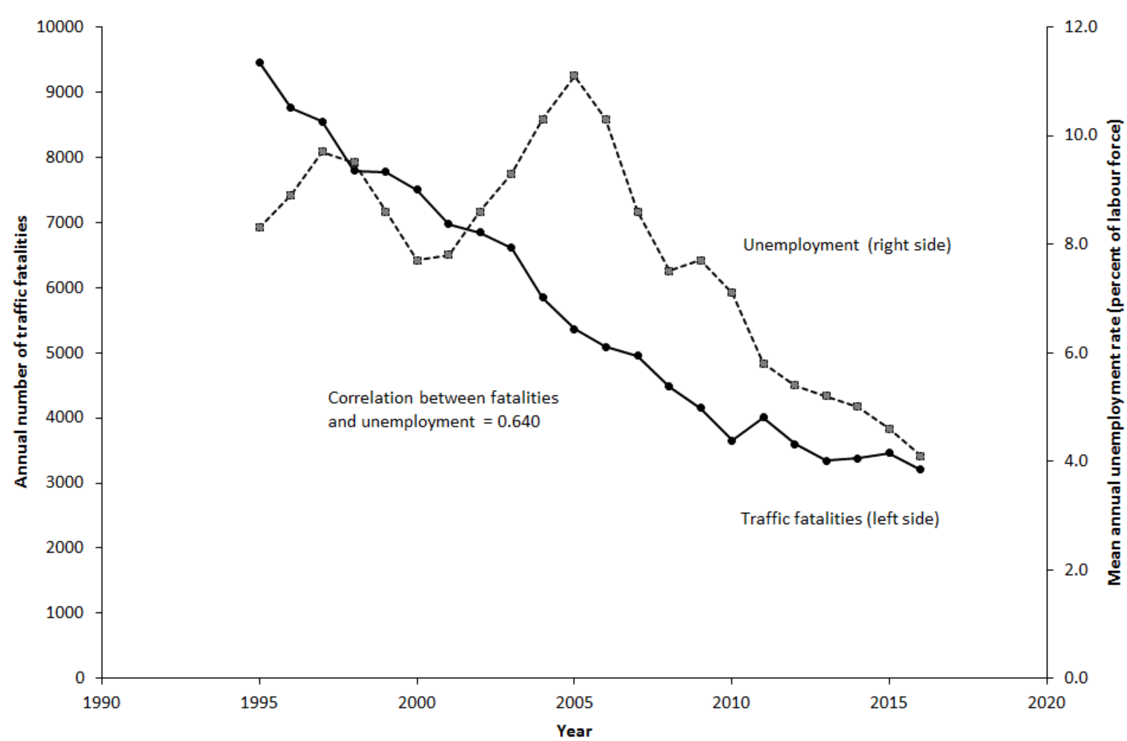


Figure 6: Traffic fatalities and unemployment in Germany 1995-2016



Traffic fatalities in the United Kingdom hardly declined between 1995 and 2003 (Figure 7), while unemployment rate declined in the same period. Between 2003 and 2010, there was a sharp decline in the number of traffic fatalities in the United Kingdom; in recent years the decline has once more almost stopped. The visual impression from Figure 7 is that these changes are closely related to changes in unemployment rate. Traffic fatalities decline when unemployment rate increases and stop declining when unemployment rate declines.

Figure 7: Traffic fatalities and unemployment in the United Kingdom 1995-2016

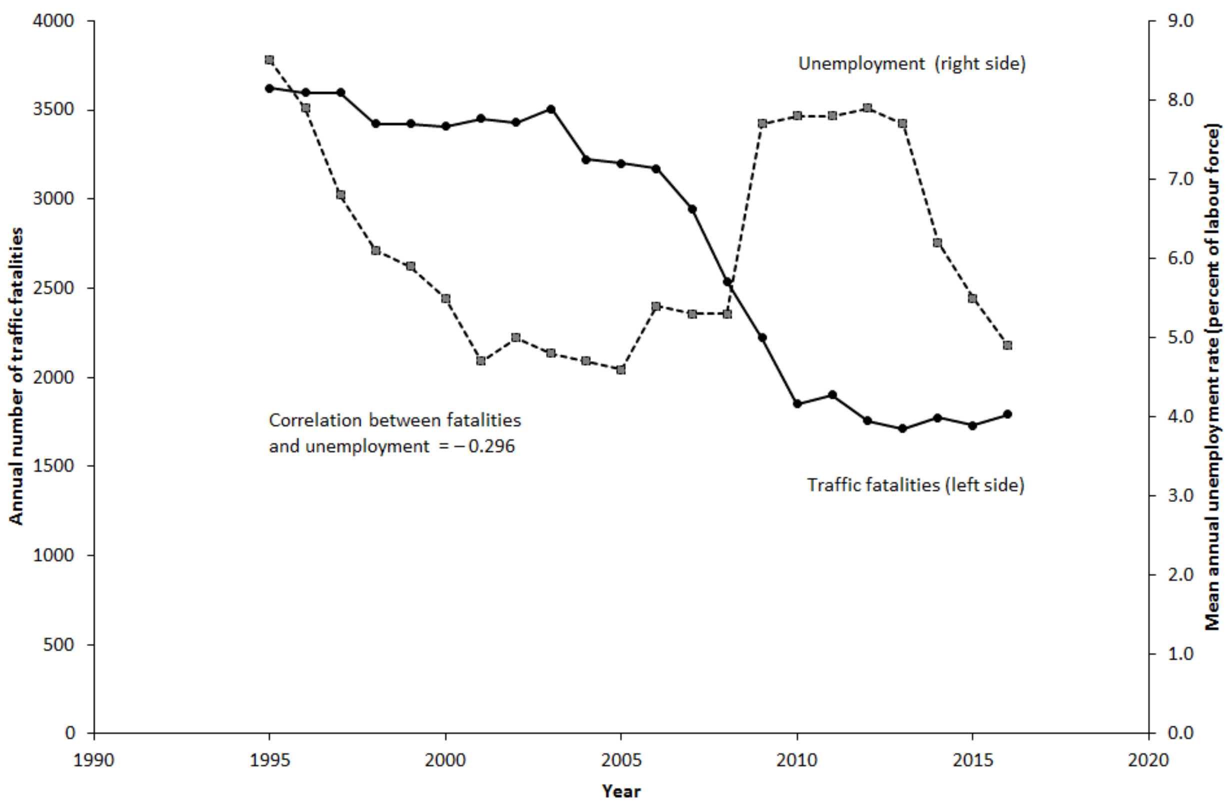
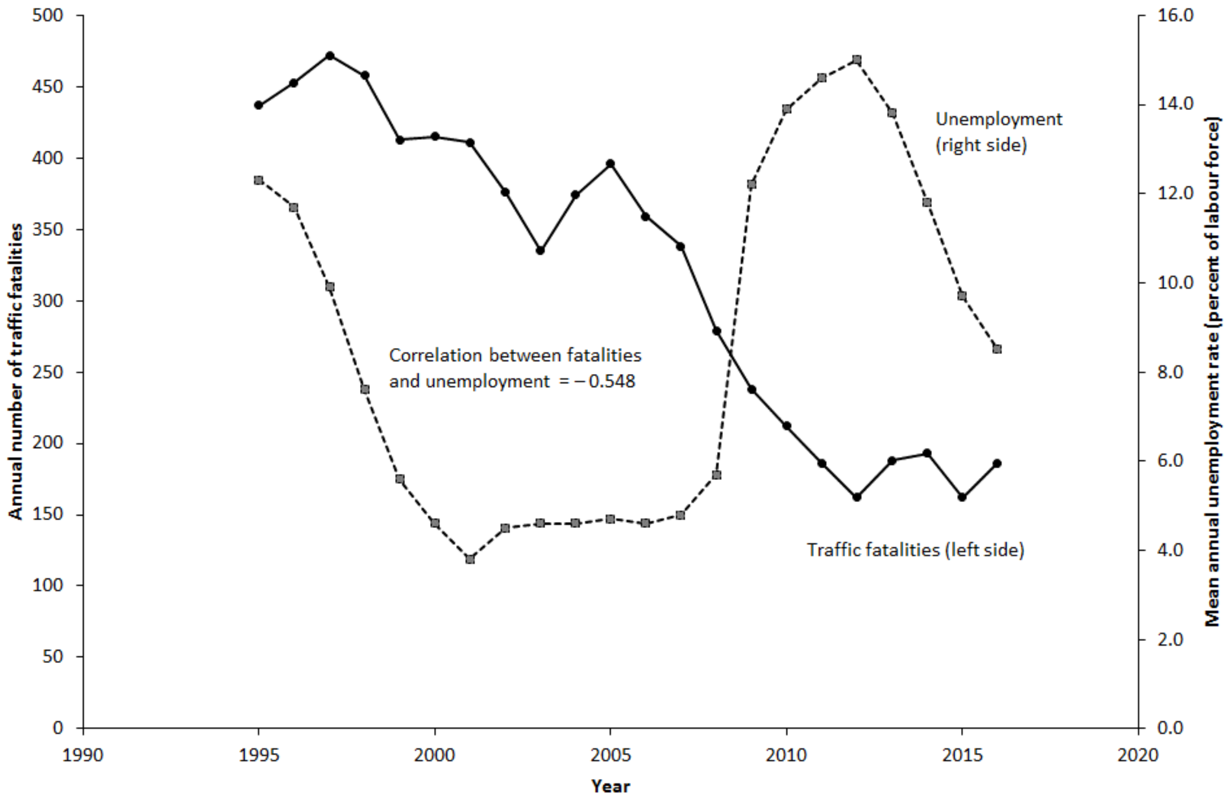
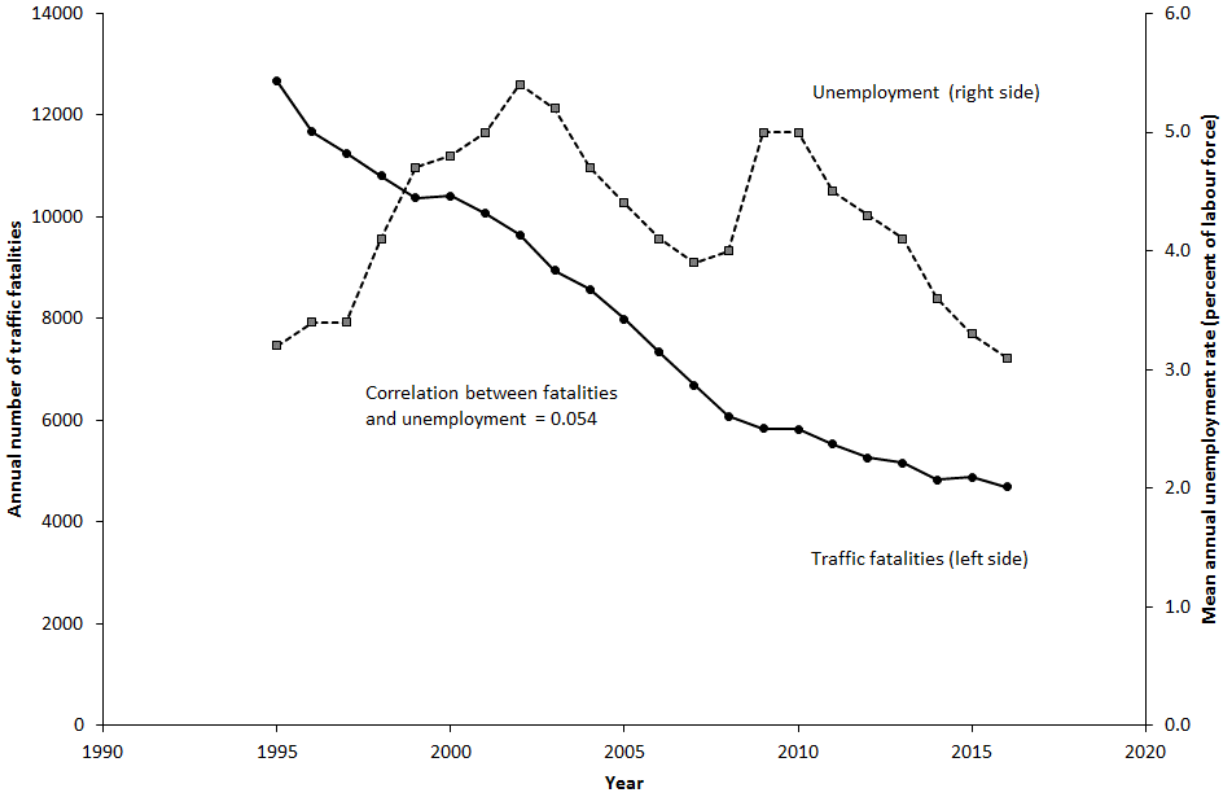


Figure 8: Traffic fatalities and unemployment in Ireland 1995-2016



The changes over time in traffic fatalities and unemployment in Ireland (Figure 8) show an interesting pattern. From 1995 to 2001, both the number of traffic fatalities and unemployment rate declined. Following this there were some years when the unemployment rate was stable, whereas the number of traffic fatalities fluctuated up and down with no clear trend. Then, in 2006 a sharp increase in unemployment started, lasting until 2012. In the same period, the number of traffic fatalities declined rapidly. After 2012, unemployment has declined, but the number of traffic fatalities has stopped declining. The Irish experience, as well as that of some other countries, suggests that the number of traffic fatalities has become more sensitive to changes in unemployment in recent years than it was in the first years after 1995.

Figure 9: Traffic fatalities and unemployment in Japan 1995-2016



The long-term decline in the number of traffic fatalities in Japan (Figure 9) is remarkably stable and does not seem to be influenced at all by the fluctuations in unemployment. One must ask why changes in the number of traffic fatalities seem to be more closely related to changes in unemployment in some countries than in others. Note that the highest rate of unemployment recorded in Japan is slightly more than 5%, which is lower than in most other countries included in this study.

In the Netherlands (Figure 10), the number of traffic fatalities has declined substantially, but at a somewhat irregular rate. There was a large decline in 2004. In recent years, the decline has almost stopped. It is difficult to see any clear pattern between changes in unemployment rate and changes in traffic fatalities in Figure 10. Both unemployment and traffic fatalities declined from 1995 to 2001. Between 2008 and 2015 the unemployment rate increased, but decline in traffic fatalities slowed down.

Figure 10: Traffic fatalities and unemployment in the Netherlands 1995-2016

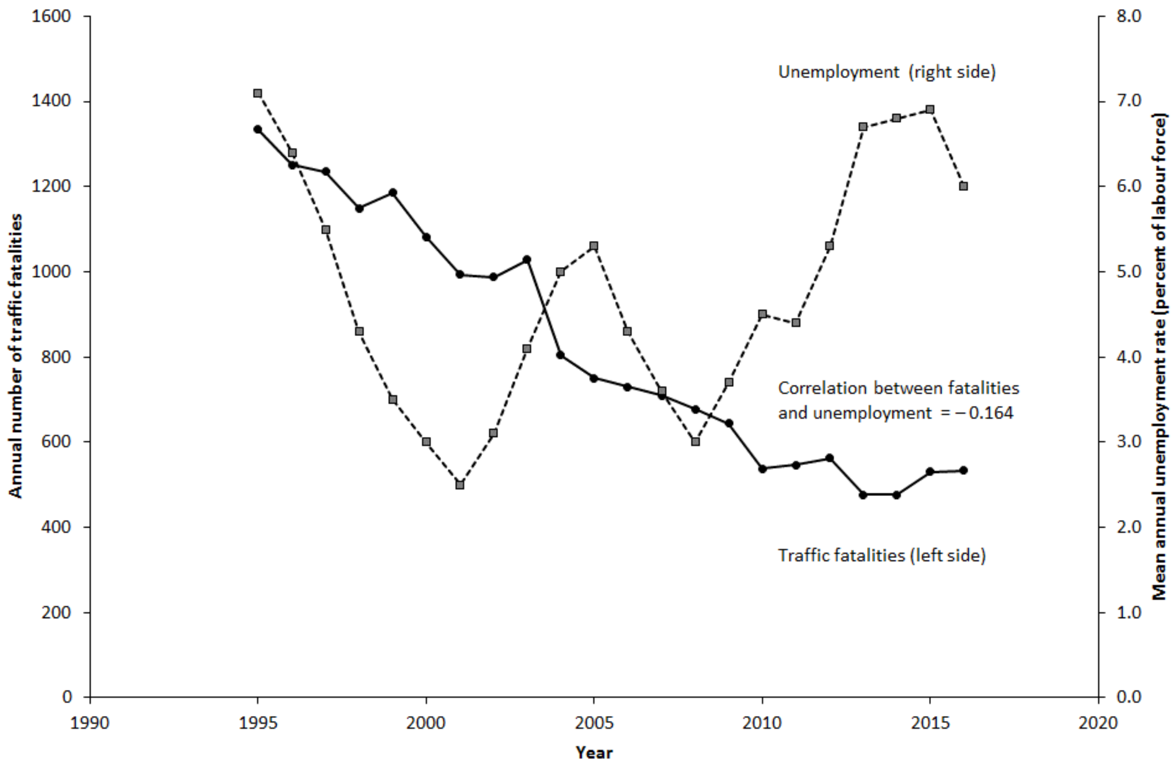
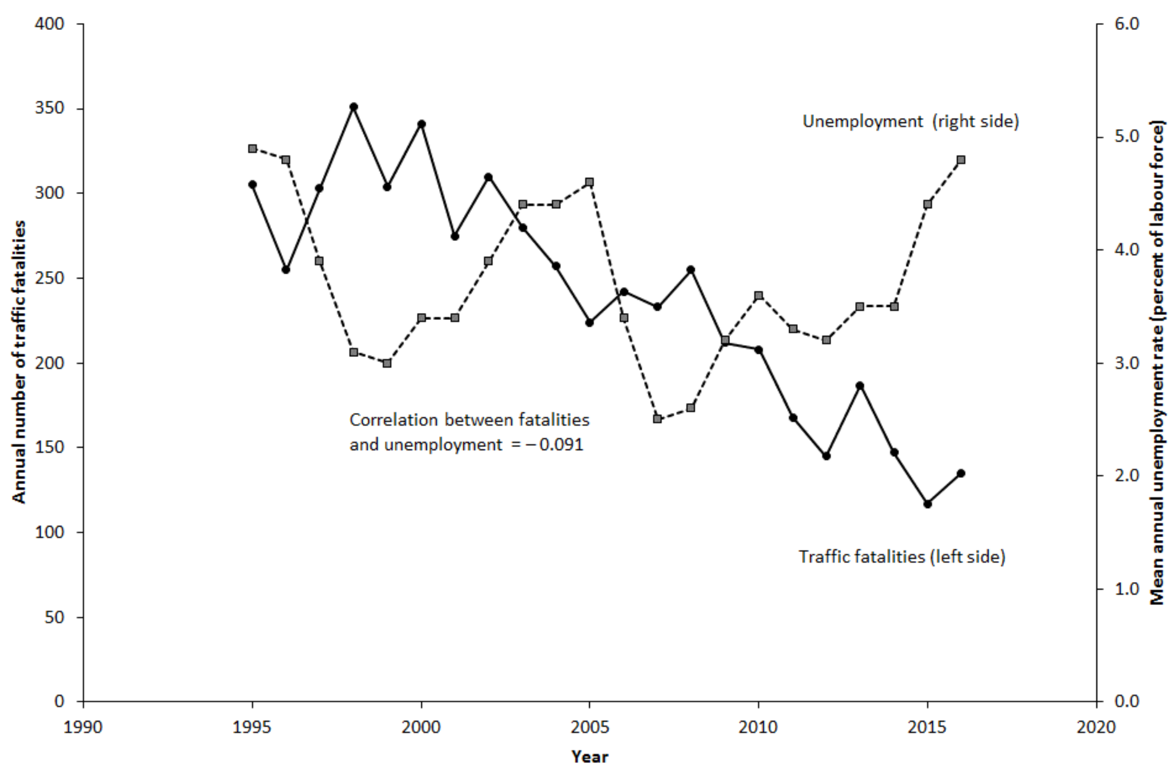
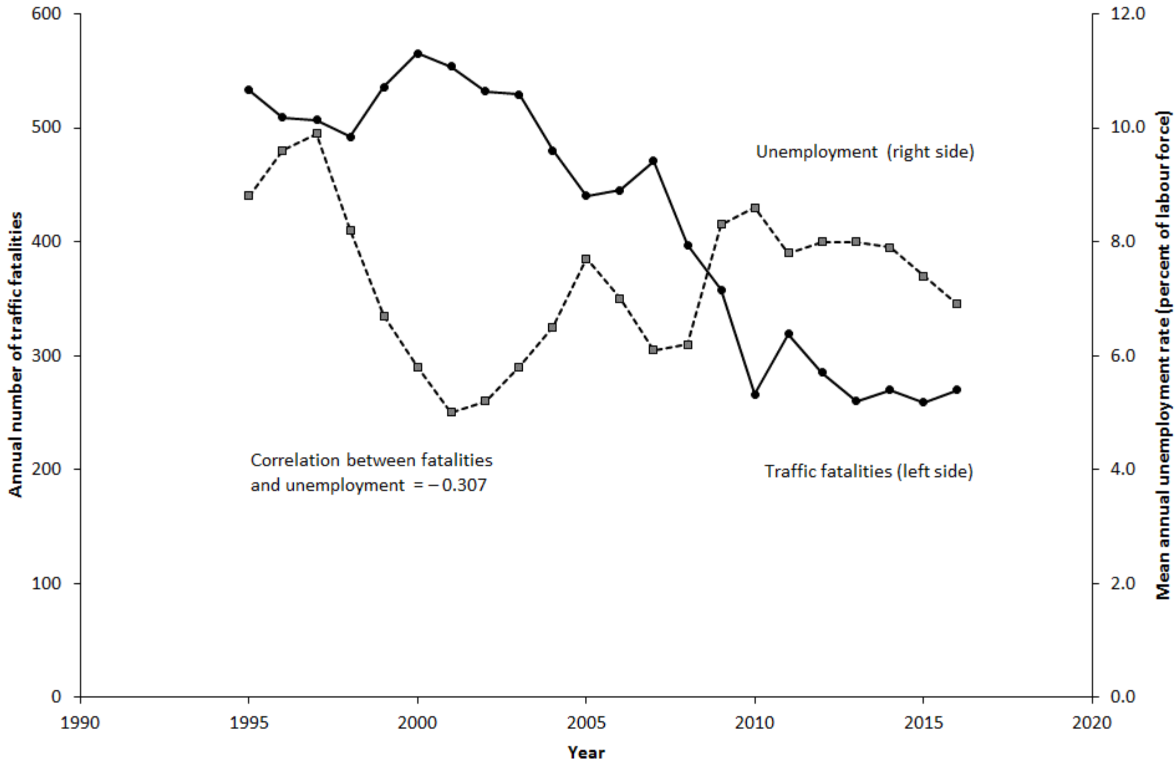


Figure 11: Traffic fatalities and unemployment in Norway 1995-2016



There has been a decline in the number of traffic fatalities in Norway, but year-to-year fluctuations are large (Figure 11). Changes in the number of traffic fatalities appear to be only weakly related to changes in unemployment rate.

Figure 12: Traffic fatalities and unemployment in Sweden 1995-2016



In Sweden (Figure 12), the number of traffic fatalities remained largely unchanged between 1995 and 2003. During the same period, there was a decline in unemployment, at least until 2001. The increase in unemployment rate between 2008 and 2010 was associated with a sharp decline in the number of traffic fatalities. In recent years, unemployment rate has declined, but the number of traffic fatalities has stopped declining.

There has been a quite stable decline in the number of traffic fatalities in Switzerland (Figure 13). There is, as in Austria, a strong negative correlation with unemployment rate, but this correlation arises mainly because of a long-term trend for unemployment rate to increase. The year-to-year fluctuations give a less tidy impression.

In the United States (Figure 14), the number of traffic fatalities was growing slowly between 1995 and 2005. During this period, the number of traffic fatalities did not seem to be related to fluctuations in unemployment rate. This changed dramatically after 2006, when a sharp increase in unemployment was associated with a decline in traffic fatalities. After 2010, unemployment rate has declined, and the number of traffic fatalities increased.

To sum up, the relationship between the number of traffic fatalities and unemployment rate differs between countries and is not necessarily stable over time within the same country. Analyses have therefore been performed country-by-country and separately for the periods 1995-2005 and 2006-2016 in order to capture as much as possible of the heterogeneity in the relationship between changes in unemployment and changes in the number of traffic fatalities. A drawback of this approach is that each analysis is based on only 10 (1995-2005) or 11 (2006-2016) data points, which makes it difficult to include more than one independent variable.

Figure 13: Traffic fatalities and unemployment in Switzerland, 1995-2016

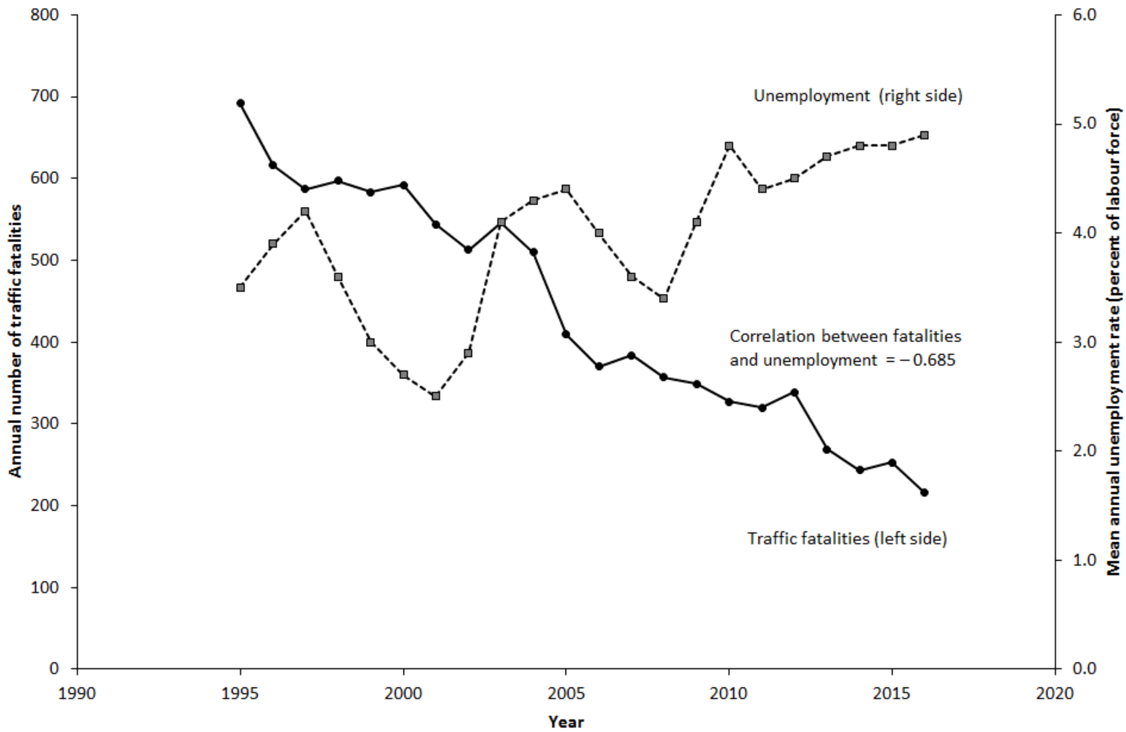
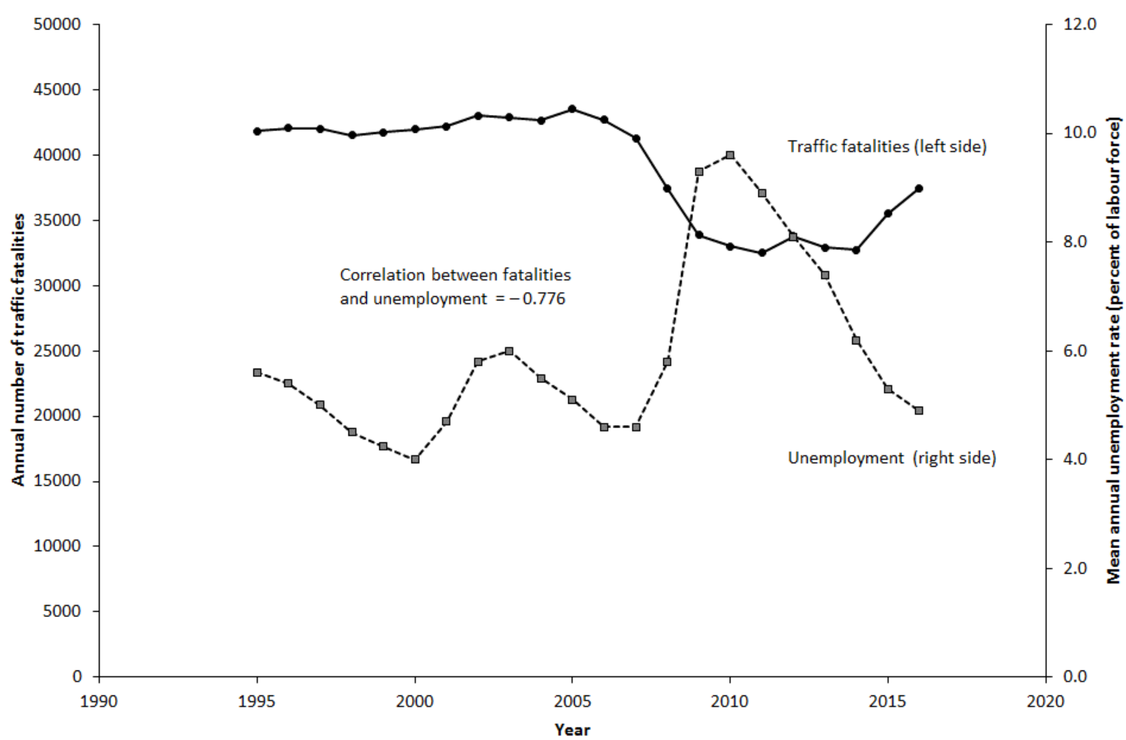


Figure 14: Traffic fatalities and unemployment in the United States 1995-2016



Models for statistical analysis

In the analyses presented in the ITF-report, various versions of multiple regression models were fitted to the data (ITF, 2015, pp. 43-142). None of the models were entirely satisfactory and the final results were based on a synthesis of three types of models. The principal problem was the high correlation between time and some of the other independent variables, in particular Gross Domestic Product (GDP) per capita. In this update, a new approach has therefore been taken to statistical analysis. Two models of analysis have been applied.

The first model is a linear regression model based on annual percentage changes in the relevant variables, i.e. the annual percentage change in unemployment and the annual percentage change in the number of traffic fatalities. To determine the relationship between these variables, models of the following form were fitted to the data for each country and each of the periods 1995-2005 and 2006-2016:

$$\left(\frac{Y_n - Y_{n-1}}{Y_{n-1}}\right) \times 100\% = a + b\left(\frac{X_n - X_{n-1}}{X_{n-1}}\right) \times 100\% \qquad (1)$$

Where n = year, Y_n= number of fatalities in year n, X_n= unemployment rate in percent in year n, and a, b= coefficients to be estimated. This simple model effectively captures the two main influential factors of interest in this study. The constant term shows the long-term trend in the number of traffic fatalities, i.e. the mean annual percentage change during the period covered by analysis. The coefficient for percentage change in unemployment shows the fluctuations around the long-term trend that are associated with changes in unemployment. Since both variables are stated as percentage change, the coefficient for change in unemployment can be interpreted as an elasticity: it shows the percentage change in the number of fatalities associated with a one percent growth of unemployment. As an example of how the variables are defined, consider Austria, where there were 1 210 traffic fatalities in 1995 and 1 027 in 1996. The dependent variable for the year 1996 has the value: [(1 027 – 1 210)/1 210] · 100 = –15.1. Unemployment rate increased from 3.9% in 1995 to 4.3% in 1996. Hence, the independent variable is: [(4.3 – 3.9)/3.9] · 100 = 10.3.

The second type of model was proposed by Allsop (ITF, 2015, pp. 13-21) in the ITF-report on improvements to road safety when economic times are hard. The following is an example of the model:

$$\left(\frac{\text{fatalities in year } n}{\text{fatalities in year } n\text{-}1}\right) = e^{\alpha}\left(\frac{\text{unemployment rate in year } n}{\text{unemployment rate in year } n\text{-}1}\right)^{\gamma} \qquad (2)$$

where $100(e^{\alpha} - 1)$ is the annual percentage trend and γ measures the elasticity of the annual number of traffic fatalities with respect to the change in unemployment rate from year n – 1 to year n. The model is fitted as follows:

$$\left[\ln(Y_n) - \ln\left(Y_{n-1}\right)\right] = \alpha + \gamma \cdot \left[\ln(X_n) - \ln(X_{n-1})\right] \qquad (3)$$

Thus, again using Austria as an example, the dependent variable in 1996 is:

Ln(1 027) – ln(1 210) = –0.164, and the independent variable is: ln(4.3) – ln(3.9) = 0.098. The predicted annual change in the number of fatalities was estimated as:

$$\text{Annual CMF} = e^{\left[\alpha + \gamma\left(\ln(X_n) - \ln\left(X_{n-1}\right)\right)\right]} \qquad (4)$$

Where CMF is an abbreviation for crash modification factor and e denotes the exponential function. Thus, for 1996 the CMF for Austria was estimated as 0.941. This model will be referred to as the log-linear model, since it is linear in parameters when both sides of equation 2 have been transformed to natural logarithms.

Statistical weighting of data points

The data points used in the linear regression model are not equally precise. In particular, there is a trend for the number of fatalities to decline. The precision of a percentage difference in the number of fatalities depends on the number of fatalities. Thus, assuming that random variation in fatality counts can be modelled by means of the Poisson distribution, the difference between 1 000 and 900 is more precise than the difference between 200 and 180. Both differences represent a 10% decline, but standard error of the first (based on counts of 1 000 and 900) is 21.8 (which is 21.8% of the difference) and the standard error of the second is 9.7 (which is 48.5% of the difference). To account for this, each annual difference in the number of fatalities was assigned a statistical weight equal to:

$$\text{Statistical weight} = \frac{1}{\left(\frac{1}{\textit{count in year n}}+\frac{1}{\textit{count in year n+1}}\right)} \qquad (5)$$

This statistical weight is identical to a fixed-effects statistical weight in the log-odds technique of meta-analysis (Borenstein et al., 2009). A series of statistical weights defined as in equation 5 will, however, be correlated. The number of fatalities in year n + 1 is entered again as year n for the next annual change. To adjust for these correlations, each statistical weight was divided by the length of the time series which is 22 for the total number of fatalities and 21 for fatalities between 18 and 24 years of age. A similar correction for correlations between multiple estimates in the same study was applied by Mrozek and Taylor (2002) and Lindhjem et al. (2012). A further condition for using the statistical weights is that they are not correlated with the dependent variable, the annual percentage change in the number of fatalities. Such a correlation can bias coefficient estimates. In general, there was no or only very weak correlations (Pearson's r less than 0.2) between the statistical weights and the annual percentage change in the number of fatalities. The weights were therefore applied.

No statistical weights were applied in the log-linear model, as the value of the logarithm depends on the number of traffic fatalities and thus adjusts for the fact that a given percentage difference between small numbers is less precise than the same percentage difference between large numbers.

Both the linear and log-linear models are bivariate models. One might think that such simple models have a high risk of omitted variable bias. An omitted variable may create bias if it is correlated both with the independent variable (changes in unemployment) and the dependent variable (changes in fatalities). A test for Norway found that vehicle-kilometres of travel is correlated both with the number of fatalities and unemployment. However, inclusion of both unemployment and vehicle-kilometres of travel in the log-linear model (both variables were included as the difference between ln(X) in year n and ln(X) in year n – 1) lead to considerably poorer model predictions than if unemployment only was included. The model predicted a much too high number of fatalities, especially towards the end of the period. It was therefore decided to rely on the bivariate models.

Exploratory analysis

Exploratory analysis was made to test for: (1) The consistency and stability over time of the relationship between changes in unemployment and changes in the number of traffic fatalities, and: (2) Whether the estimates of the relationship between changes in unemployment and changes in the number of traffic fatalities found the 14 countries can be regarded as representative of a larger group of countries.

To examine the stability over time of the relationship between changes in unemployment and changes in the number of traffic fatalities, the study period was divided in two: 1995-2005 and 2006-2016. Regressions were run for each period and the coefficients compared. It was found that the relationship between changes in unemployment and changes in the number of traffic fatalities does change over time. Results are therefore presented separately for each of the two periods.

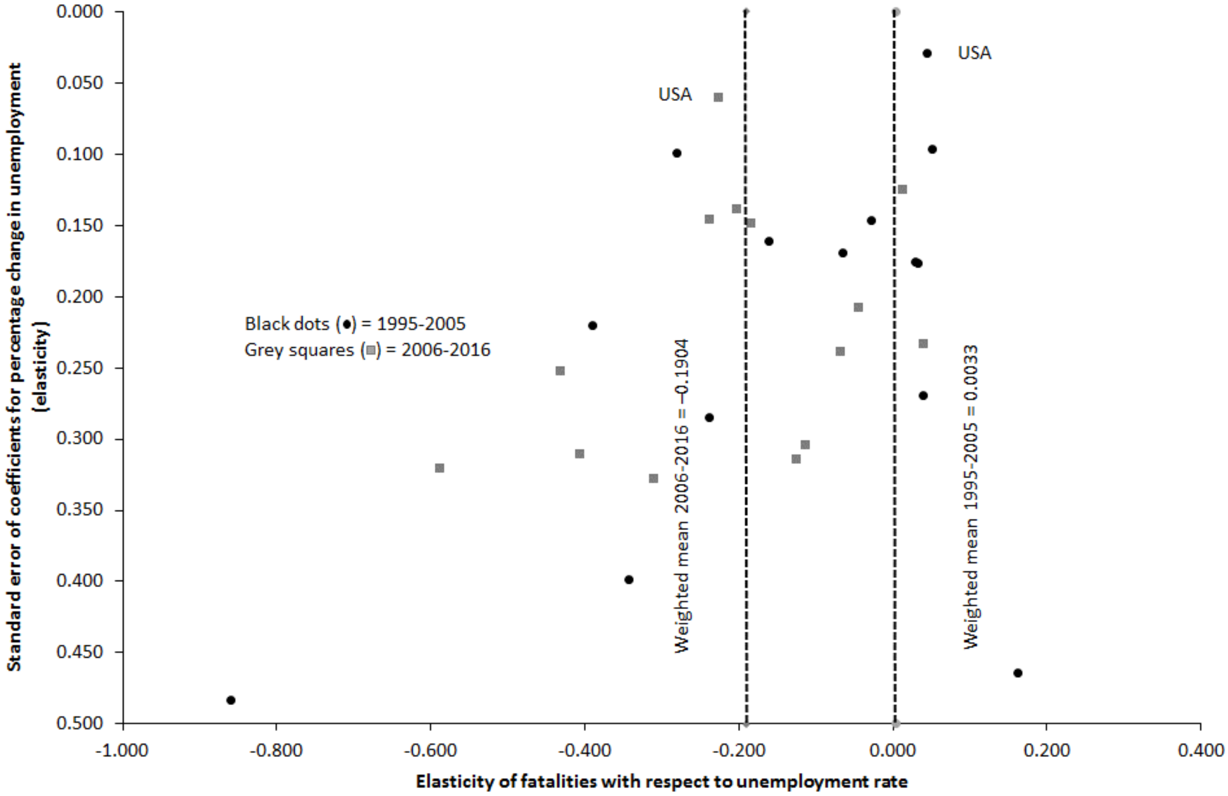
To examine the representativeness of the 14 countries, a funnel plot has been developed and analysed. A funnel plot is a scatter diagram in which the estimates of interest are plotted on the horizontal-axis and their standard errors on the vertical-axis. The vertical-axis is usually inverted, so that estimates with small standard errors are plotted on top of the diagram. A funnel plot is usually applied in meta-analysis to test for the possible presence of publication bias. Tests for publication bias rely on the assumption that if there is no bias, the distribution of the data points in a funnel plot should be symmetric around the weighted mean. If the distribution is skewed, missing one tail, that is taken as an indication of publication bias.

In the present context, the funnel plot is not used to detect publication bias, but sample selection bias, which is treated as analogous to publication bias. The analogy is the following: If the sample of 14 countries studied is biased, there may be an overrepresentation of estimates in one direction, i.e. either showing a strong negative relationship between unemployment and traffic fatalities or showing a strong positive relationship.

It should be remembered that the sample of countries studied does not include countries where the recession of 2008-2010 was comparatively mild, like Australia, nor countries where it was very severe, like Greece and Spain. To test for skewness in the distribution of estimates, the trim-and-fill method was applied (Duval and Tweedie 2000a, 2000b; Duval 2005). This method corrects skewness in a distribution by trimming away data points until the remaining data points are symmetric around the trimmed mean.

The difference between the mean for the full distribution and the trimmed mean indicates the size of publication bias, or, in this case sampling bias. Figure 15 shows a funnel plot of estimates of the elasticity of the number of traffic fatalities with respect to changes in unemployment. Estimates are based on the log-linear model. The linear model gave similar results but estimates for the United States contributed more to the weighted mean estimate in the linear model than in the log-linear model.

Figure 15: Funnel plot of estimates of elasticity of fatalities with respect to unemployment



For the first period (1995-2005) the weighted mean estimate indicated a weak positive relationship (weighted mean elasticity = 0.0033) between changes in unemployment and changes in the number of traffic fatalities, meaning that increased unemployment was associated with an increased number of fatalities.

This summary estimate is strongly influenced by data for the United States, which in this period, more specifically between 1999 and 2003, experienced an increase both in unemployment and in the number of traffic fatalities. The trim-and-fill analysis indicates that the sample is biased. Five data points were trimmed away. See the appendix for details about the trim-and-fill analysis. Thus, the results for 1995-2005 are strongly influenced by the atypical experience of the United States during this period. The United States represented 72% of the statistical weights for 1995-2005.

In the second period (2006-2016), the weighted mean elasticity was –0.1904. Trim-and-fill trimmed away two data points, and the trimmed weighted mean elasticity was –0.1773. This is only 7% smaller than the weighted mean based on all data points. The difference between the weighted mean estimate based on the full sample and the trimmed mean is not statistically significant (difference = 0.0131; standard error of difference = 0.0577).

The contribution of the United States to the statistical weights was 45%. Thus, estimates for the 2006-2016 period are regarded as unbiased. This means that it is regarded as unlikely that inclusion of more countries in the study would have changed the main results.

Results

General pattern

Estimates for the period 2006-2016 are regarded as the most representative and updated. Most results for total fatalities, 12 out of 14, show that when unemployment increases, there is a larger decline in traffic fatalities than implied by the long-term trend. Coefficients and their standard error are reported in Table 1. Table 1 also reports the goodness-of-fit of the models in terms of R-squared.

Table 1: Estimated coefficients with standard errors and p-values

	Estimates for 1995-2005				Estimates for 2006-2016			
Country	Coefficient	Standard error	P-value	R-squared	Coefficient	Standard error	P-value	R-squared
Austria	-0.240	0.284	0.422	0.082	-0.045	0.207	0.832	0.005
Belgium	-0.391	0.220	0.113	0.284	-0.069	0.238	0.779	0.009
Denmark	0.038	0.269	0.892	0.002	-0.433	0.252	0.120	0.247
Finland	-0.861	0.483	0.113	0.284	-0.311	0.327	0.366	0.091
France	0.161	0.464	0.738	0.015	0.038	0.233	0.875	0.003
Germany	-0.162	0.161	0.345	0.112	-0.408	0.310	0.221	0.161
The United Kingdom	-0.066	0.169	0.708	0.018	-0.240	0.145	0.131	0.234
Ireland	0.029	0.175	0.873	0.003	-0.203	0.138	0.175	0.194
Japan	0.051	0.096	0.607	0.034	0.012	0.124	0.927	0.001
The Netherlands	-0.028	0.146	0.851	0.005	-0.186	0.148	0.239	0.150
Norway	-0.343	0.398	0.415	0.085	-0.127	0.314	0.695	0.018
Sweden	-0.282	0.099	0.021	0.504	-0.590	0.320	0.098	0.274
Switzerland	0.031	0.176	0.866	0.004	-0.115	0.304	0.713	0.016
The United States	0.044	0.029	0.170	0.221	-0.228	0.060	0.004	0.617

It is seen that nearly all coefficients are far from being statistically significant at conventional levels. Indeed, only one of the coefficients was statistically significant at the 5% level. The models in most cases explain only a small share of the variance from year-to-year in the changes in the number of fatalities. There were 9 (1995-2005) or 10 (2006-2016) degrees of freedom. Improving the models by adding more independent variables was therefore not feasible.

The coefficients have hence been applied to develop predicted numbers of fatalities. It will be seen that, despite the lack of statistical significance, application of the coefficients is in many cases associated with changes in the predicted number of fatalities. The declining trend for fatalities aged 18-24 years was found to be stronger than for the total number of fatalities in all countries except Denmark, Finland, Norway and Sweden.

Results with respect to the elasticity of fatalities aged 18-24 to changes in unemployment were inconsistent. It is, in general, not the case that fatalities in this age group are more sensitive to changes in unemployment than traffic fatalities in general. Estimates were not statistically significant and are not reported.

Results for individual countries

Figures 16 to 29 show the actual and model-estimated number of fatalities for each of the 14 countries for the period 1995-2016. The results for each country will be briefly commented.

In Austria (Figure 16), there has been a fairly steady decline in the number of fatalities, and fluctuations in unemployment have hardly influenced this trend. The log-linear model fitted the data better than the linear model. There was no autocorrelation of residual terms (lag 1). In Belgium (Figure 17), fluctuations in unemployment influenced the number of fatalities early in the period, but after 2000 there has been a steady decline, not influenced by variations in unemployment. The log-linear model fitted the data best. There was a minor autocorrelation in residual terms (0.165 at lag 1).

Figure 16: Actual and model-estimated number of fatalities in Austria, 1995-2016

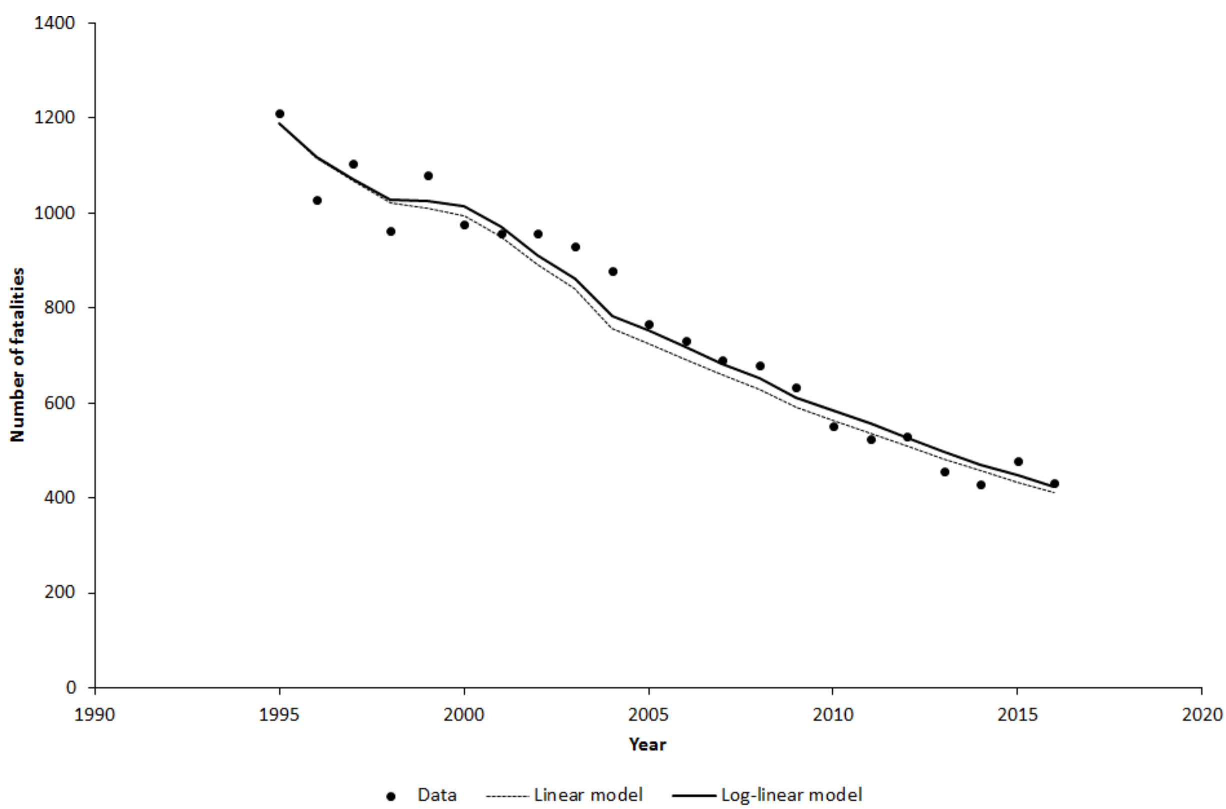
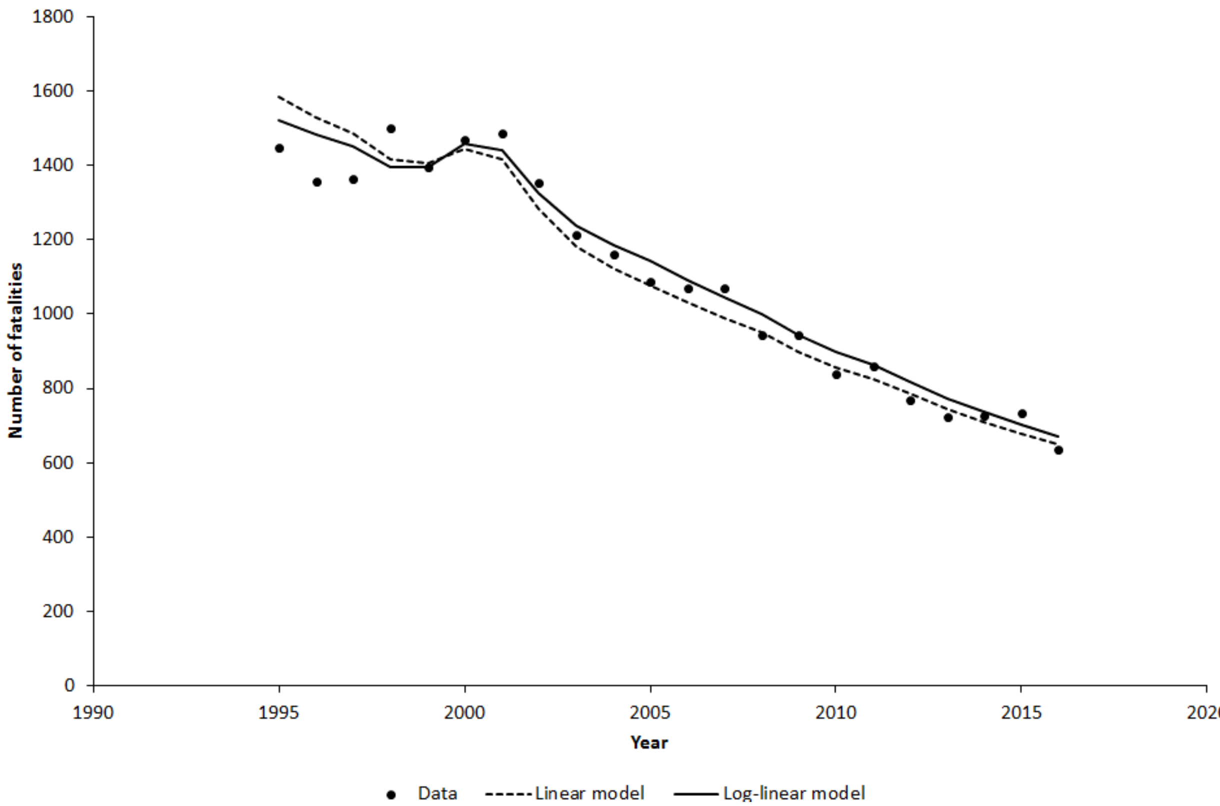
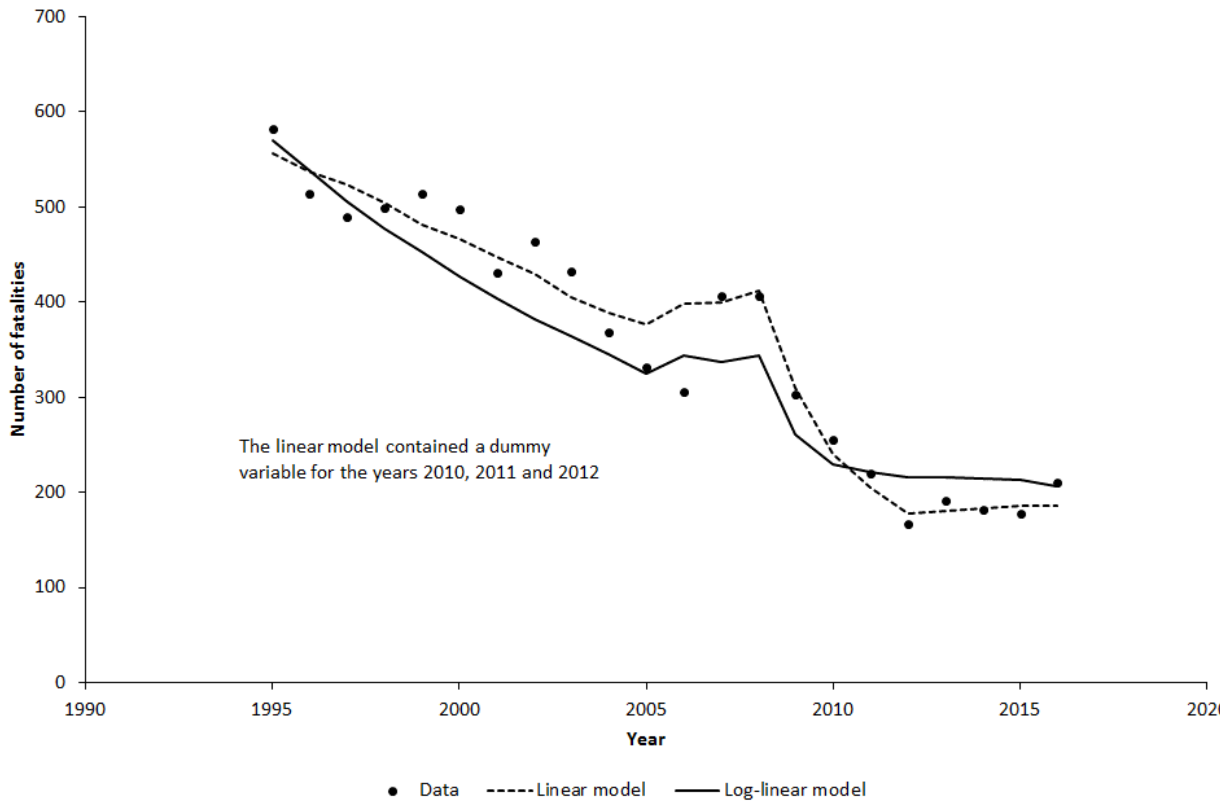


Figure 17: Actual and model-estimated number of fatalities in Belgium, 1995-2016



Denmark (Figure 18) has seen large annual fluctuations in the number of fatalities after 2005. A dummy for the years 2010, 2011 and 2012, when the number of fatalities declined sharply was found to be highly statistically significant and was added to the linear model. The model then fitted the data very well. The log-linear model did not include a dummy for the years 2010, 2011 and 2012, but still fitted the data quite well. A model not containing ad hoc terms that have no substantive interpretation (the dummy does not say why fatalities declined sharply in 2010, 2011 and 2012) should always be preferred. The residual terms of the log-linear model were, however, correlated (0.553 at lag 1).

Figure 18: Actual and model-estimated number of fatalities in Denmark (1995-2016)



In Finland (Figure 19), there are large variations in the number of fatalities from year to year and these variations are to some extent influenced by variations in unemployment. On the whole, the log-linear model fitted the data best. There was a minor autocorrelation of residual terms (0.122 at lag 1).

Turning to France (Figure 20), the linear regression model fitted an almost straight line to the data, with no discernible influence from fluctuations in unemployment. The log-linear model fitted a slightly more curved line, but both models fit the data poorly. A dummy for the year 2003, when there was a large reduction of fatalities, was not statistically significant and thus not added to the model. Overall, the log-linear model had the smallest residual terms, but these had a high autocorrelation (0.776 at lag 1). The models for Germany (Figure 21) fit the data somewhat better than the models for France and indicates a rather small influence from fluctuations in unemployment. The linear and log-linear models gave almost identical estimates, but the log-linear model fitted the data best. It had highly auto-correlated residual terms (0.576 at lag 1). Despite this, both models correctly describe the long-term trend in the number of fatalities.

Figure 19: Actual and model-estimated number of fatalities in Finland, 1995-2016

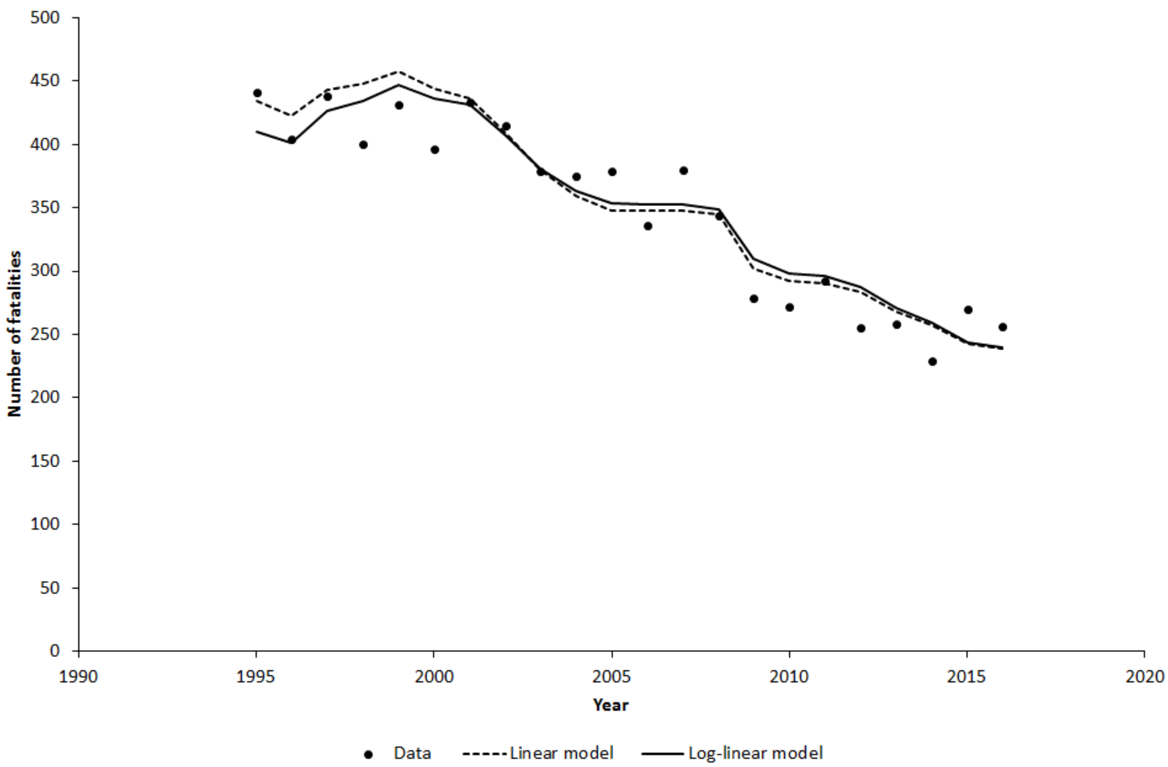


Figure 20: Actual and model-estimated number of fatalities in France, 1995-2016

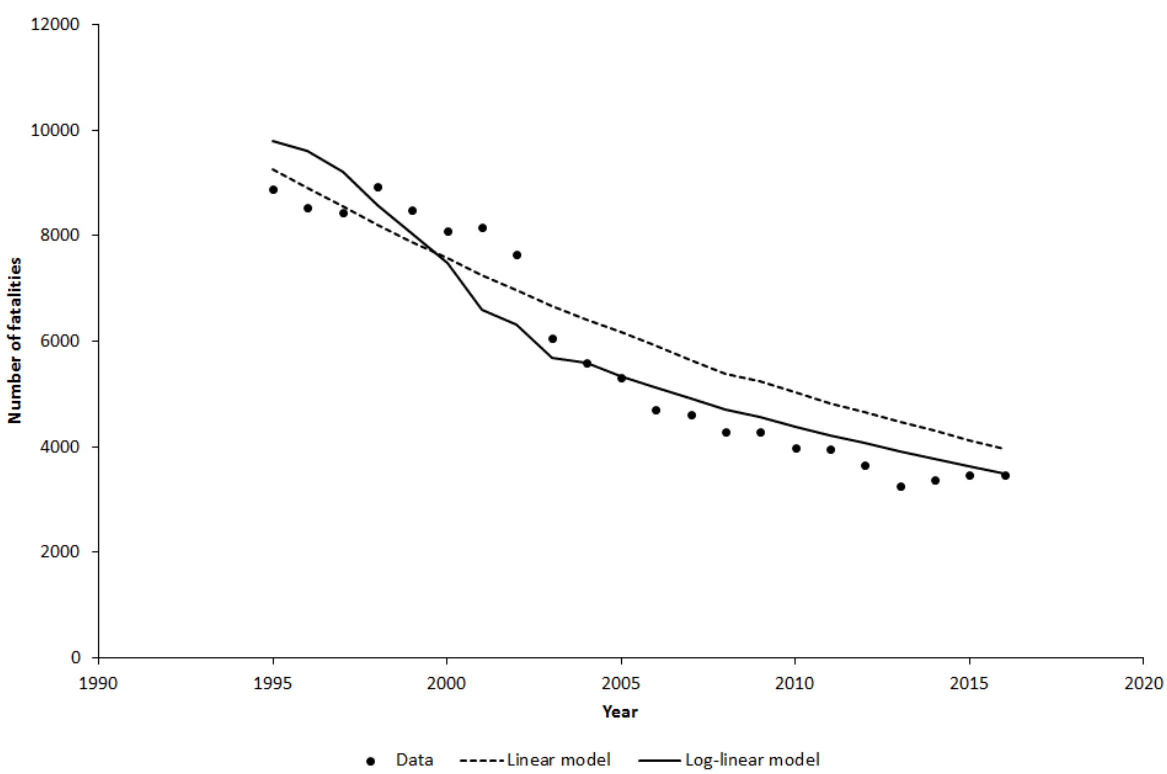


Figure 21: Actual and model-estimated number of fatalities in Germany, 1995-2016

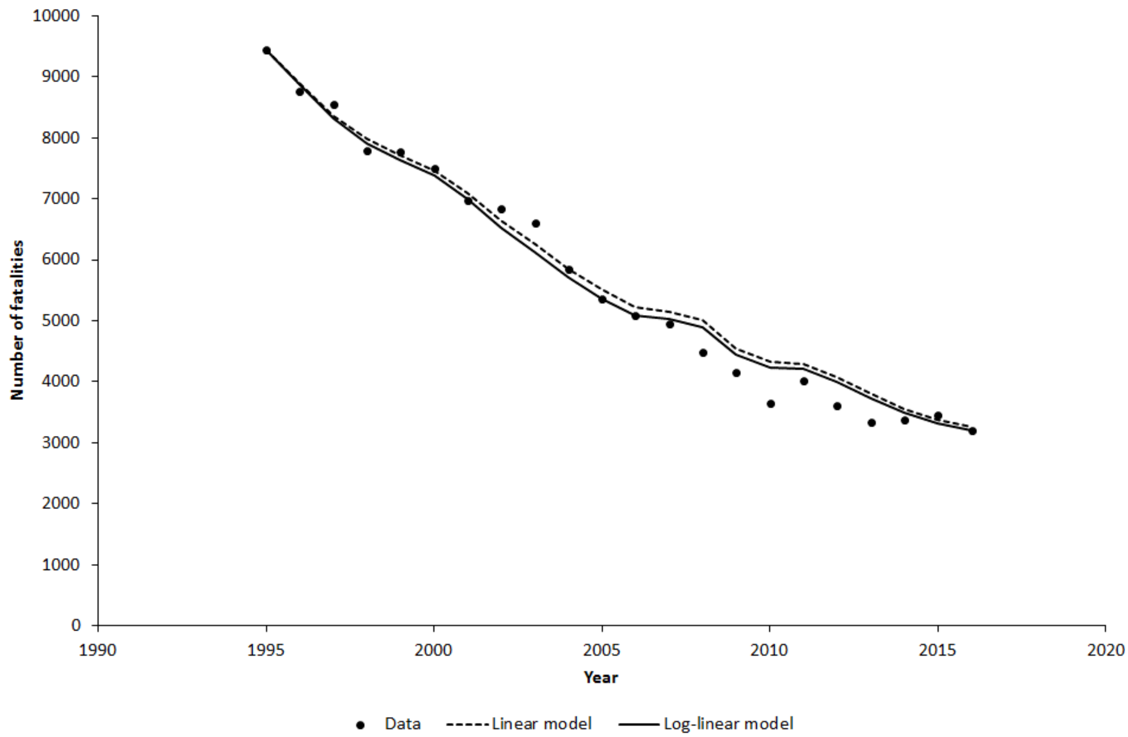
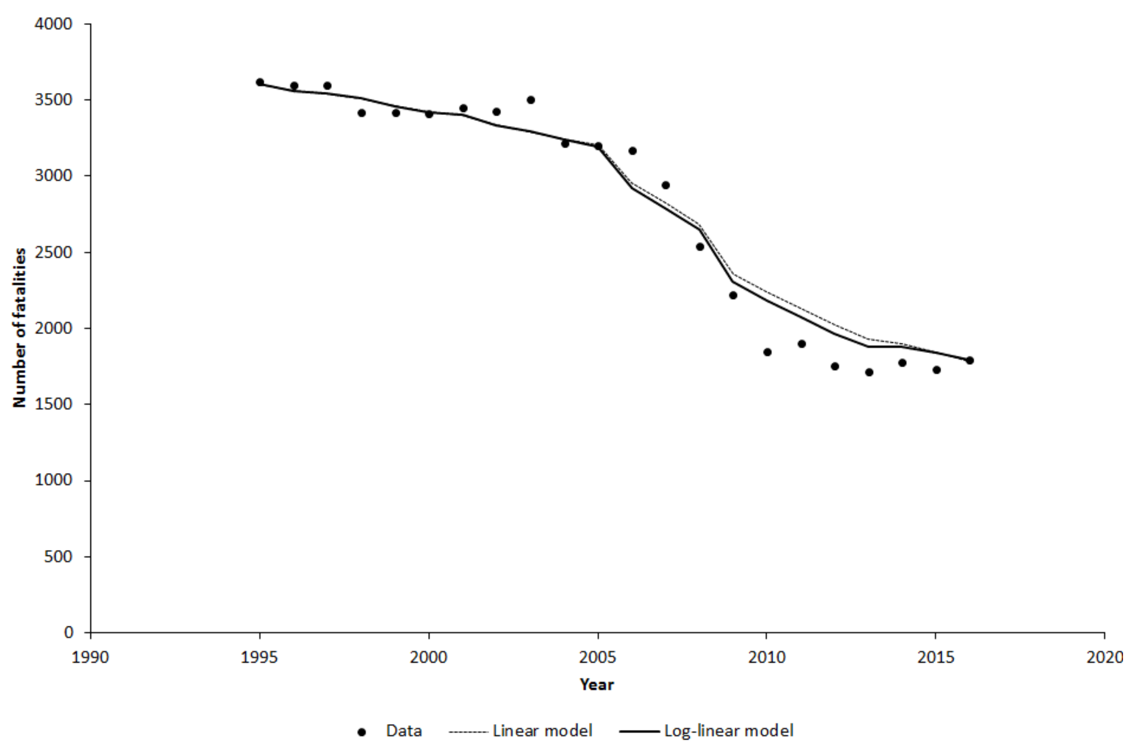
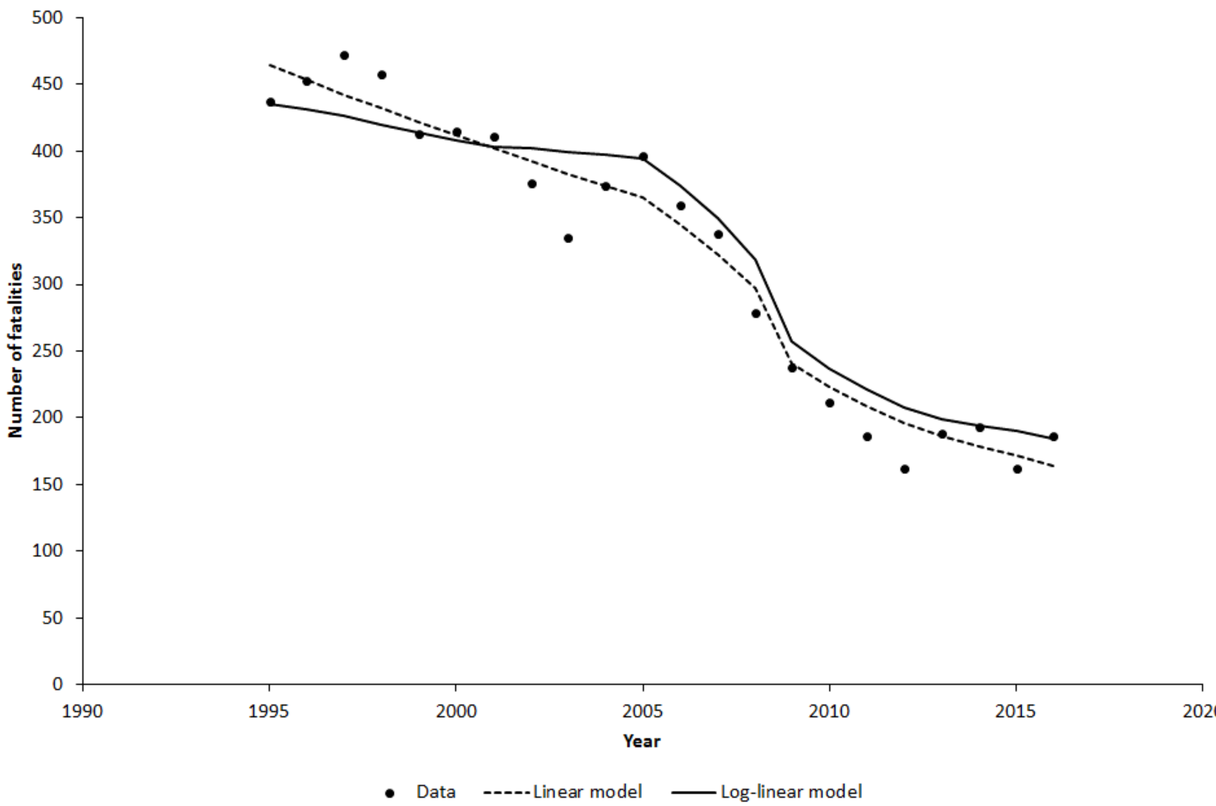


Figure 22: Actual and model-estimated number of fatalities in the United Kingdom, 1995-2016



In the United Kingdom (Figure 22), the largest change is a shift in the long-term trend around the year 2006. Fluctuations in unemployment have a comparatively small effect compared to the long-term trend. The two models give similar estimates, but the log-linear model has the better fit (autocorrelation of residual terms at lag 1 = 0.556). Results for Ireland (Figure 23) are very similar to those for the United Kingdom. For Ireland, the linear model fitted better than the log-linear model and had moderately autocorrelated residual terms (0.262 at lag 1). In Japan (Figure 24), there has been a very steady declining trend in the number of fatalities and no influence from fluctuations in unemployment can be detected. Both models fit the data poorly, although the log-linear model is marginally better (autocorrelation of residual terms at lag = 0.765). However, both models capture the long-term trend adequately.

Figure 23: Actual and model-estimated number of fatalities in Ireland, 1995-2016



The linear model for the Netherlands (Figure 25) consistently predicts too many fatalities after 2004. To try to correct for this, a dummy was added for 2004, but it was not statistically significant, despite the fact that there was a larger decline in fatalities in 2004 than in any other year in the time-series. The log-linear model comes closer to the data, but also predicts too many fatalities. Overall, the log-linear model fits best, but has autocorrelated residual terms (0.674 at lag 1). The results for Norway (Figure 26) are similar. According to the linear model, too many fatalities are predicted for all years after 2003. A dummy for the years 2004 and 2005, when there was a sharp decline in the number of fatalities was not statistically significant. The log-linear model performs a lot better. It is clearly superior and did not have autocorrelated residual terms (0.029 at lag 1).

Sweden (Figure 27) had a large reduction in fatalities in 2010. A dummy intended to capture this was highly statistically significant and therefore added to the linear model. The model then fitted the data well. The log-linear model did not include a similar dummy, but nevertheless fitted the data better than the linear model with no autocorrelation of residual terms (-0.081 at lag 1). It is thus the best model.

Figure 24: Actual and model-estimated number of fatalities in Japan, 1995-2016

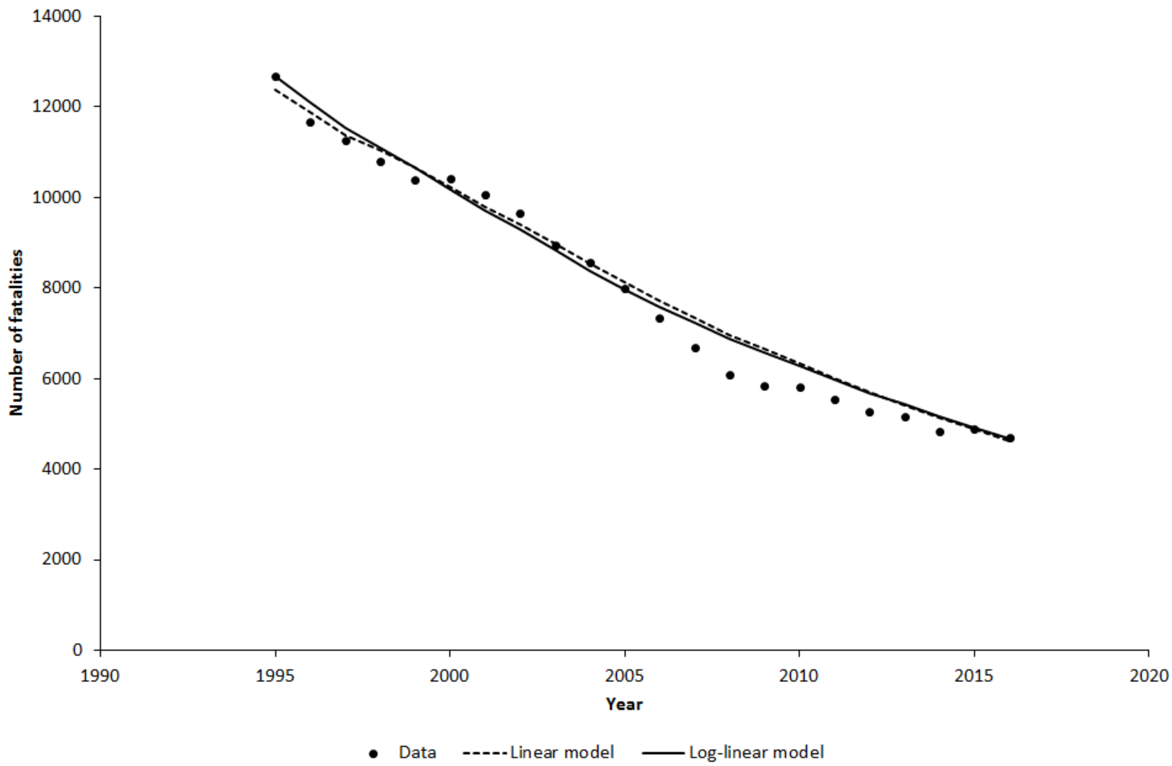


Figure 25: Actual and model-estimated number of fatalities in the Netherlands, 1995-2016

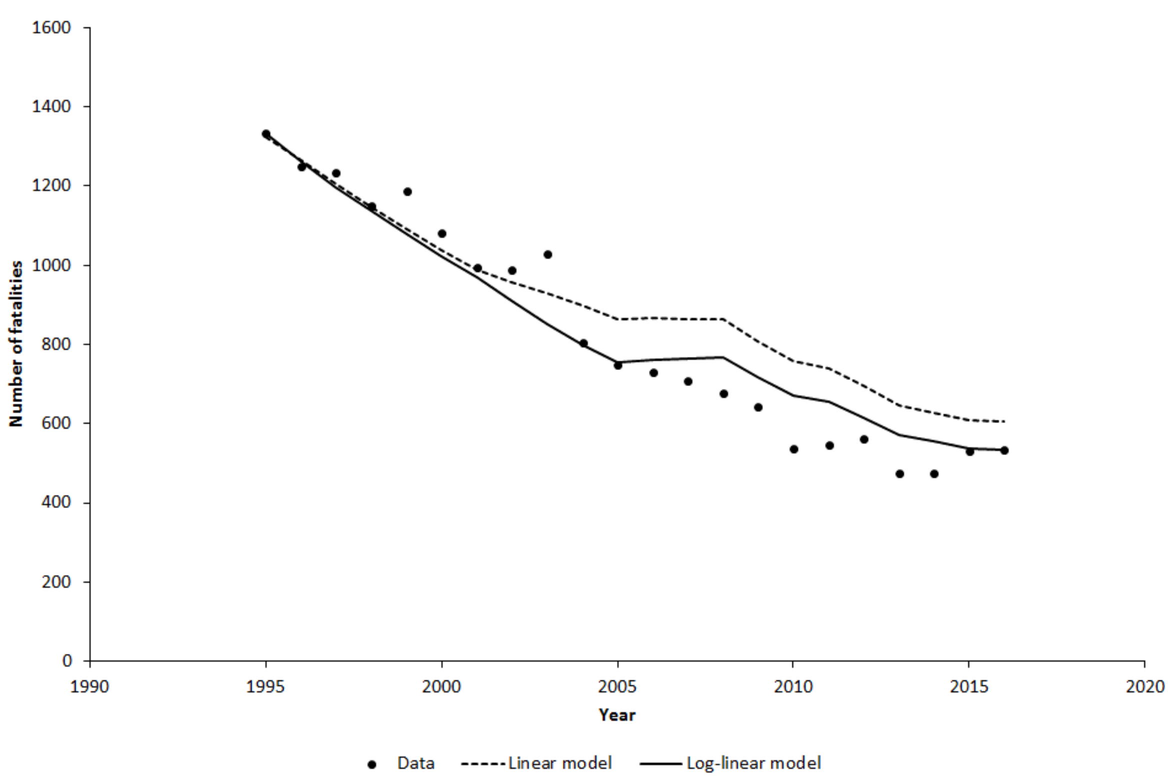


Figure 26: Actual and model-estimated number of fatalities in Norway, 1995-2016

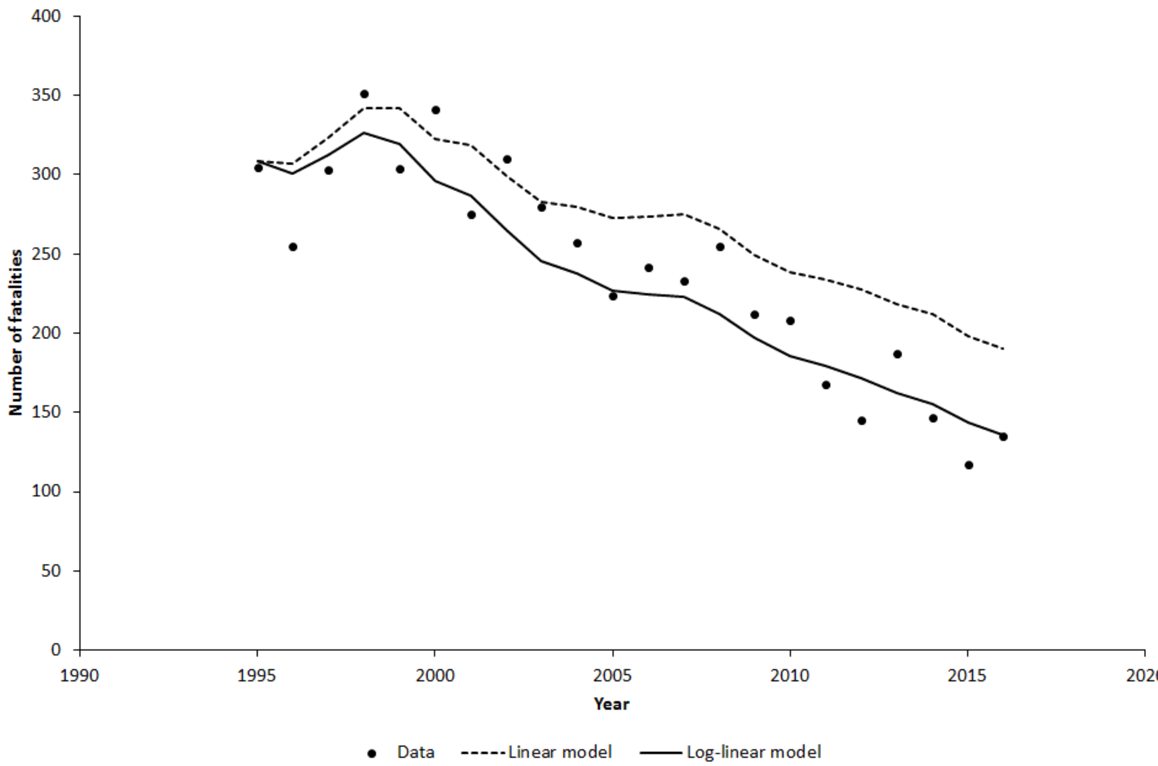
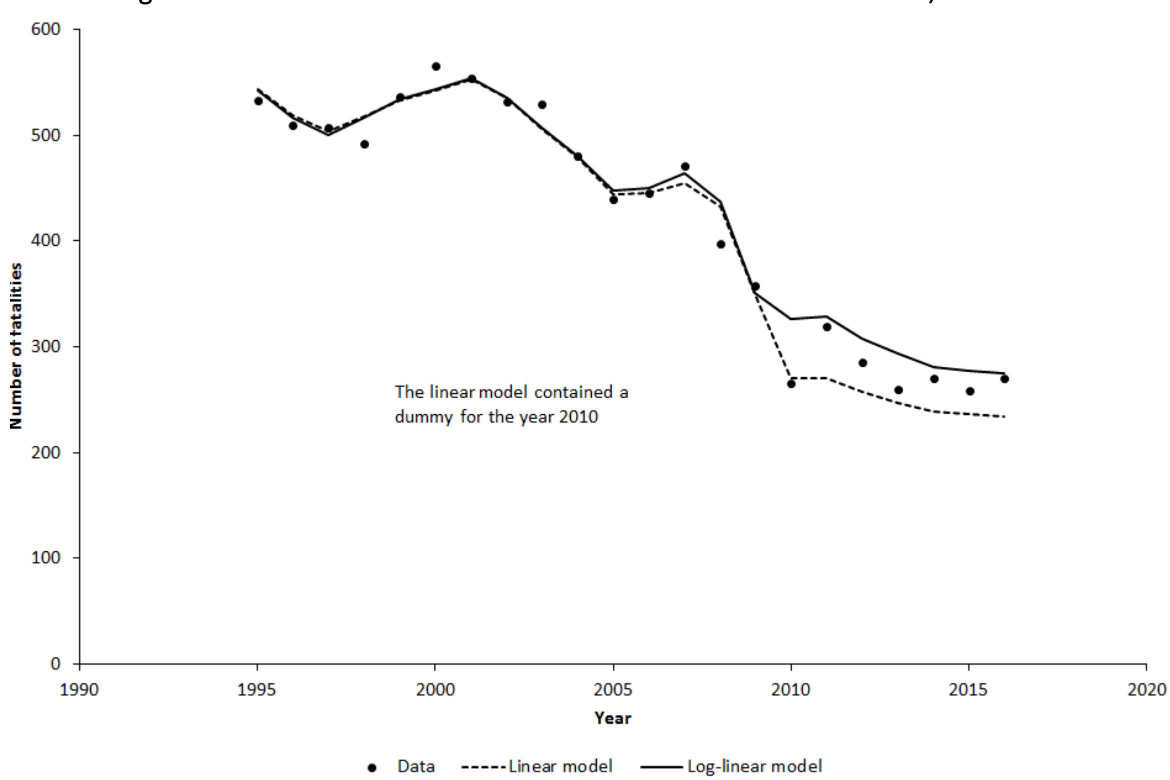


Figure 27: Actual and model-estimated number of fatalities in Sweden,1995-2016



The models for Switzerland (Figure 28) indicates a steady decline in the number of fatalities, with no discernible influence from fluctuations in unemployment. The linear model fitted marginally better than the log-linear model but had auto-correlated residual terms (0.455 at lag 1). Finally, for the United States (Figure 29), the log-linear model fits better than the linear model and is able to capture the increase in the number of traffic fatalities in recent years. It does, however, have autocorrelated residual terms (0.717 at lag 1).

Figure 28: Actual and model-estimated number of fatalities in Switzerland, 1995-2016

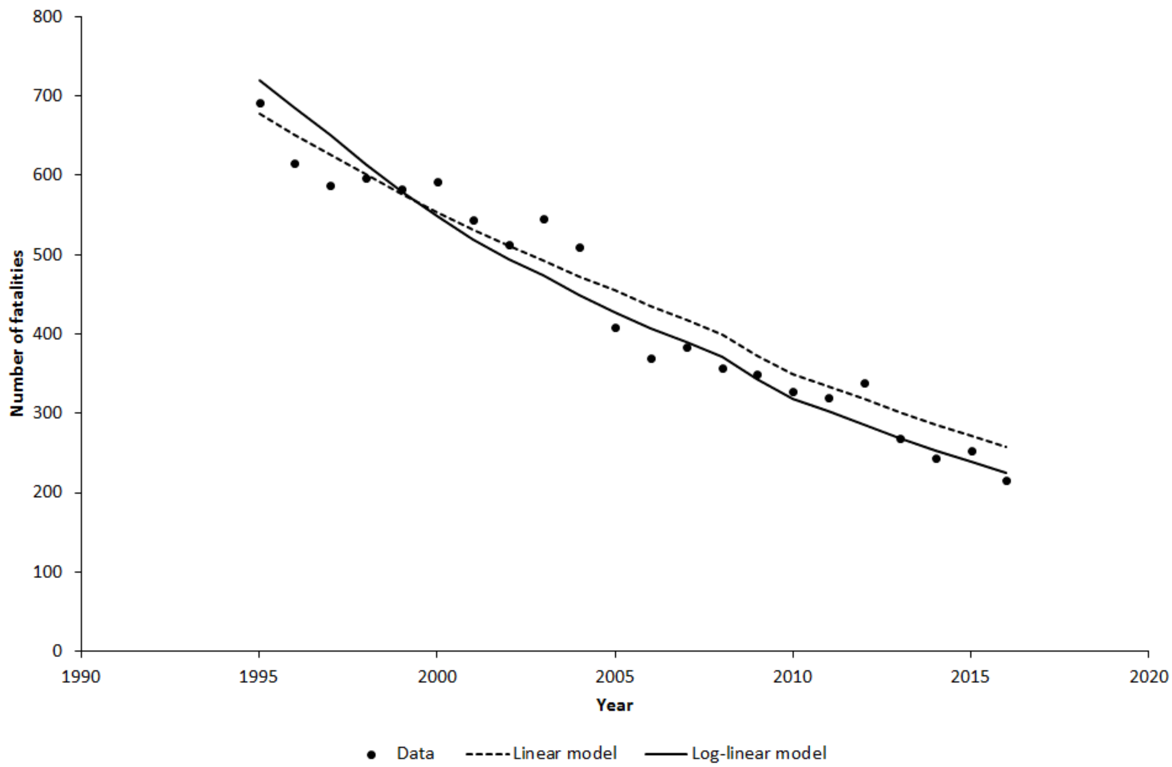
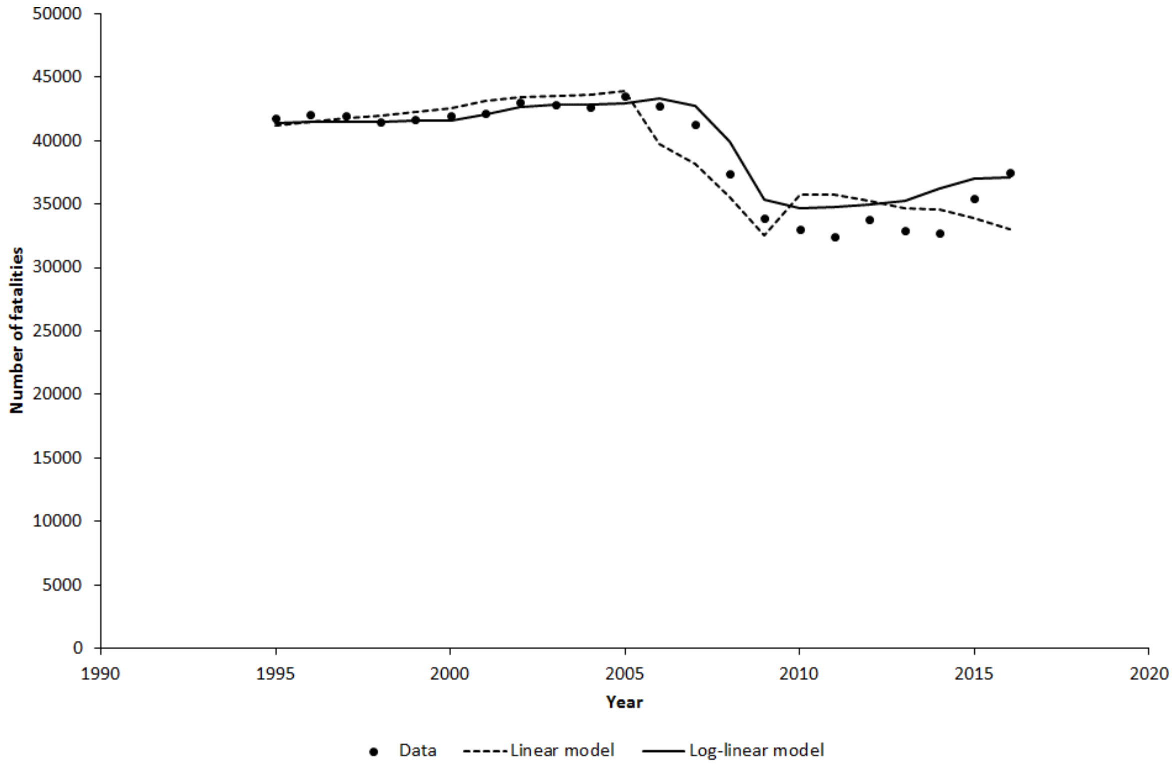


Figure 29: Actual and model-estimated number of fatalities in the United States, 1995-2016



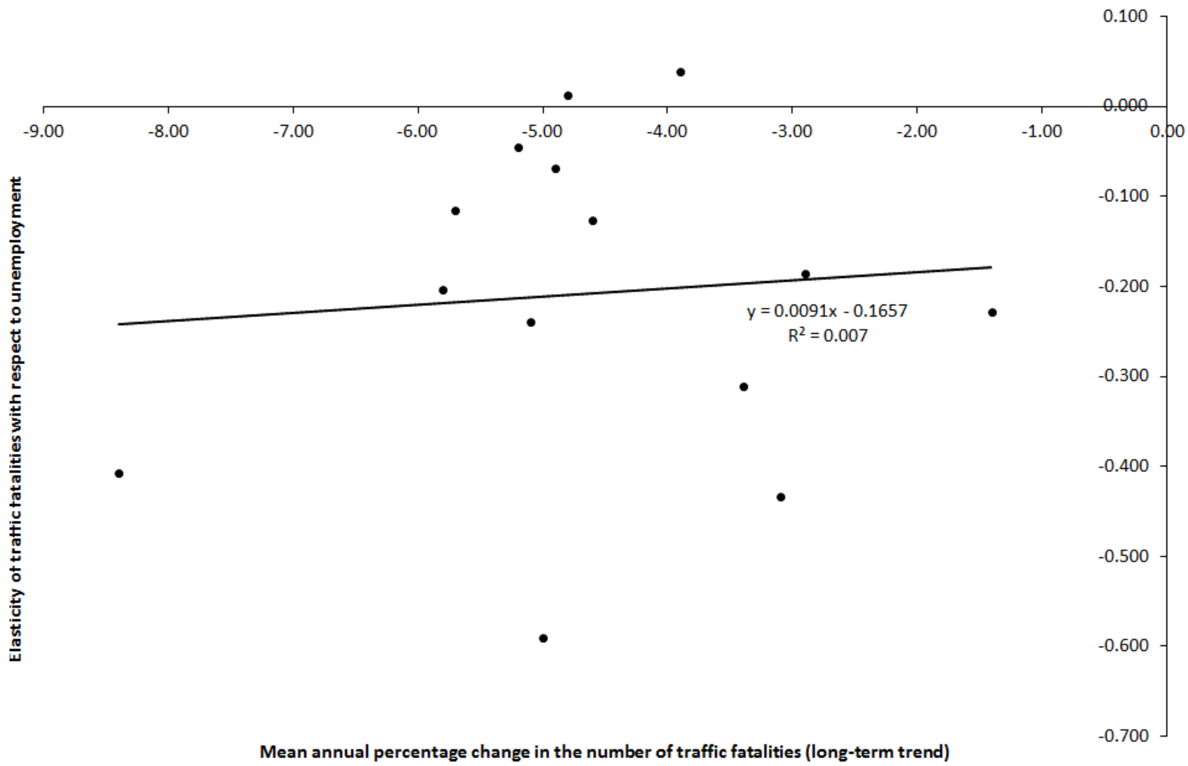
Discussion

The main findings of this study are the same as in the ITF-report (ITF, 2015). Economic recession is associated with a larger reduction of the number of traffic fatalities than expected according to long-term trends. In a few countries, there is evidence that when economic growth resumes and unemployment is reduced, the decline in the number of traffic fatalities slows down or even reverses. Yet, in most of the countries included in the study, the decline in the number of traffic fatalities that was evident before 2010 has continued after 2010.

There are considerable differences between countries with respect to how sensitive the number of traffic fatalities is to changes in unemployment. In some countries, like Sweden and the United States, changes in unemployment are associated with large changes in the number of fatalities. In other countries, like France and Japan, fluctuations in unemployment hardly affect the long-term declining trend in the number of fatalities. Why is the relationship strong in some countries and weak in others?

The answer to this question is likely to be found in two areas of public policy. On the one hand, if road safety policy is effective, and succeeds in bringing about a sustained reduction of the number of traffic fatalities year after year, it may be more resilient to the effects of other factors, like unemployment, than if it is less effective.

Figure 30: Relationship between long-term trend in the number of fatalities and sensitivity of fatalities to changes in unemployment, 2006-16

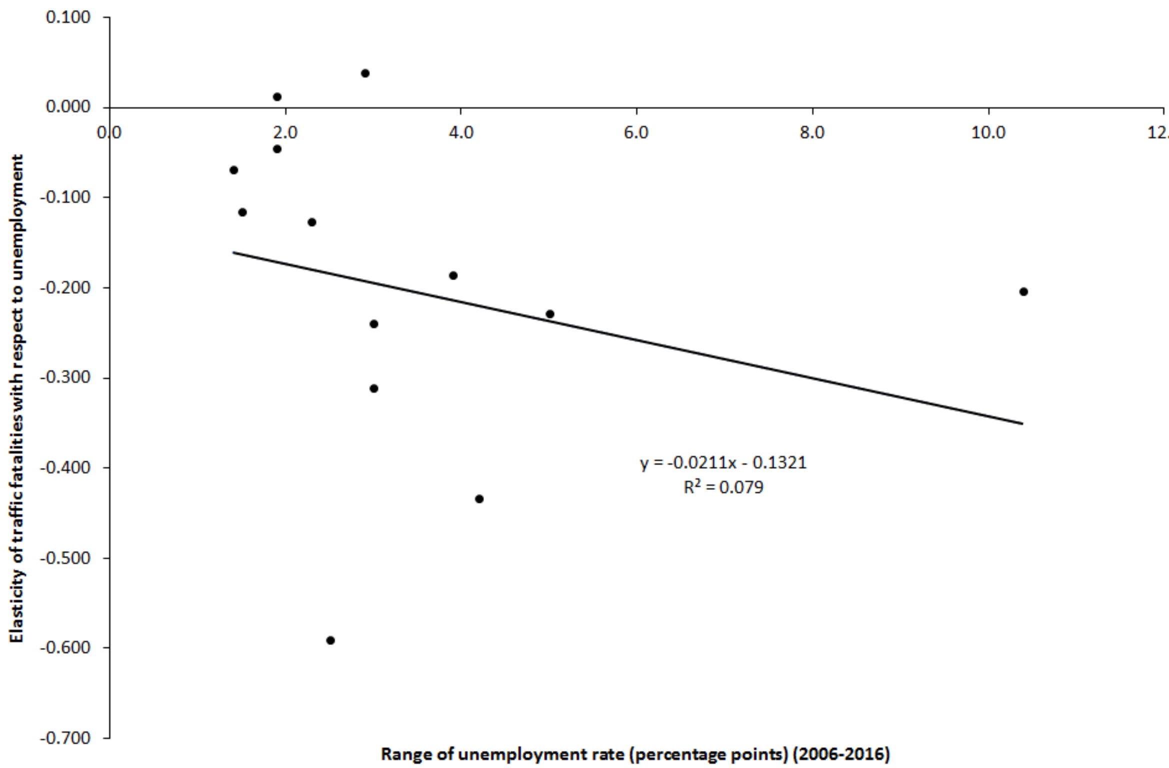


On the other hand, labour market policies may be more effective in some countries than in other countries. An effective labour market policy succeeds in restricting the growth of unemployment and keeps the fluctuations in unemployment over time within a narrow range. If labour market policy is effective, it may restrict the fluctuation in unemployment so much that it does not have a large influence on the number of traffic fatalities.

Figure 30 shows the relationship between the mean annual percentage change in the number of traffic fatalities (the long-term trend) and the elasticity of the number of traffic fatalities with respect to unemployment. There is no relationship between the variables. It is therefore not the case that countries that have a strong downward trend in the number of traffic fatalities are less sensitive to changes in unemployment than countries with a weaker downward trend in the number of traffic fatalities.

The effectiveness of labour market policy is indicated by the difference between the highest and lowest rate of unemployment observed between 2006 and 2016. Thus, in Denmark, the highest rate was 7.6% and the lowest 3.4%. The difference, in percentage points, is 4.2. The lower the value, the more effective is labour market policy in preventing unemployment from fluctuating. Figure 31 shows the relationship between the fluctuation of unemployment rate and the elasticity of traffic fatalities with respect to changes in unemployment.

Figure 31: Relationship between range of fluctuation in unemployment and elasticity of traffic fatalities to changes in unemployment (2006-2016)



There is weak negative relationship between the variables. If the data point to the far right, which seems to be an outlier, is omitted, the negative relationship becomes stronger. This indicates that in countries that succeed in keeping fluctuations in unemployment within a narrow range, these fluctuations are less related to fluctuations in the number of traffic fatalities than in countries where unemployment varies more. This may sound as a logical and mathematical necessity, but should not be regarded as that, since it is sometimes possible to counteract the influence of a specific variable on the number of traffic fatalities by changing a different variable. As an example, the large decline in traffic fatalities that would normally be associated with a large increase in unemployment may not take place if, at the same time, speed limits are raised.

Conclusions

The main conclusions of the research presented in this paper can be summarised as follows:

- In most of the 14 countries included in the study, an increase in unemployment is associated with a decline in the number of traffic fatalities.
- The association between unemployment and traffic fatalities has become more consistently negative from 1995-2005 to 2006-2016.
- Traffic fatalities among road users in the 18-24 years age group are not consistently more sensitive to changes in unemployment than the total number of traffic fatalities.
- There is a tendency for the number of traffic fatalities to be weakly associated with changes in unemployment in countries that succeed in keeping fluctuations in unemployment within a narrow range.

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Appendix: Explanation of trim-and-fill analysis

Table 2: Trim-and-fill analysis

Coefficients	Weights	Coefficients x weights	Differences	Rank	Differences	Rank
-0.161	**4.64**	**-0.75**	**-0.158**	**-8**	**-0.127**	**-8**
-0.051	108.51	-5.53	-0.048	-6	-0.017	-5
-0.044	1189.06	-52.32	-0.041	-5	-0.010	-4
-0.038	13.82	-0.53	-0.035	-4	-0.004	-2
-0.031	32.28	-1.00	-0.028	-2	0.003	1
-0.029	32.65	-0.95	-0.026	-1	0.005	3
0.028	46.91	1.31	0.031	3	0.062	6
0.066	35.01	2.31	0.069	7	0.100	7
0.162	38.58	6.25	0.165	9	0.196	9
0.240	12.40	2.98	0.243	10	0.274	10
0.282	102.03	28.77	0.285	11	0.316	11
0.343	6.31	2.17	0.346	12	0.377	12
0.391	20.66	8.08	0.394	13	0.425	13
0.861	4.29	3.69	0.864	14	0.895	14
Total	**1647.16**	**-5.52**	**1501.47**	**-51.20**		
		-0.0033		-0.0341		
		L = 3.93		L = 4.96		
		R = 5		R = 5		

Start by multiplying each coefficient by -1. The reason for doing so, is that coefficients are expected to be negative, and the trim-and-fill method is based on positive ranks. Thus, the most negative coefficients become the most positive and vice versa.

Rank coefficients from the most negative to the most positive. The result is shown in the first column of the table. The coefficients refer to the period 1995-2005. For each coefficient, find its statistical weight (column 2). Multiply each coefficient by its statistical weight (column 3). Add the weights and the products. The result is shown at the bottom of columns 2 and 3 (1647.16 and -5.52). Divide the sum of products (-5.52) by the sum of weights (1 647.16). The result is -0.0033, shown at the bottom of column 3. This is the weighted mean coefficient (multiplied by minus 1).

The next step is to compute the differences between the individual coefficients (column 1) and the weighted mean coefficient. The first difference is -0.161 – (-0.0033) = -0.158. This is listed in the fourth column under the heading differences. The differences are then ranked from smallest to largest. The ranks are signed. The smallest difference is -0.026, which gets the rank of -1. Next comes -0.028, ranked as -2, and so on. Once all ranks have been computed, two test statistics in trim-and-fill, L and R can be computed.

The estimator R is based on the length of the rightmost number of ranks associated with positive effects, i.e. the number of positive ranks larger than the absolute value of any of the negative ranks. Denoting this length with γ, the estimator is defined by $R_0 = \gamma - 1$. The estimator L is based on the sum of ranks for the positive effects. Denoting the ranks by r_i, the sum of positive ranks is defined by

$$\boldsymbol{T_n} = \sum_{\boldsymbol{r_i}>0} \boldsymbol{r_i} \quad ,$$

an estimator of the number of missing studies is defined by:

$$L_0 = \frac{4T_n - n(n+1)}{2n-1}.$$

Thus, L = ((4*79)-(14*15))/((2*14)-1) = 3.93. R = 5, since the most negative rank is -8, and the length of ranks 10-14 = 5. The five bottom estimates (0.240; 0.282; 0.343; 0.391; 0.861) are trimmed away and the weighted mean re-estimated. L and R are re-estimated. The result (L = 4.96; R = 5) once again trims away five data points; the same as in the first round and the iteration stops.

International Transport Forum

Updated Estimates of the Relationship Between the Business Cycle and Traffic Fatalities

This paper updates analyses of the relationship between fluctuations of the business cycle and the number of traffic fatalities published in 2015 by the International Transport Forum. Since then, the global recession that started in 2008 has ended and economic growth has returned to most International Transport Forum countries. The paper revisits the affect that declining or stable high rates of unemployment have on traffic fatalities.

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