Estimating the impact of unemployment on mortality in Europe. Different methods, different results?

Marcello Morciano [a, b] , Marc Suhrcke[c,d] , Veronica Toffolutti[e]

a) Division of Population Health, Health Services Research & Primary Care, University of Manchester, Manchester, UK;
b) Institute for Social and Economic Research (ISER), University of Essex;
c) Centre for Health Economics, University of York, UK;
d) UKCRC Centre for Diet and Activity Research (CEDAR), Institute of Public Health, Cambridge, UK;
e) Dondena Centre, Bocconi University, Milan, Italy;

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Abstract: Drawing from a dataset covering 23 European countries from 1980-2013, we estimate the impact of unemployment on overall mortality and nine important causes of death using different statistical approaches. We confirm previous results of a pro-cyclical response of overall mortality to unemployment for people aged below 65, with an even stronger relationship after 2009 and with significant heterogeneity across sub-groups of countries. However, we found that estimates are fragile to changes in the assumptions in econometric models when cause-specific mortality rates are modelled. While it seems unlikely that our findings can be entirely explained by measurement issues we argue that the mechanisms that lead to the pro-cyclicality might be more complex.

KEY WORDS: unemployment; mortality; Europe.

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Correspondence to: Veronica Toffolutti, Dondena Centre, Bocconi University, via Roetgen, 1- 20136 Milan, Italy, E-mail: veronica.toffolutti@unibocconi.it Phone: +39 02 5836.5886.

1. Introduction

A considerable body of literature has recently devoted empirical attention to examining how health responds to transitory changes in economic conditions (see e.g., Modrek *et al.*, 2013; Catalano *et al.*, 2011 for a review). The bulk of the evidence - at least as far as high income countries are concerned – suggests that mortality (a proxy of population health) is pro-cyclical (i.e. mortality declines (increases) with economic recessions (booms)), while suicides are counter-cyclical (i.e. they increase (decrease) with economic recessions (booms)).

If the empirical correlation reflects a causal relationship, it could result from a stress-related mechanism (economic recession might reduce stress-induced illness because of the reduced work opportunities; lower workloads lead to a reduction of motorised transports, and hence to fewer work-related and traffic-related accidents), from an increase in the time available to invest in health-promoting activities (e.g. seeking medical treatment or physical activity) or from a reduction of immigration flows, which in turn fewer imported diseases.[1]

The Catalano *et al.*, (2010) review reveals a lack of consensus on the magnitude and significance of the estimated relationship with different time spans, geographical coverage, as well as econometric approaches that have played a role in its indeterminacy. Estimates from observational studies are sensitive to misspecification (Ionides *et al.*, 2013, Neumayer *et al.*, 2009), measurement errors and to age-and cause-specific decompositions (Miller *et al.*, 2009, Ionides *et al.*, 2013) and to non-linearity in the relationship (Bonamore *et al.*, 2015, Ionides *et al.*, 2013). Recently, Ruhm (2015) found that the significant pro-cyclical association found for the U.S. in the period 1976-1995 turned out to be not significant anymore in the period 1999-2010.

The goal of this paper is to explore the role played by different statistical approaches (and their underlying assumptions) in determining the sign and magnitude of the empirical correlation between unemployment and mortality. We, first, apply estimators previously used in the literature for modelling such relationship on an identical set of data taken from the World Health Organization (WHO) on 23 European Union (EU) countries in the period between 1980 and 2013. Estimates from the widely used pooled Ordinary Least Squares (OLS) estimator, adjusted for the presence of both serial and among-countries correlation, are contrasted with instrumental variable GMM (Generalized Method of Moments) estimation, which is robust to endogeneity problems. We found that, as far as overall mortality is concerned, when country-specific time

[1] The counter-cyclical arguments are that economic recessions reduce individuals' health-related investments thought a reduced consumption of privately funded care and healthy behaviours and increase psychological costs due for example to an increased likelihood of job loss and difficulties in meeting financial obligation.

trends are properly addressed, OLS and GMM estimators provide similar evidence in favour of a pro-cyclical relationship with overall and accidental mortality. However, the significance of GMM estimates is significantly diluted when we look at suicidal mortality, which turns out to be not significant anymore. Conversely, mortality due to cirrhosis and chronic liver diseases turns out to be strongly pro-cyclical, while using OLS it tends to be a-cyclical, highlighting a potential mediator mechanism. Specifically, : economic expansion might increase the consumption of health-damaging goods such as alcohol and drugs (Ruhm and Black, 2002) which in turn might also lead to social-isolation that is one of the main drivers for suicides (Barstad, 2008; Durkenheim 1897).

We assessed the robustness of our findings across time and space. We test for structural break in the time series prior to the recent economic crisis. We found that the overall mortality has become even more pro-cyclical –in terms of magnitude - after the Great Recession. The analysis by cause of death reveals a strong pro-cyclical relationship for vehicle accidents and malignant neoplasms and more surprisingly for suicides.

A multiple group GMM model is used to investigate whether the estimated relationships varies according to the type of welfare state in place, using both the classification on the relative size of social expenditure on GDP (Gerdtham and Ruhm, 2006) and the Esping-Andersen (1996) welfare state classification.

The remaining of the paper is organized as follows: sections 2 briefly presents the data used and section 3 compares the main econometric methods used in the literature. Section 4 provides a battery of robustness checks. Finally, section 5 concludes.

2. The Data

This paper uses country-level data from *the European Health for All Database (HFA-DB),* released by WHO, HFA-DB provides demographic, socio-economic, macroeconomic, mortality, health and lifestyle indicators covering over 53 Member States starting from 1970. We focus on 23 European Union (EU) countries covering the period 1980 to 2013 for which sufficiently complete information on the relevant variables are available[2], no data are available beyond that period. We focus our analysis on EU countries to limit the heterogeneity in the sample.

[2] In the HFA-DB country-specific overall mortality rate series are available from 1980 onwards. Cause-specific mortality rates are missing for the years 1989 and 1990. Missing values are imputed using the WHO's Mortality Indicator Database (MDB). Data on mortality attributable to chronic and liver diseases, vehicle accidents and homicides rates are not available for Denmark and Slovakia for the period 1989-1990. A detailed list of the data

For our study the variables of primary interest are the age-standardized overall mortality rate and eight cause-specific mortality rates[3]. The annual unemployment rate is our indicator of the macroeconomic condition of a country.

How do the main econometric methods applied in the literature compare?

In choosing our methodologies we rely on those applied in a set of widely cited papers in the field that arguably represent the breadth of the approaches used. A more detailed presentation of the specifications used in the literature is given in the on-line Appendix A3.

The series of influential literature initiated by Christopher Ruhm uses OLS estimators for panel data regression models, as presented in equation 1:

$$\ln(M_{it}) = U_{it}\gamma + \boldsymbol{x}'_{it}\boldsymbol{\beta} + \alpha_i + \varepsilon_{it} \tag{1}$$

where M_{it} is the mortality rate indicator for country *i* and year *t*, *U* is the unemployment rate, $\boldsymbol{x}$ represents a vector of covariates that might potentially influence both mortality and unemployment. The term α_i is a country-specific effect that captures time invariant unobservables that are potentially correlated with the mortality and unemployment rates observed in a given country. Assuming that all potential sources of endogeneity have been accounted for, to gain efficiency the term ε_{it} has to be spherical (i.e. $\mathrm{E}({\varepsilon_{it}}^2) = \sigma_\varepsilon^2$ and $\mathrm{E}(\varepsilon_{it}\varepsilon_{it-1}|U_{it}) = 0 \;\forall\; t, i$).[4]

Equation (1) models the contemporaneous impact of unemployment on mortality which corresponds to the conditional expectation $E(M_{it}|U_{it}, \boldsymbol{x_{it}}, \alpha_i)$. Such an effect can be consistently captured by γ under the *strict exogeneity assumption,* which posits that the error term ε_{it} and the explanatory variables are uncorrelated after controlling for $\boldsymbol{x_{it}}$ and α_i:

$$\mathrm{E}(\varepsilon_{it}|U_{it}, \boldsymbol{x_{it}}, \alpha_i) = 0 \tag{2}$$

Ruhm (2000) estimated the model in equation (1) through a *least-squares dummy variable* (LSDV) approach. The coefficient of interest, γ, was obtained by using the within-state variation

available can be found in On-line Appendix Table A1. On-line Appendix Table A2 provides descriptive statistics and details on trends in mortality and unemployment as observed in the data for the period under analysis.

[3] We use age-standardized death rates to eliminate the effects of differences in population age structures.

[4] If the error term is heteroskedastic, OLS is no longer efficient but still consistent. Efficiency can still be restored within the OLS estimation framework by using –for example- the Huber-White "sandwich" robust covariance estimator.

among 50 US states (and the District of Columbia) for the period 1972-1991. Gerdtham and Ruhm (2006) highlight the potential problems associated with the violation of the strict exogeneity assumption. They proposed to include controls for country specific time trends by interacting the linear trend with the country dummies. To facilitate the comparison among the different unemployment rates series they also proposed to standardize the unemployment rate (i.e. subtracting from the yearly unemployment rate of a country its overall mean and dividing the difference by its overall standard deviation).

The LSDV approach shares the same statistical properties (*i.e.* are equivalent) of a *within-group (Fixed Effect, FE)* estimator where the country effects are "differenced out" by subtracting the over-time country-specific average ($\overline{ln(M_{it})}$) and ($\overline{U_{it}}$, $\overline{\boldsymbol{x_{it}}}$) from $ln(M_{it})$ and $U_{it}, \boldsymbol{x_{it}}$, respectively, and then cancelling out the country-specific error component α_i. Used by e.g. Stuckler et al. (2009) and Bender et al. (2013) in assessing the association between unemployment and mortality rates in Europe, the main contribution of the FE estimator is to provide a consistent estimation of γ even if, as it could be for this application, the correlation between U_{it} and α_i is different from zero. Moreover, a FE estimator should be preferred to a LSDV in terms of efficiency, simplicity and–as in our case (see appendix 8) – when the error terms are serially uncorrelated (Wooldridge, 2002).

Closely related to the FE estimator is the *first difference (FD) estimator*, which instead of subtracting the over-time average change uses a one-period change in mortality ($M_{it} - M_{it-1}$), unemployment ($U_{it} - U_{it-1}$) and the controlling variables ($\boldsymbol{x}_{it} - \boldsymbol{x}_{it-1}$) to eliminate the unobservable fixed country-specific effect. The FD estimator, used e.g. by Tapia-Granados on US (2005) and Japanese data (2008), has the distinctive advantage of requiring weak (sequential) exogeneity,[5] so that the differenced error term should be uncorrelated with the differenced explanatory variable terms. The choice between FE and FD depends on the structure of ε_{it} if it is serially uncorrelated, then the FE approach is more efficient, whereas if ε_{it} is also distributed as a random walk, then the FD approach is more efficient. As we report in the section 3, FE and FD estimates did not differ significantly for all the estimates, therefore we do not have striking evidence to reject the stict exogeneity assumption.

[5] In other words, while strict exogeneity states that the error component ε_{it} is uncorrelated with regressors in every time period (past, present and future), the sequential exogeneity states that ther error component is uncorrelated with current and past regressor, no mention of future ones.

By seeing mortality as a proxy of population health influenced by dynamic factors,[6] it must be state-dependent, being its current value a function of its own past values. In the presence of cycle or trends in the data, both OLS (even with lagged dependant variables) and FE produce biased estimations (see Gerry (2012), Greene, (2007), Nickell, (1981)). By using the Fisher-type test (Choi, 2001), we found evidence of non-stationarity of the (log of) mortality in our data (p-value<0.001) (see appendix 4). Even if strict exogeneity holds, state dependency (i.e. current mortality is a function of its past value) might lead to biased estimation (Arellano, 2009), because of endogeneity induced by the correlation of the lagged dependent variable with fixed effects and time-varying error terms).[7]

A common way of tackling endogeneity problems is by means of instrumental variables – i.e. variables that are correlated with the explanatory variable (endogenous variable), but uncorrelated with the error term and the outcome variable.[8] Lagged variables are in principle ideal instruments but their use is problematic in an OLS framework.[9] The standard Arellano-Bond estimator (*AB-GMM*) uses as instruments the lags of the dependent variable, without the need to specify *a priori* the number of lagged independent variables included in the model. Applied by Neumayer (2004) and Bonamore et al (2015) to study the effects of macroeconomic fluctuations on health in Germany over the period 1980-2000, AB-GMM is known to be rather inefficient when instruments are weak (e.g., if time dependency is strong) given the use of information contained in first differences of variables only. The Blundell-Bond's (1998) estimator (*BB-GMM*) which employs as instruments both first-differenced and level equations offers a better approach that has not yet been used in the literature discussed here. Compared to the AB-GMM, the efficiency gains in the BB-GMM estimator that results from the introduction of more instruments comes at the cost of making the additional assumption that first-differenced instruments are uncorrelated with the fixed-effects.[10]

6 Example of population health determinants are e.g. health behaviour factors, exposure to pollutants and health spending as well as socio-economic and demographic structure of the population.

[7] We run Durbin-Wu-Hausman (Wooldridge, 2001 p.284) test to check the endogeneity in the LSDV. Results available upon request.

[8] It is worth noting that if the measurement error bias is fixed over time, a simple FD and/or FE estimation will tackle this issue.

[9] Cameron and Trivedi (2005, chapter 22) showed that in such cases, the violation of the strict exogeneity assumption leads to inconsistent estimates.

[10] It is worth noting that the testing of an Arellano-Bond estimator vs. an Blundell-Bond estimator can be seen as an indirect validation of the performance of an Arellano-Bond estimator, which can perform poorly if the autoregressive parameters are too large or if the ratio of the variance of the panel-level effect of idiosyncratic error is too large (Roodman, 2009).

3.3 Empirical Results from the comparisons of models proposed in the literature

In this section we employ the main estimation strategies presented in sections 3.1 on the same dataset presented in Section 2. It is important to clarify that our main focus is to explore whether and, if so, in how far the estimates are affected by model specification assumptions. Our estimates, therefore, are likely to differ from the ones originally published that use different data, definitions, country and/or time coverage.

Model 1a refers to the LSDV model with country-specific dummy variables proposed by Ruhm (2000). In order to test whether time trends play a role in determining results, model 1b includes controls for country-specific fixed-effects, and country-specific time trends. Models 2a and 2b are similar to previous models but with unemployment that enters in the model in the standardized form suggested by Gerdtham and Ruhm (2006). Model (3) uses the FE approach proposed by Stuckler et al. (2009) whereas Model (4) uses the FD estimator proposed in Tapia-Granados (2008). Following Neumayer (2004), model (5) applies an AB-GMM estimator whereas the BB-GMM is used, for the first time in our knowledge, in model (6), as well we present for the first time to our knowledge, the BB-GMM including as instrumental variable two lags of the unemployment rate rather than one lag in model (7).

Table 1 reports elasticities for overall and cause-specific mortality. Cause-specific mortality rates are presented in a descending order from most to least frequent on average. We first assess the differences in the direction of the association, if any, and then proceed to examining differences in the magnitude of the estimated elasticity. Finally, we compare the models in terms of goodness-of-fit. Where significant, all models provide evidences of pro-cyclical overall mortality: mortality declines as unemployment surges. The effect, however, is rather modest in magnitude and statistically significant in only 4 out of the 9 models considered. A one-percentage point rise in the unemployment rate is associated with a reduction by between 0.8% and 1.6% in the age-specific overall mortality. In line with previous literature (Miller *et al.* 2009, Ionides *et al.* 2013, Catalano *et al.* (2010)…), the biggest effect is due to accidents (VA: -1% to -4.4%; other accidents: -0.5% to -2%), CCLD (-0.5% to -2.3%), and CVDs (+0.1% and -1.2%;). We found a counter-cyclical relationship for deaths due to MN (+0.1% to +0.6%) and suicides (+0.45% to 4.5%, but when we use GMM), again among the (few) estimates that turned out to be statistically significant. No significant effect (at 5% level or lower) have been found for mortality due to pneumonia and homicide.

TABLE 1:

Semi-elasticities of unemployment and cause-specific mortality under different econometric strategies (23 EU countries, 1980-2013)

	LSDV (in level or standardized)				FE	FD	GMM		
	Model 1a	Model 1b	Model 2a	Model 2b	Model 3	Model 4	Model 5	Model 6	Model 7
Overall Mortality	-0.001 (0.013)	0.003 (0.011)	0.007 (0.008)	-0.008** (0.004)	-0.001 (0.001)	-0.001 (0.001)	-0.014** (0.006)	-0.016** (0.007)	-0.013** (0.006)
Cause-Specific Mortality									
Malignant-Neoplasms (MN)	0.002 (0.011)	0.003 (0.004)	0.013** (0.005)	0.002 (0.002)	0.000 (0.001)	0.000 (0.001)	**-0.010** **(0.009)**	-0.010 (0.008)	-0.008 (0.008)
Cardio-Vascular Diseases (CVDs)	0.018 (0.023)	-0.008 (0.012)	0.030** (0.014)	-0.013*** (0.004)	0.000 (0.001)	0.000 (0.001)	**-0.006** **(0.005)**	-0.008 (0.006)	-0.004 (0.005)
Accidents	-0.019 (0.021)	0.023 (0.021)	-0.023* (0.013)	-0.019** (0.009)	-0.011*** (0.003)	-0.010*** (0.003)	**-0.045***** **(0.012)**	-0.055*** (0.011)	-0.059*** (0.012)
Suicides	0.029* (0.017)	0.124*** (0.013)	0.021** (0.010)	0.061*** (0.008)	0.006*** (0.002)	0.006*** (0.002)	**0.013** **(0.018)**	0.008 (0.015)	0.009 (0.012)
Vehicle Accidents (VA)	-0.112*** (0.022)	-0.122*** (0.020)	-0.053*** (0.016)	-0.083*** (0.010)	-0.011*** (0.003)	-0.012*** (0.003)	**-0.073***** **(0.010)**	-0.065*** (0.011)	-0.061*** (0.014)
Cirrhosis and Chronic Liver Diseases (CCLDs)	-0.027 (0.057)	-0.016 (0.026)	-0.031 (0.021)	-0.020* (0.010)	-0.003* (0.001)	-0.003* (0.002)	**-0.042***** **(0.011)**	-0.030** (0.012)	-0.031*** (0.011)
Pneumonia	0.068 (0.048)	0.046 (0.038)	0.042* (0.023)	0.005 (0.019)	-0.005 (0.003)	-0.004 (0.004)	**-0.006** **(0.029)**	-0.022 (0.026)	-0.018 (0.019)
Homicide	-0.019 (0.024)	0.082** (0.032)	-0.004 (0.016)	0.023* (0.013)	-0.000 (0.002)	-0.000 (0.002)	**0.009** **(0.019)**	-0.016 (0.017)	-0.006 (0.017)

Notes: Robust standard errors in parenthesis. For models 3 and 4 we clustered standard errors at country level using . All models control for population structure by mean of the % of males aged between 0 and 65. However, this was not possible for Model 3 (because of collinearity with the time-trends controls) and Model 4 because the original model proposed by Tapia-Granados (2008) did not include other covaritates. Including it in model 4 does not alter significantly results. *Source*: WHO data (see section 2 for details). *Level of significance:* * p<0.1, ** p<0.05, *** p<0.01.

In what follows we assess whether and, if so, in how far different underlying assumptions embedded in each model could influence the estimated association.

We start by testing the relevance of including country-specific time trends. T-test comparisons indicate that when the presence of linear time trends is taken into account by means of country-specific and time trends (models 1b and 2b), the insignificant pro-cyclical association estimated in the absence of these controls becomes significant when introduced. This is the case for the pro-cyclical association for overall mortality (for model 2b only) and for cause-specific deaths due to accidents, cirrhosis and chronic liver diseases and cardio-vascular diseases (and the significance increases in the case of fatal vehicle accidents). It is also true for the counter-cyclicality of deaths due to MN and suicides. Our analysis would suggest that country-specific time trends play a non-negligible role in explaining the association between unemployment and mortality and therefore should be taken into account in the specification. Failure to do so (as in models 1a and 2a), tends to lead to non-significant associations, probably due to the inflation of the standard errors.[11] By contrast, whether or not the model involves the standardization of *U* does not significantly affect the estimates, as confirmed by non-significant t-test differences between models 1a and 2a and/or models 1b and 2b. –

The FE estimator (model 3) shows no significant effects for overall mortality as obtained using the FD estimator in model 4, in line with models which do not include time and country-specific trends (models 1a and 2a). FE and FD estimators provide very similar results also for cause-specific mortality: a significant pro-cyclical association is found for external causes (accidents and vehicle accidents); a counter-cyclical association for suicides which is in magnitude about half that for the effects found using models in levels (model 1b).

GMM estimators (models 5 and 6) can be utilized in assessing the violation of the strict exogeneity assumption in a dynamic context.[12] Overall mortality is significantly pro-cyclical ($p<0.05$), and not significantly different from estimates obtained using model 1b. It seems that controlling for country-specific time trends may be sufficient to remove the bias due to endogeneity problems (Ionides et al. 2013, p. 2) using a simpler OLS estimator that would perform better that an FE or FD estimator. Under the AB-GMM estimator, only suicides and CVDs are pro-cyclical whereas pro-cyclicality of accidents is found also with the BB-GMM

[11] The standard errors for model 1a and 2a are almost two times those obtained for models 1b and 2b. As Mukherjee et al. 2003 noticed "*if our omitted variables play an important role in explaining the variation in the dependent variable, we would expect the estimated error variance to fall with the inclusion of the omitted variables in the regression, unless the sample size is very small*" [pp. 217].

[12] Both model 5 and 6 pass the over-identification test (Hansen, 1982), although we interpret this as a coherency of the instruments "rather than their validity" (see e.g., the discussion made by Parente and Silva, 2012).

estimator. This is in sharp contrast with OLS estimates but in line with two previous studies which documented a pro-cyclical relationship for suicides (Neumayer, 2004 and Barstad, 2008) that motivate such a result through the income and stress-related mechanisms. Specifically, : economic expansion might increase the consumption of health-damaging goods such as alcohol and drugs (Ruhm and Black, 2002) which in turn might also lead to social-isolation that is one of the main drivers for suicides (Barstad, 2008; Durkenheim 1897).

3. Diagnostic analysis

One question that arises from the comparison of existing models is about the extent to which different estimates depend on substantial violations of the standard assumptions embedded in each of these approaches. If the results from the existing methodologies are indeed sensitive to changes in the underlying assumptions, there will be a need to look for modifications in the methods used to analyse the relationship between macroeconomic fluctuations and health. In this section we examine four such robustness checks:

(1) *Potential breaks in the association over-time*: the association between unemployment and mortality may not remain stable over time. Below we check in particular whether the association has changed after the onset of the recent recession (the so-called "Great Recession" (Keeley and Love, 2010; Jenkins et al, 2012) that started in the summer of 2008 (section 4.2).

(2) *Heterogeneity of effects across groups of countries*: The effects of macroeconomic fluctuations may not be homogeneous within a large sample of countries. We examine the extent to which effects may systematically differ between certain sub-groups of countries (section 3.4.3).

The previous section confirmed that the inclusion of country-specific time trends with robust standard errors in a classical OLS model (model 1b) yields the same results – in the case of all-cause-mortality – as a more robust and less restrictive estimator, like the GMM. Hence, in what follows we will compute all our results using the OLS estimator.

3.1. Did the Great Recession significantly alter the relationship between unemployment and mortality?

We test the presence of a structural break in the time-series of overall mortality by adopting a standard difference-in-differences estimation (Card and Krueger, 1994). Specifically, we introduce a dummy variable in equation (1) which takes the value of 1 for the period 2008 onwards and 0 otherwise and its interaction with unemployment. The interaction term is negative (-0.004, $p<0.05$) meaning that the association has become even more pro-cyclical after the crisis, even though the crisis itself did not lead to an increase in the overall mortality[13].[14] The analysis of cause-specific mortality reveals that the Great Recession has led to an even stronger pro-cyclical association for vehicle accidents, suicides and malignant neoplasms. On the other hand, the relationship of unemployment with deaths by accidents and CCLDs has become pro-cyclical after the crisis whereas the counter-cyclicality of homicides has been significantly reduced.

The reinforcement of the pro-cyclicality of overall mortality in the EU sharply contrasts with the recent findings from US obtained by Ruhm (2015), who documented a weakness of the pro-cyclicality in the period 2006-2010 compared to the period prior to 2006.

3.2. Homogeneity across groups of countries

In this section, we model equation (1) in a multiple-group framework, in which clusters of countries are generated according to *i)* the tertiles of each country's share of social protection expenditure in GDP and *ii)* the Esping-Andersen (1990) welfare state classification. The latter classification – apart from being widely used in political and social sciences (Aassve *et al.* 2007, Coburn, 2004) – has the advantage of being time-invariant. By clustering countries according to the presence and adequacy of social protection programmes it defines four clusters: the "Corporatist-Statist" countries, with a high degree of status segregation and "etatism" (e.g. Germany); the "Liberal" countries characterized by *"means-tested assistance, modest universal transfers, or modest social-insurance plans predominate"(*Esping-Andersen, 1990) (e.g. The UK); the "Socio-Democratic" countries, with universalist benefit programmes and a high degree of equality in the benefit structure(e.g. Sweden); and the "Mediterranean" countries, where family networks represent the most important source of welfare support (e.g. Italy). In addition, we introduced a new cluster, the "Eastern" which includes all the former Eastern European countries.[15]

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[13] The coefficient associated with unemployment is -0.002 ($p<0.05$). The coefficient for dummy "crisis" (which captures the direct effect on overall mortality) is 0.004 but not significant at conventional level (standard error 0.016) (which is the effect captured by the coefficient associated with "crisis"). A conventional F-test rejects the hypothesis that the three coefficients are jointly equal to zero.

[14] Un-tabulated results reveal that the largest drop in overall mortality occurred in the Liberal (UK and Ireland) and Mediterranean countries.We speculate that socio-economic gradient might play a significant role in explaining this results, in fact the literature finds significant socio-economic differences in the association between economic crisis and health behaviours (Nandi et al. (2013). Unfortunately, only micro-data can clarify this matter.

[15] Specifically, the "conservative" cluster includes the Netherlands, Austria, Belgium, France, Luxembourg and Germany. The Socialist one includes Denmark, Norway and Sweden. The Liberal one includes Ireland and the United Kingdom. The Mediterranean one includes Greece, Italy, Spain and Portugal. Finally the Eastern one includes Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovenia and Slovakia. See Appendix Table A1 for details.

The multiple group estimates in Table 2 are estimated using a GMM-system of equations, which are solved for all the groups simultaneously, yielding group-specific parameter estimates. A log-likelihood test ratio reveals strong support in favour of a multiple group specification against the restrictive model that imposes equality in the relationship between mortality and unemployment for both classifications (30.30, p <0.001; 47.10, p <0.001).

According classification *a)*, overall mortality is found to be pro-cyclical for the low and high social expenditure countries but a-cyclical for the medium ones. Specification *b)* points out strong pro-cyclicality for Corporatist Socio-democratic and Eastern countries and no significant effects for Mediterranean and Liberal countries.[16] It is worth noting that the Mediterranean countries are all classified as medium expenditure countries in terms of social expenditure. Therefore both classifications provide robust evidence of the a-cyclical relationships for this group of countries.

In Figures 2 and 3, we compare the implication of the estimated multiple-group models also with respect to the linearity of the relationship. The results suggest that the log-quadratic functional form fits the data best due to the non-linear relationships found for low and medium social expenditure countries. The log-quadratic classification seems to be more appropriate also for the corporatist-statist countries in the Esping-Andersen's classification. Again graphical inspections reveal that the three specifications are not strikingly different in terms of their predicted values, if we exclude mainly countries characterised by a very low unemployment rate (below 5%). For all countries with a low level of unemployment the relationship seems to be counter-cyclical. For the medium social expenditure countries (i.e. Mediterranean countries) the relationship seems to be slightly counter-cyclical even at a higher unemployment rate. For most of the countries with a high level of social expenditure (i.e. corporatist-statist and social-democratic countries) the relationship appears to be significantly counter-cyclical for levels of unemployment above 5%.

TABLE 2:

Testing homogeneity across groups of countries in the relationship between unemployment and overall mortality rates, using two grouping criteria

Classification a) (% of social expenditure over GDP)			Classification b) (Esping-Andersen's welfare state classification		
Group	E	S.E.	Group	E	S.E
Low Social Expenditure Countries	-0.002**	0.001	Eastern Countries	-0.002**	0.00
Medium Social Expenditure Countries	0.000	0.001	Mediterranean Countries	0.001	0.00

[16] Liberal countries are characterized by an extremely high level of means-tested benefit policies. It can be speculated that the supposedly more efficient distribution of resources/benefits may help explain why the health response to unemployment is comparatively small.

High Social Expenditure Countries	-0.002**	0.001	Socio-Democratic Countries	-0.004**	0.00
			Corporatist- Statist Countries	-0.006***	0.00
			Liberal Countries	-0.001	0.00
N	579		579		
BIC	-1878.6		-1576.3		
AIC	-2419.4		-2343.3		

Level of significance: * p<0.1, ** p<0.05, *** p<0.01.

FIGURE 2 was here!

As well as for overall mortality also cause-specific mortality appear to be heterogeneous across group of countries. The countries that seem to be affected the most are Corporatist-Statist ones, which exhibit strongly (slightly) pro-cyclical association for Malignant Neoplasms, CVDs, Suicides, Vehicle Accidents, CCLDs and Pneumonia. Malignant neoplasms appear to be slightly pro-cyclical in Socio-Democratic countries and for those countries pneumonia appear to be strongly counter-cyclical. Both vehicle accidents and CCLDs appear to be slightly counter-cyclical in Mediterranean countries. Slightly pro-cyclical suicides rates have been found for Eastern countries. Slightly pro-cyclical homicides rates have been found for Liberal countries As far as social-expenditure classification is concerned, our results show that Cardiovascular Diseases, Accidents, Suicides, (Vehicle Accidents, Pneumonia and Homicides) appear to be (slightly) pro-cyclical in High income countries. No other significant effects have been found.

4. Robustness Checks

As a further sensitivity check, we also assess the relevance of *measurement errors* and *non-linearity in the relationship*. And moreover we assess the impact of unemployment on infant mortality and older-population (65+) mortality.

4.1. Measurement errors

In practice, aggregated data – as in our case country-level indicators – might be prone to significant measurement error. The problem of measurement errors has been carefully studied in the statistical literature for several decades (Fuller, 1981) but has often been neglected in the literature of macroeconomic fluctuations and health. To the best our knowledge, only Stuckler *et al.* (2009) have tested the robustness of their results to outliers, excluding the data points for which the unemployment rate rose by more than 3% in a year. In this vein, we assess the robustness of our findings by assuming that some of the very significant year-to-year changes observed in mortality and unemployment rates are driven by possible errors in the data-collection or by some unobservable non-random idiosyncratic events not fully captured in the econometric model. Our check involves imposing more stringent top and bottom coding in the data according to observed proportional changes over time for the two variables of interest. Results, available upon requests, provide evidence that measurement errors may not be a major concern for the analysis on overall mortality and death rates for but this is not the case for

4.2. Non-linearity in the relationship

It is at least conceivable that the magnitude and/or the sign of the relationship between mortality and unemployment may change depending on the level of a country's unemployment with the effects that becomes relevant after a certain level of unemployment is reached. We tested the presence of non linearity fluctuations and mortality, we test the performance of a polynomial fractional model (Royston and Altman, 1994)[17] and of two other variants of the 'linear in *U*'-model from equation (1): one in which U is included linearly in logarithm *[ln(U)]* and another including U in a log-quadratic form. Both the linear and log-linear specifications have the advantage of simplicity and incorporate the property of being invariant to the unemployment level. In addition to these standard forms, the more flexible log-quadratic function $f(U) = \gamma_1 \ln(U_{it}) + \gamma_2 [\ln(U_{it})]^2$. For all these functional forms, we test the effect of departing from the linearity assumption.

Table 4 presents the results of this robustness check, and Figure 1 provides a graphical inspection of the estimated relationship according the four different specifications. Based on the Bayesian Information criterion (BIC) criterion the model that fits the data best is the a second-degree fractional polynomial model of the form: $ln(M_{it}) = \boldsymbol{x'_{it}\beta} + U_{it}^{-0.5}\gamma_1 + U_{it}^{-0.5}\gamma_2 lnU + \varepsilon_{it}$. By contrast, the Akaike information criterion (AIC) points in favour of a the polynomial fractional specification.

Despite the inconclusiveness of goodness of fit tests in choosing the "best" model specification, Figure 1 clearly points out that when the unemployment rate is low, the quadratic model fits best the data, while when the unemployment rate is between 3% and 13% the polynomial model and the linear model essentially overlap each other, while when the unemployment rate is higher than 13% the model that fits best the data is the polynomial one. From a graphical inspection, a log-linear function is not significantly different from a linear-in-level function, except at the top of

[17] Specifically, we model the relationship between overall mortality and unemployment rates using the fp command in STATA (Royston and Ambler, 1999). It allows for a more general specification in fractional polynomial in *E:* $ln(M_{it}) = U_{it}^{(p_1,p_2,\ldots,p_J)}\boldsymbol{\gamma_p} + \boldsymbol{x'_{it}\beta} + \varepsilon_{it}$ with $U^{(p)}$ being any possible regular power except that $U^{(0)}$ is to be interpreted as meaning *ln(U)* rather than $U^{(0)} = 1$.

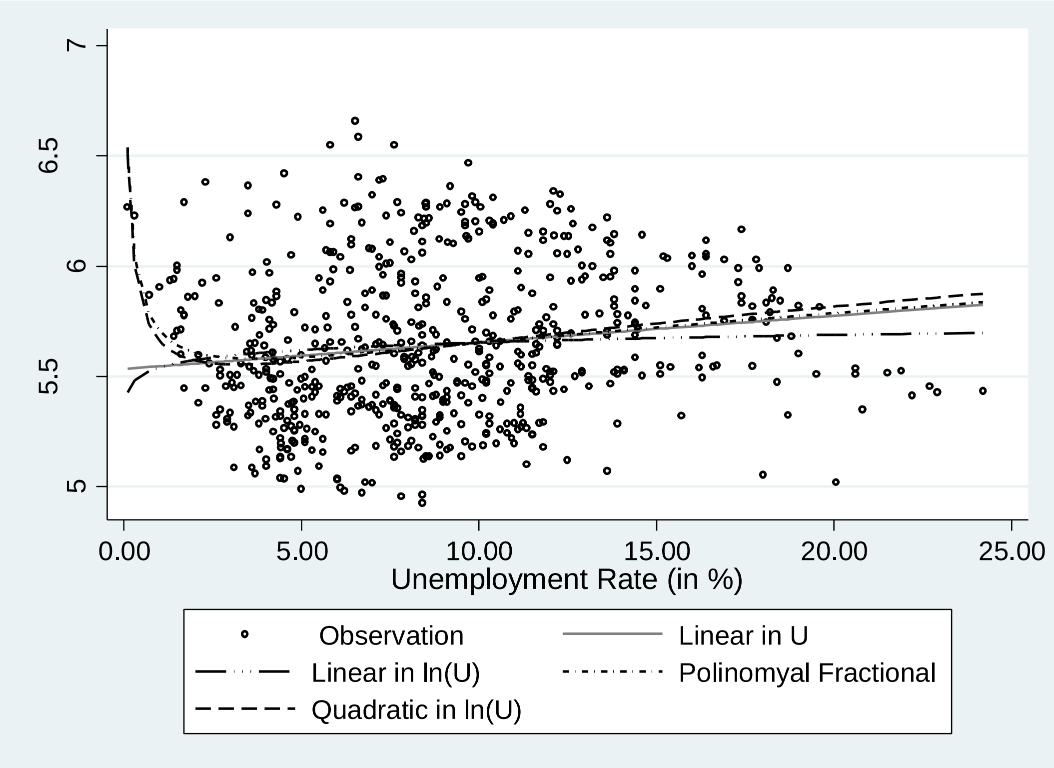
the unemployment rate distribution for which the log-linear model seems to fit better the data. Hence, we opted for the simpler model and from now on all the estimation presented employ a 'linear in E'-model.

TABLE 4:
Estimated relationship between unemployment and overall mortality according to different functional forms

	linear in U[a]	Polynomial fraction of U	linear in ln(U)	Quadratic in ln(U)
U	-0.002*** (0.001)			
$U^{-0.5}$		0.033*** (0.010)		
$U^{-0.5}\times\ln(U)$		-0.018*** (0.003)		
ln(U)			-0.014 (0.011)	0.035*** (0.012)
$[\ln(U)]^2$				-0.014*** (0.003)
BIC	-1738.6	-1715.3	-1660.8	-1755.6
AIC	-1965.4	-2068.5	-2009.7	-1986.3

Notes: Standard errors in parentheses. ([a]) estimates from model (1b) of Table 1 "*overall mortality*". *Source*: : Overall mortality data from WHO for the period 1980-2010, see Table A1 for further details. *Level of significance:* * p<0.1, ** p<0.05, *** p<0.01.

FIGURE 1:
Estimated form of the mortality-unemployment relationship



Notes: Row WHO data (*Observation*) and predicted probabilities estimated from model 1b (*Linear*) and three variants in which *U* enters in the specification in natural logarithm (*Log-linear*); in a log-quadratic form (*Log-quadratic*) and by using a polynomial fraction specification (*Polynomial fraction*). See text for details.

With respect to cause specific mortality we confirm the results for the overall mortality: i.e. the quadratic model seems more appropriate when the unemployment rate is low, whereas the polynomial fractional model seems the one that fits the data best when the unemployment rate is high, while in the core-distribution there is basically no-difference among the models.

4.3. Mortality over 65 and Infant Mortality

On the one hand, infant mortality is strongly pro-cyclical when state dependency is kept into account either via GMM or via time-trends and not significant otherwise, on the other hand overall mortality for people older than 65 is a-cyclical when state dependency is addressed and strongly counter-cyclical otherwise.

TABLE 6:

Estimated relationship (semi- elasticities) between unemployment and cause-specific mortality according different econometric models proposed (25 EU countries, 1980-2010)

	LSDV models (in level or log-level)				Fixed-effects (within-group) model	First-difference model	GMM	
Cause of death	Model 1a	Model 1b	Model 2a	Model 2b	Model 3	Model 4	Model 5	Model 6
Overall Mortality 65+	0.004** (0.001)	0.000 (0.001)	0.019*** (0.006)	0.001 (0.002)	0.000 (0.000)	0.000 (0.000)	-0.000 (0.001)	-0.000 (0.001)
Infant Mortality	-0.006* (0.004)	-0.004*** (0.001)	-0.028* (0.015)	-0.017*** (0.006)	0.000 (0.002)	0.001 (0.002)	-0.007** (0.003)	-0.009** (0.004)

Notes: Robust standard errors in parenthesis. For models 3 and 4 we clustered standard errors at country level using …. To avoid bias due to outliers, in the spirit of Stuckler et al. (2009), we exclude observations when year-to-year change was higher than 150. All models control for population structure by mean of the % of males aged between 0 and 65. However, this was not possible for Model 3 (because of collinearity with the time-trends controls) and Model 4 because the original model proposed by Tapia-Granados (2008) did not include them. Including them in model 4 does not alter significantly results. *Source*: Elaborations on WHO data. See section 2 for details. *Level of significance:* * p<0.1, ** p<0.05, *** p<0.01.

Where significant, OLS results on all-cause for people older than 65 mortality reveal a counter-cyclical association with unemployment: mortality declines as unemployment drops. The effect, however, is rather modest in magnitude and statistically significant in only 2 out of the 8 models considered and only for those models that do not keep into account country-specific time trends. The significant results suggest that a 1-percentage point rise in the unemployment rate is associated with a reduction by between 0.4% and 1.9% in the age-specific standardized overall mortality rate.

Conversely infant mortality is strongly pro-cyclical when state dependency is kept into account either via GMM, or via time-trends and not significant otherwise, on the other hand overall mortality for people older than 65 is a-cyclical when state dependency is addressed and strongly counter-cyclical otherwise.

6. Conclusions

In this paper we use data from 25 European Countries covering the period 1980-2010 to explore the relationship between unemployment on one hand and overall mortality as well as eight important causes of death on the other hand (i.e. malignant neoplasms, cardiovascular diseases, accidents, suicides, motor vehicle accidents, CCLDs and chronic liver diseases, pneumonia and homicides).

In our analysis we applied the most commonly used econometric approaches from the relevant empirical literature. While our findings confirm previous results of a pro-cyclical relationship with overall mortality for people aged below 65, the statistical significance of the point estimates varies considerably according the underlying assumptions embedded in the econometric approach employed. Reassuringly, we found evidence that when country-specific time trends are properly addressed, OLS and GMM estimators lead to very similar results in the pro-cyclical relationship with overall mortality. However, when applying GMM estimators which are robust to endogeneity problems, we find that accidents, CVDs (with AB model only) and most surprisingly suicides are strongly pro-cyclical. Therefore, as far as cause-specific mortality is concerned we conclude that our results based on approaches other than GMM should be considered with caution, in particular when the econometric approach relies on strict exogeneity assumption.

We have also investigated the sensitivity of the relationship to various key assumptions.

We tested the presence of a structural break in the association due to the economic down-turn affecting Europe since August 2008. We found clear evidence of an even stronger pro-cyclical relationship after 2009. This result is at odds with the recent US evidence showing that the pro-cyclicality in the relationship has been getting weaker during the period 2006-2010 (Ruhm, 2013). Although, this result should be interepreted with caution since it masks some heterogeneous effect across countries and possibly socio-economic status.

We, then, tested the homogeneity in the pro-cyclical relationship across groups of countries which differ in the type of the welfare system in place (using two different classification criteria). Log-likelihood-ratio tests suggest that a multiple-group specification is preferred to a pooling of countries, even if we account for time and country fixed-effects. We found clear evidence of high heterogeneity across groups of countries. Countries with the lowest (i.e. Eastern countries) and the highest (i.e. Socio-democratic and Corporatist-Statist countries) social expenditure (as a % of GDP), exhibit a pro-cyclical relationship whereas an a-cyclical relationship is found for Mediterranean countries.

Reassuringly, we did not find evidence of a bias due to possible measurement errors affecting both indicators of interest. This would suggest that the significant pro-cyclical relationship with overall mortality we estimated is robust to the presence of possible outliers in our data.

We then explored the robustness of the common linearity assumption in the relationship. We found that even if a non-linear functional form fit best the data, the estimates are not strikingly different from the ones obtained using a more common linear model. However, non-linearity mainly arises at the margins of the unemployment distribution. The relationship is found to be counter-cyclical at low unemployment level whereas the pro-cyclical relationship slightly increases in magnitude at very high levels of unemployment.

Our clear conclusion is that – on average – a significant pro-cyclical relationship in the EU countries is found only for overall mortality. This relationship, however, is time- and country-specific, with sign, level of significance and magnitudes that depend on the time interval considered (before/after the crisis), the level of social protection and type of welfare state in place in a country) and the observed level of unemployment. Therefore applied models should take into account such heterogeneities, if meaningful inferences about the implication of the estimated association should to be drawn, in particular given the growing discussions around the effect of *policies* (i.e. austerity measures) in determining changes in mortality rates.

At the same time the ambiguous evidence on cause specific mortality might cast doubt about the association between macroeconomic fluctuation and cause-specific mortality.

The main limitation of the present study is that does not reveal a causal relationship between macroeconomic shocks and health, but an association between the two. Another important issue is the low explanatory power of this kind of models. Miller et al. (2009) pointed out that more than 70 percent of the deaths in 2004 in the USA occurred among people age 80 or over, and therefore cannot be explained by these models. At the same time, the authors addressed the low explanatory power to heterogeneity effect across ages groups that we are not able to capture given the nature of our data, the authors – in fact- found the largest pro-cyclical effect among the working age group is driven by those at the younger end of the 20s to 44 years old age range.

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Appendix

Table A1:
List of countries, data availability and group membership according the two classification criteria used in the paper

Country	Years of data available		Group membership	
	Mortality rates	Unemployment rate	Esping-Andersen classification	Social-Expenditure classification
Austria	1980-2010 (S, MN, CVD, CCLD, VA, HM); 1981-2009 (ALL) 1980-2008 (PN) 1981-2010 (AC)	1980-2011	Conservative	High
Belgium	1980-1999 and 2004-2006(S, MN, CVD, CCLD, VA, HM) 1981-1999 and 2004-2006(ALL) 1980-1998, 2003-2004 (PN) 1981-2000, 2003-2006 (Ac)	1971-2011	Conservative	High
Bulgaria	1980-2011(S, MN, CVD, CCLD, VA, HM) 1981-2009(ALL) 1980-2009(PN) 1981-2010 (AC)	1990-2006, 2008-2011	Eastern	Low
Czech Republic	1980-2007 (S, MN, CVD, CCLD, VA) 1986-2009 (ALL) ; 1980-2010 (CB) 1985-2008(PN) 2005-2010 (AC) 1986-2010 (HM)	1980-2004, 2005-2011	Eastern	Low
Denmark	1980-2006 (S, MN, C); 1980-1988, 1991-2005 (CB, CCLD, VA, Hm) 1994-2006 (ALL) 1993-2004(PN)	1973-2011	Socio-Democratic	High

	1995-2006 (AC)			
Estonia	1981,1982, 1985-2010(S, MN, C) 1981,1982, 1985-1988, 1991-2010 (CB, VA, HM) 1981,1982, 1985-2009 (ALL) 1990-2010 (CCLD) 1981-1982, 1986-2010 (AC) 1981-1982, 1984-2008 (PN)	1989-2011	Eastern	Low
Finland	1980-2010(S, MN, CVD, CCLD, VA, HM) 1987-2009 9(ALL) 1986-2008(PN) 1988-2010 (AC)	1974-2011	Socio-Democratic	High
France	1980-2009 (S, MN, CVD, CCLD, VA, HM) 1981-2009 (ALL) 1980-2007 (PN) 1981-2009 (AC)	1980-2006, 2008-2011	Conservative	High
Germany	1990-2010 (S, MN, CVD, CCLD, VA, HM) 1990-2009 (ALL) 1989-2008 (PN) 1981-2010 (AC)	1991-2011	Conservative	High
Greece	1980-2009 (S, MN, CCLD, VA, HM) 1981-2009 (ALL, AC) 1981-2007(PN)	1974-2011	Mediterranean	Medium
Hungary	1980-2009 (S, MN, CVD, CCLD, VA, Hm) 1981-2009 (ALL, AC) 1980-2007 (PN)	1990-2004, 2005-2011	Eastern	Medium
Ireland	1980-2010 (S, MN, CVD, CCLD, VA, Hm) 1981-2009 (ALL) 1980-2008 (PN) 1981-2010 (AC)	1974-2011	Liberal	Low
Italy	1980-2003, 2006-2009 (S, MN, CVD, CCLD, VA, Hm) 1981-2003, 2006-2009 (ALL) 1980-2002, 2004-2007 (PN)	1974-2011	Mediterranean	Medium

Latvia	1981-2004, 2007-2009 (AC) 1980-2010 (S, MN, CVD, VA, HM) 1981-2009 (ALL) 1980, 1983, 1984, 1991-2010 (CCLD) 1980-2008(PN) 1981-2010 (AC)	1992-2011	Eastern	Law
Lithuania	1981,1982,1985-2010 (S, MN, CVD, VA, Hm) 1981,1982, 1985-2009 (ALL) 1980, 1983, 1984, 1991-2010 (CCLD) 1980-1981, 1984-2008(PN) 1982-1983, 1986-2010 (AC)	1991-2011	Eastern	Low
Luxembourg	1971-2010(S, MN, CVD, CCLD, VA, Hm) 1981-2009 (ALL) 1980-2008 (PN) 1981-2010 (AC)	1980-2011	Conservative	Medium
Netherlands	1980-2010(S, MN, CVD, CCLD, VA, HM) 1981-2009 (ALL) 1980-2008 (PN) 1981-2010 (AC)	1980-2011	Conservative	High
Poland	1980-1979, 1983-1996, 1999-2010 (S, HM) 1983-1996, 1999-2009 (ALL) 1980-1996, 1999-2010 (MN, CVD, CCLD) 1980-19985, 1998-2008 (PN) 1984-1997, 2000-2010 (AC) 1980-1971,1983-1996,1999-2010 (VA)	1990-2006,2007-2011	Eastern	Low
Portugal	1971-2004, 2006-2010(S, MN, CVD, CCLD, HM) 1981-2004, 2006-2009 (ALL) 1980-2003, 2005-2008 (PN) 1971-2003, 2006-2010(VA) 1981-2005, 2007-2010 (AC)	1980-2011	Mediterranean	Medium
Romania	1989-2010 (S, HM) 1989-2009 (ALL)	1991-2011	Eastern	Low

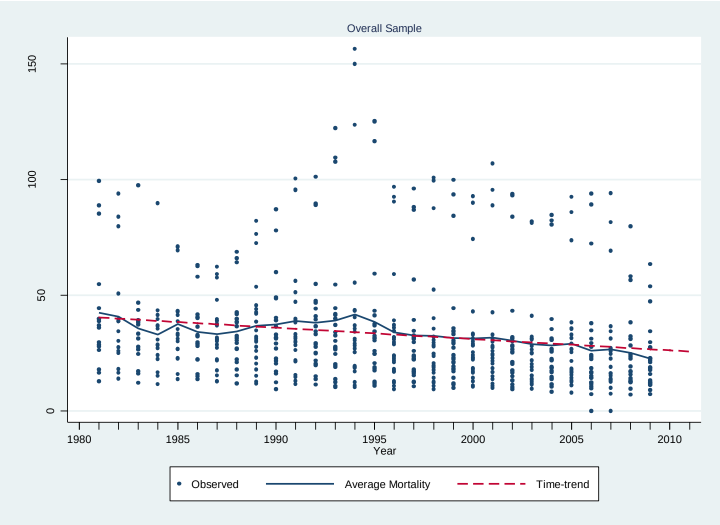
	1980-1978, 1980-2010 (MN, CVD, CCLD) 1980-2008 (PN) 1989-1993, 1996-2010(VA) 1990-2010 (AC) 1986-2005, 2008-2010 (S)			
Slovakia	1992-2009 (ALL) 1971-2009 (MN, C) 1971-1988, 1991-2010 (CB, CCLD) 1991-2008 (PN) 1986-1988, 1991-2005, 2008-2010 (VA) 1993-2010 (AC) 1986-1988, 2000-2005, 2008-2010 (HM)	1990-2007	Eastern	Low
Slovenia	1985-2010 (S, MN, CVD,); 1985-2009 (ALL) 1991-2008 (PN) 1986-2010 (AC)	1980,1982,1984-2007	Eastern	Low
Spain	1980-2010 (S, MN, CVD, CCLD, HM) 1981-2009 (ALL) 1980-2008 (PN) 1981-2010 (AC)	1974-2006, 2008-2011	Mediterranean	Medium
Sweden	1980-2010 (S, MN, CVD, CCLD, HM) 1987-2009 (ALL) 1986-2008 (PN) 1988-2010 (AC)	1980-2006, 2008-2011	Socio-Democratic	High
United Kingdom	1980-2010 (S, MN, CVD, CCLD, HM) 1981-2009 (ALL) 1986-2008 (PN) 1981-2000, 2002-2010 (AC)	1980-2006, 2007-2011	Liberal	Medium

Notes: Overall mortality (ALL) broken down by cause-specific deaths. Namely, S=Suicide; MN= Malignant Neoplasm ; CVD= Cardio-vascular; CCLD= Cirrhosis and Chronic Liver Diseases s: PN= pneumonia and influenza; VA= vehicle accidents; AC= accidents; HM= homicides. *Source*: WHO data.

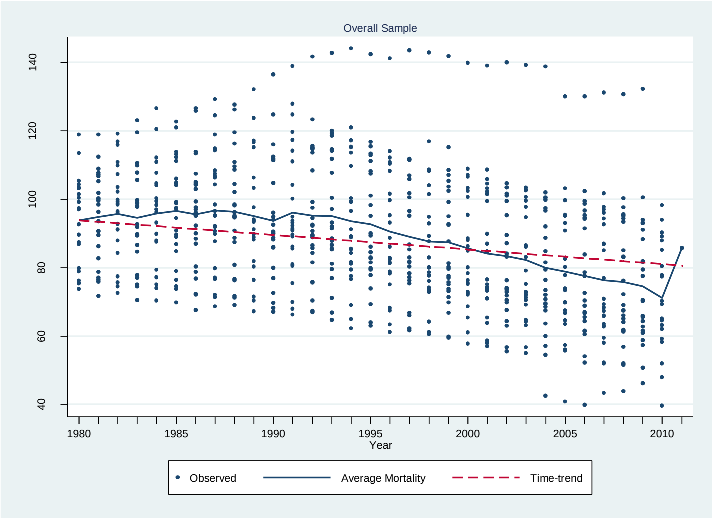
Appendix 2:

Trends in mortality and unemployment since 1980

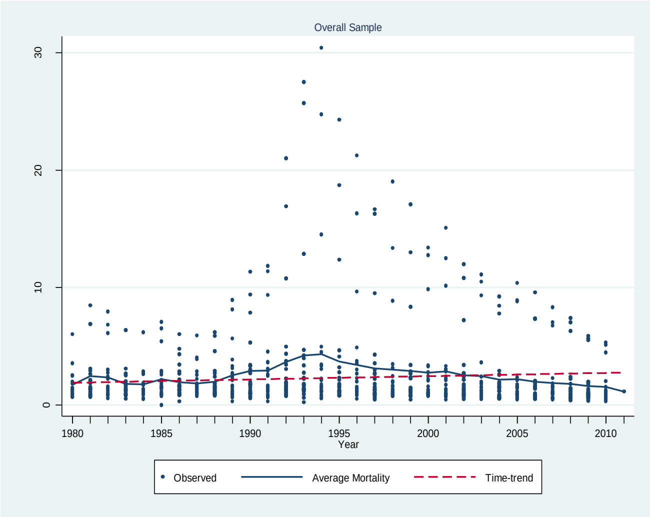
Overall Mortality



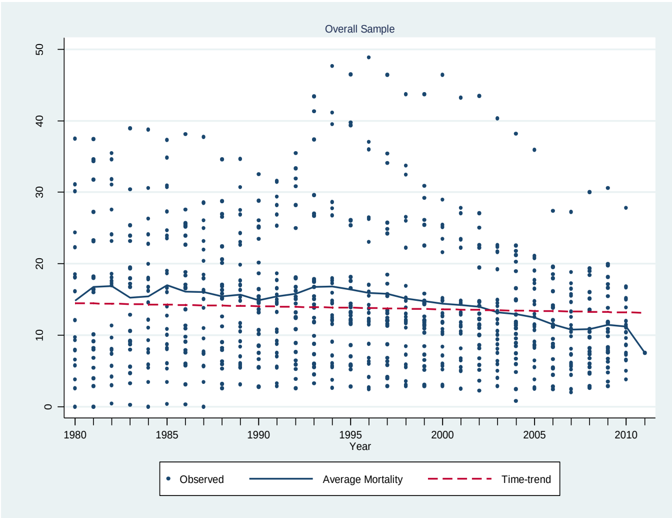
Malignant Neoplasm



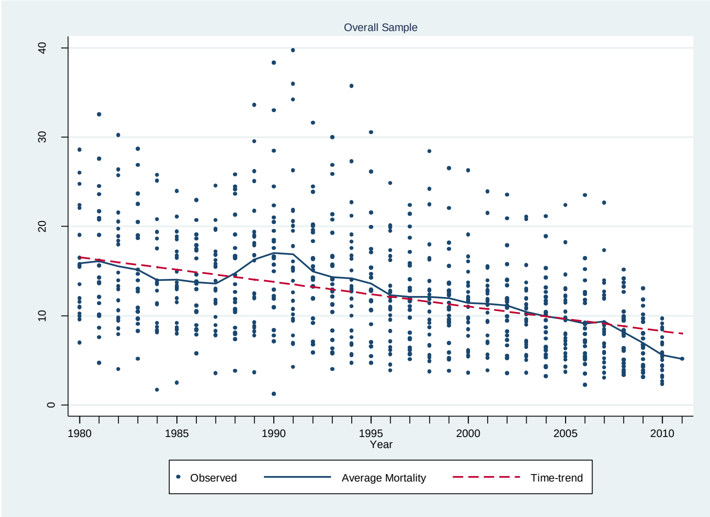
Homicides



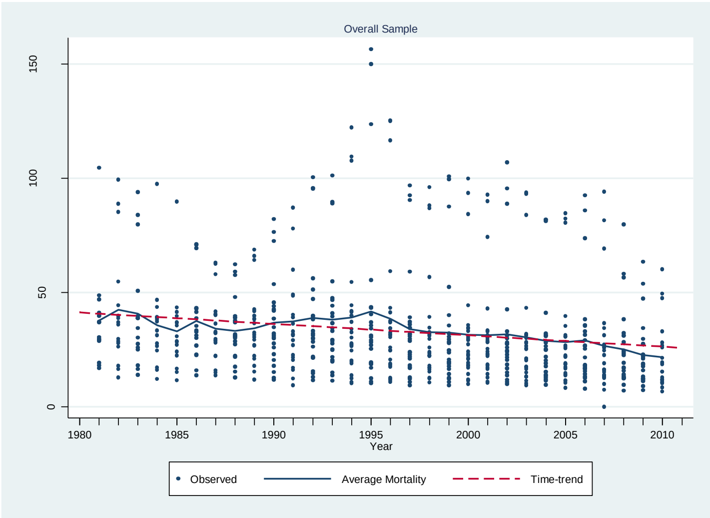
Suicides



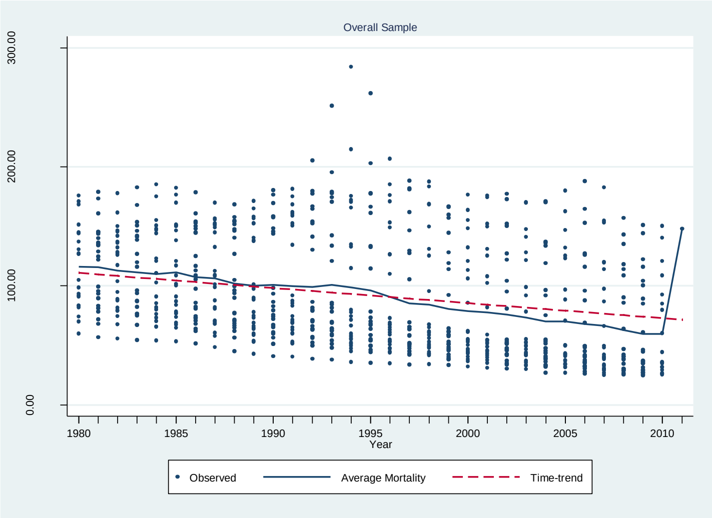
Vehicle Accidents



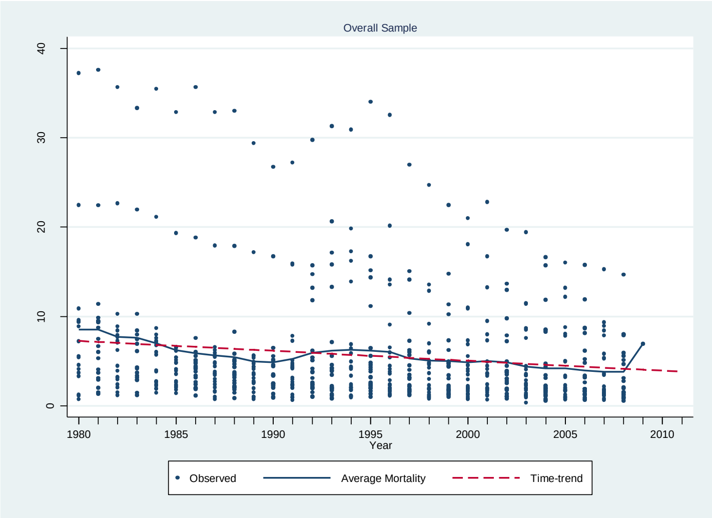
Accidents



Cardio-vascular diseases


Overall Sample
300.00
200.00
100.00
0.00
1980
1985
1990
1995
2000
2005
2010
Year
Observed
Average Mortality
Time-trend

Pneumonia


Overall Sample
40
30
20
10
0
1980
1985
1990
1995
2000
2005
2010
Year
Observed
Average Mortality
Time-trend

Appendix 3:

Summary of the literature

Paper	Model	X	Data	Result	Interpretation
Ruhm (2000) -QJE	Using the subscripts *j* and *t* to index the state and year, the basic regression equation is $ln(H_{jt}) = \alpha + \boldsymbol{X_{jt}\beta} + E_{jt}\gamma + \sum_{j=1}^{J} \delta_j C_j + \varepsilon_{jt}$ for *H* the mortality rate, *E* the proxies for economic conditions, *X* a vector of supplementary regressors, and e the error term. The fixed-effect *Cj* controls for time-invariant state characteristics, a*t* accounts for nationwide time effects, and captures the impact of	The percentage of the state population with three levels of educational attainment (high school dropout, some college, college graduate), in two ethnic groups (Black, Hispanic), and two age categories (<5, >=65 years old). Ethnic status and age are measured over the full population; educational attainment refers	Aggregate data from 50 USA state + District of Columbia for the period 1972-1991. **Outcomes:** 10 death rates 1) Malignant Neoplasms, 2) Cardiovascular Diseases 3) Pneumonia and Influenza 4) CCLDs 5) Motor Vehicle Accident 6) Other accidents 7) Suicide 8) Homicide 9) Infant Mortality 10) Neonatal Mortality. The author, beside using the overall mortality, uses as outcome the age specific mortality rates (20-44, 45-64, 65+).	Mortality is found pro-cyclical but for suicide which are counter-cyclical Analysis of the BRFSS suggests that this is	**The opportunity cost of time:** increases in economic upturn so people has less time for leisure (e. g. physical activity) and also for medical care utilization. **Health as an Input into the Production:** during the economic upturn workers are at risk at higher stress level and the physical exertion of

	within-state deviations in economic conditions. Observations are weighted by the square root of state populations to account for heteroskedasticity. The author predicts also the future effects, using as explanatory variable the four year lagged unemployment rate. The author used also as main explainatory variable the employment-to-population ratio (Not reported) The same model as above, but we should add the individual dimension.	to persons aged 25 and higher. These variables are constructed using census data for the years 1970, 1980, and 1990. Values for the noncensus years are interpolated by assuming a constant rate of growth between census periods.	In the second part of the paper Ruhm uses the Behavioral Risk Factor Surveillance System Data (BRFSS, micro data), for the period 1987-1995, to examine whether individuals change their lifestyle because of the crises **Outcomes:** tobacco use and drinking, height-adjusted weight, physical activity, diet, and preventive medical care.	partially due to decreases in smoking and obesity, improved diets, and increased physical activity.	the job might imply and higher risk of accidents. **Migration flows:** in countries such as the USA, economic upturn might lead to increase in the migration flows. On the one hands this might lead to an increase in death rates because of the crowding, the importation of new disease (the underline assumption is that most of migrants come from poorer

					countries). On the other hand, since there is a selection in the migrants (healthy and young people), there might be a negative correlation between economic upturn and mortality.
Gerdtham & Ruhm (2006)- EHB	$ln(H_{jt}) = \alpha + \boldsymbol{X_{jt}\beta} + E_{jt}\gamma + \sum_{j=1}^{J} \delta_j C_j + \sum_{j=1}^{J} z_j TC_j + \varepsilon_{jt}$	The regressions control for the percentage of the population that is male and in three age ranges (15–64, 65–74, and 75+). Country fixed-effects, general time effects, and (usually) country-	Aggregate data on 23 Organization for Economic Cooperation and Development (OECD) countries over the 1960–1997. Standardized unemployment rates are our primary proxy of labor market conditions, with	The main finding is that total mortality and deaths from several common causes rise when labor markets strengthen. More precisely, a 1% point	

	Where His the mortality rate, E the unemployment rate, X a vector of regressors controlling for the age and sex distribution of population, a year-specific intercept, C a country fixed-effect, country-specific linear time trends (Cj T),and e a disturbance term. The regressions are usually estimated by weighted least squares (with observations weighted by the square root of the national population) to account for heteroscedasticity.	specific time trends are included. Logarithm of the net national disposable income per capita in thousands of the U.S.$ PPP (1990)	information supplied from two source: Rates for 10 countries (Australia, Canada, France, Germany, Italy, Japan, The Netherlands, Sweden, United Kingdom, and the United States) come from a consistent series developed by the U.S. Bureau of Labor. Standardized rates for 13 additional countries (Austria, Belgium, The Czech Republic, Denmark, Finland, Ireland, Luxembourg, New Zealand, Norway, Poland, Portugal, Spain, and Switzerland) are obtained from several issues	decrease in the national unemployment rate is associated with growth of 0.4% in total mortality and the following increases in cause-specific mortality: 0.4% for cardiovascular disease, 1.1% for influenza/pneu monia, 1.8% for liver disease, 2.1% for motor	

	There also specification unweighted and using an AR(1).		of the OECD Employment Outlook. **Outcomes:** total mortality rate and deaths from nine leading causes: malignant neoplasms (cancer), major cardiovascular (heart) disease, influenza/ pneumonia, CCLDs, motor vehicle accidents, other accidents, suicides, homicides, and infant deaths.	vehicle deaths, and 0.8% for other accidents.	
Tapia-Granados-(2008)-Demography	$\Delta H_{jt} = \alpha_t + \Delta E_{jt}\gamma \quad + \varepsilon_{jt}$, Where H is the mortality rate, E the unemployment rate (or GDP, or Labour Force Participation Rate, or Lagged GDP according to the specification choses), and Δ identifies change in the	No other controls, but for the main explanatory variable. The idea behind are not variation in the observable characteristics between two subsequent periods.	Data from Japanese Statistics Bureau starting in the 1950s (different series start in different years) and generally ending between 1995 and 2002. The author presents as main explanatory variable four indicators: unemployment rate, GDP, or Labour Force Participation Rate, or Lagged GDP of the Japanese economy.	The majority causes of death have been found to be pro-cyclical, whereas suicides have been found to be generally counter-cyclical. Although, the study highlights a higher impact	

	variable of interest. More precisely, ΔHt would correspond to (Ht - Ht-1) for the model in first difference and [ln(Ht) – ln(Ht-1)] for the model where the dependent variable is expressed in rate of change. Similarly, the economic indicator is subject to a similar transformation and embedded in the model in a similar way. It should be noticed that the original model proposed by the author used lagged values of the economic indicator for capturing possible slow response of *H* on *E*. He found evidence of no lagged effects beyond lag one and therefore reported results were		**Outcomes:** Suicides, Heart disease Cerebrovascular disease Transportation accidents, Liver disease, Pneumonia, Senility, Suicide. The outcomes are presented by gender and age group.	between 1978-2002 with focus on heart disease and suicide, while around the year 2000 the fluctuations in the business cycle has, even, an higher impact, but going in the opposite direction.	

	obtained without lagged terms.				
Stuckler et al (2009)	Using the subscripts j and t to index the country and year, the $$\Delta H_{jt} = \alpha_t + \Delta E_{jt}\gamma \;\; + \eta_t t + \mu_i t + \varepsilon_{jt}$$ where H is the mortality rate, E the unemployment rate η_t indicates a time trend and μ_i a country specific trend and Δ identifies change in the variable of interest.	But for the main explanatory variable (change in unemployment rate), only a time trend and coutry specific trend is included.	Data from WHO European Health for All database for 26 European countries covering the period 1970-2007. The unemployment rate were derived from The International Labour Organisation (ILO). GDP data in current US$ were taken from the World Bank World Development Indicators 2008 edition.28 Social expenditure data in the domains of health, unemployment, active labour market programmes, family and housing, as defined in the panel, were from the OECD Health Data 2008 edition. **Outcomes:** Wide classification of death rates, which are summarized as follows: Suicide Suicide (in people aged 0–64 years) Homicide	Rises in unemploy ment are associated with significant short-term increases in premature deaths from intentional iolence, while reducing traffi c fatalities. Active labour market programm es that keep and reintegrate workers in jobs could mitigate some	

			Drug dependence and toxicomania Alcohol abuse Accidents Drowning Poisoning Ill-defined causes Transport accidents Falls Cardiovascular disease Cardiovascular disease (in people aged 0–64 years) Ischaemic heart disease Cerebrovascular disease Psychoactive substance abuse CCLDs Ulcer Neoplasms Lung cancer Alzheimer Diabetes Diabetes (in people aged 15–44 years) Maternal mortality Infant mortality Infectious diseases Tuberculosis All-cause	adverse health eff ects of economic downturns .	

Neumayer (2004)	$ln(H_{jt}) = \alpha + \boldsymbol{X_{jt}\beta} + \boldsymbol{H_{jt-1}\lambda} + E_{jt}\gamma + \sum_{t=1}^{T} t_j T_j + \varepsilon_{jt}$ Where $\varepsilon_{jt} = u_i + \omega_{it}$	The percentage of the population under 5 years as well as those aged 65 or over as two further control variables. The percentage of foreigners among the total population. Gini coefficient as a measure of income inequality. Such data are only available from 1985 onwards	Aggregate data from e German federal statistical office for the period 1980-200. Outcomes: Overall mortality and 11 death rates 1) Malignant Neoplasms, 2) Cardiovascular Diseases 3) Pneumonia and Influenza 4) CCLDs 5) Motor Vehicle Accident 6) Other accidents 7) Suicide 8) Homicide 9) Infant Mortality 10) Neonatal Mortality 11) other external mortality. The author, beside using the overall mortality, uses as outcome the age specific mortality rates (20-44, 45-64, 65+).	Aggregate mortality rates for all age groups taken together as well as most specific age groups is pro-cyclical. The same is true for mortality from cardiovascular diseases, pneumoni	

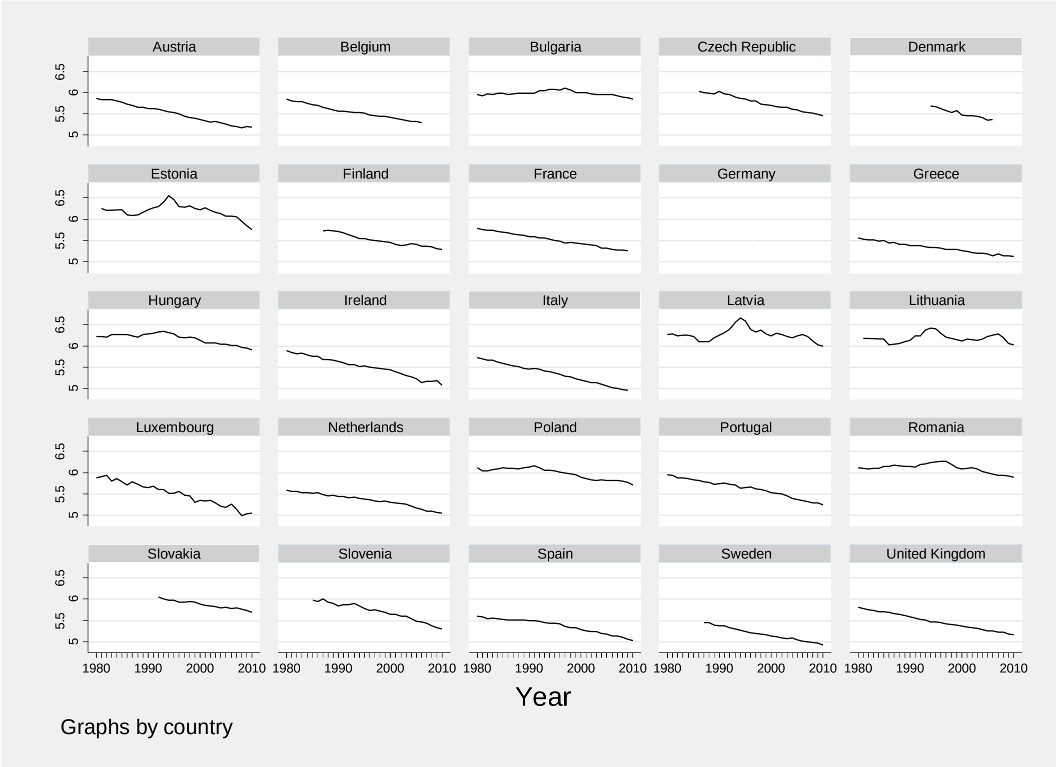
				a and influenza, motor vehicle accidents and suicides. No significant effects on homicides, other external effects and malignant neoplasms are found.	

Ruhm (2015)	$Ln(H_{jt}) = \alpha_{jt} + \boldsymbol{X_{jt}\beta} + E_{jt}\gamma + \sum_{j=1}^{J} \delta_j T_j + \sum_{j=1}^{J} z_j TC_j + \varepsilon_{jt}$ or *H* the mortality rate, *E* the proxies for economic conditions, *X* a vector of supplementary regressors, and e the error term. The fixed-effect α_{jt} controls location fixed effects, T is a general time trend and TC represents state-specific trends.	The percentage of the state population who are female, non-white, Hispanic, and by age groups (<1, 1-19, 45-54, 55-64, 65-74, 75-84, >=85).	Aggregate data from Compressed Mortality Files for the period 1976-2010. **Outcomes:** Overall mortality and 11 death rates 1) Malignant Neoplasms, 2) Cardiovascular Diseases 3) Other diseases 4) Motor Vehicle Accident 5) Other accidents 6) Suicide 7) Homicide 8) Falls 9) Drowning/submersions 10) Smoke/Fire/Flames 11) Poisoning/noxious. The author, beside using the overall mortality, uses as outcome the age specific mortality rates (<25, 25-44, 45-64, 65-74, >=75) and gender specific ones.	Deaths due to cardiovascular disease and transport accidents continue to be pro-cyclical (although possibly less so than in the past), whereas strong counter-cyclical patterns of	The changing effect of macroeconomic conditions on cancer deaths may partially reflect the increasing protective influence of financial resources, perhaps because these can be used to obtain sophisticated (and expensive) treatments that have become available in recent years. That observed for accidental poisoning probably has occurred because declines in mental health during economic downturns are increasingly associated with the use of

				cancer fatalities and some external sources of death (particularly those due to accidental poisoning) have emerged over time.	prescribed or illicitly obtained medications that carry risks of fatal overdoses.

Appendix 4:

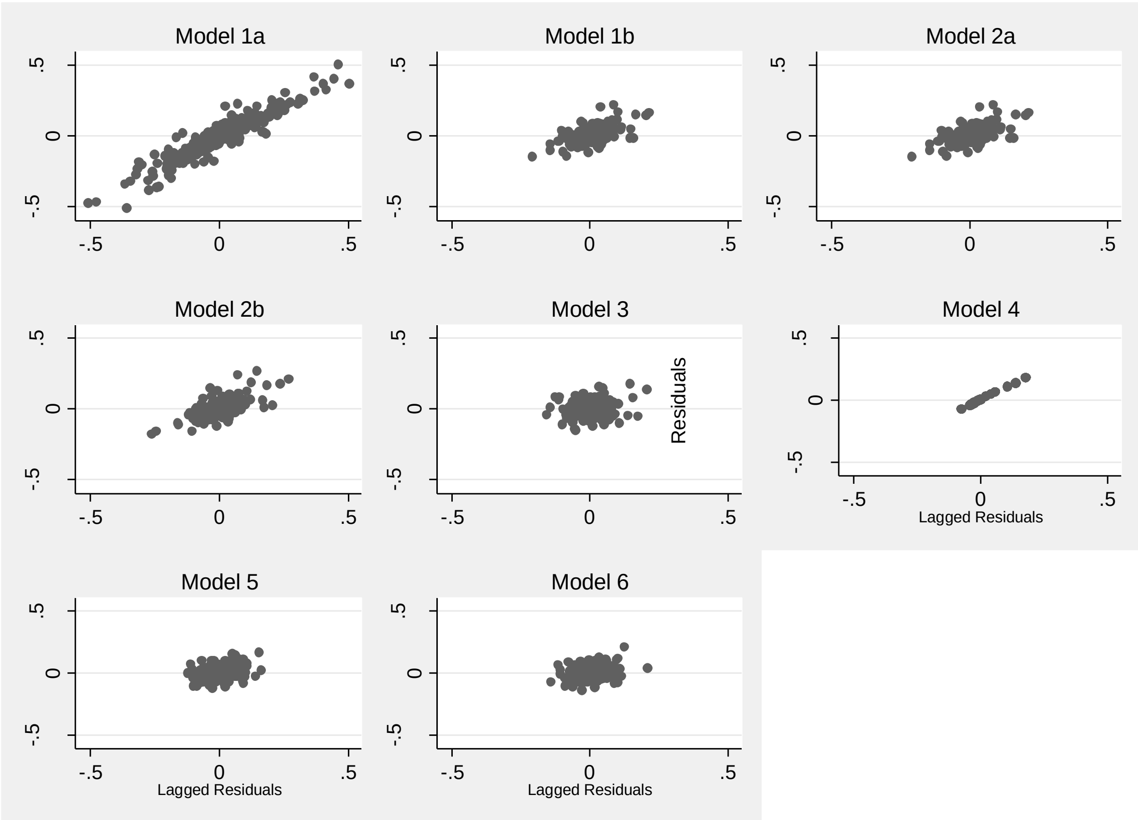
Stationarity in the Series



Fisher Test for panel unit root using an augmented Dickey-Fuller test (p-value) 0.0035

Appendix 5:

Residuals of the Model: Overall Mortality



Appendix 6:

Durbin-Wu-Hausman Test for Endogeneity

To gather evidence about the consistency of OLS estimates we estimate for each cause of mortality a Durbin-Wu-Hausman test.

We suspect that the association between unemployment rate and mortality rates is endogenous, to this end we follow four steps:

1. Run the reduced form regression against the endogenous variable (i.e. unemployment rate) using as instruments the lagged dependent variable

2. Extract the residuals

3. Run the main equation including these residuals as explanatory variables

4. Test if the residual is significantly different from zero using a F test, then we cannot reject the hypothesis of endogeneity.

	Malignant neoplasms	**CVDs**	**Accidents**	**Suicides**	**Vehicle Accidents**	**CCLDs**	**Pneumonia**	**Homicides**	**All Causes**
F-test	100.653	166.637	195.529	99.079	145.334	131.889	34.037	58.355	134.9
p-value	0	0	0	0	0	0	0	0	0

Appendix 7:

Wooldridge Test for Serial Autocorrelation

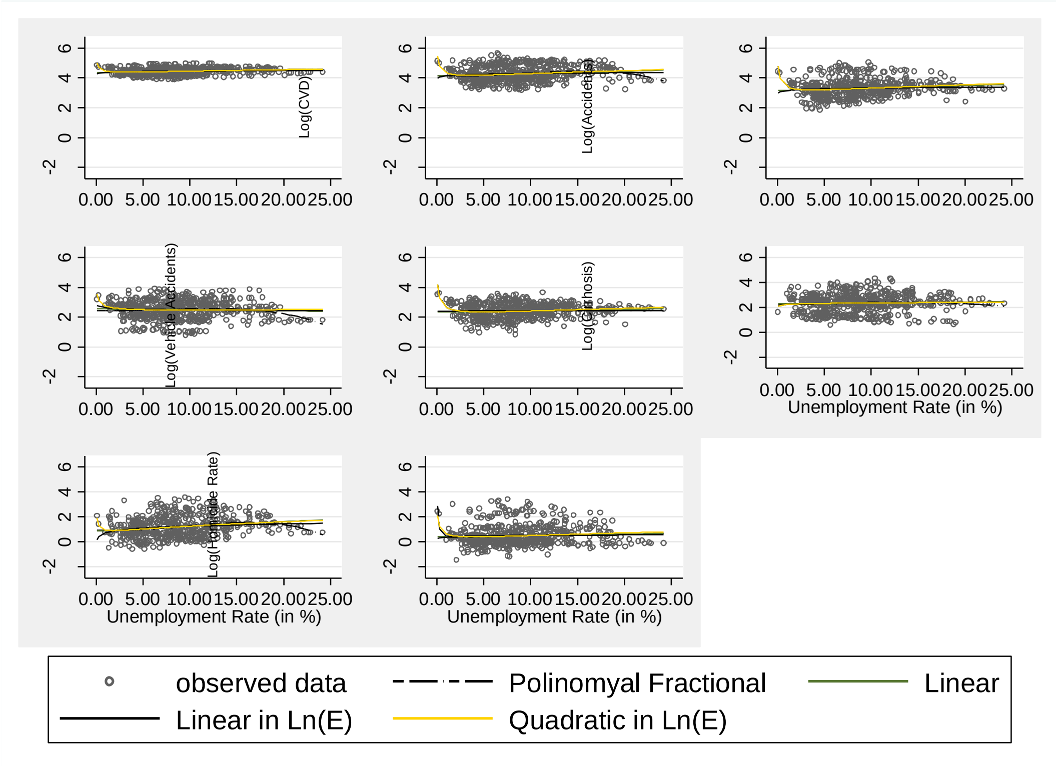
To gather evidence about the potential autocorrelation issue in our panel, we run a Wooldridge test for serial autocorrelation.

Wooldridge's procedure estimates the β1 by regressing ΔY_{it} on ΔX_{it} and obtaining the estimated residuals $\widehat{e_{it}}$. Central to this procedure is Wooldridge's observation that, if the it are not serially correlated, then Corr($\Delta\widehat{e_{it}}$, $\Delta\widehat{e_{it-1}}$) = −.5. Given this observation, the procedure regresses the residuals $\widehat{e_{it}}$ from the regression with first-differenced variables on their lags and tests that the coefficient on the lagged residuals is equal to −.5.

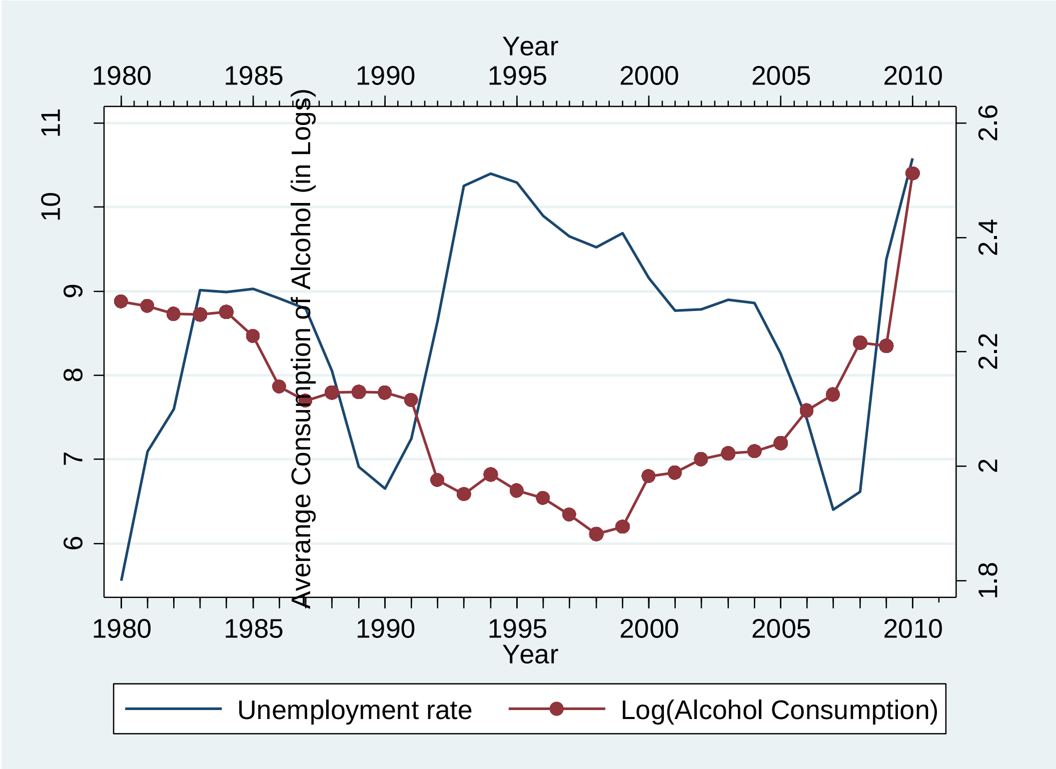
	Malignant neoplasms	**CVDs**	**Accidents**	**Suicides**	**Vehicle Accidents**	**CCLDs**	**Pneumonia**	**Homicides**	**All Causes**
F-test	2.348	4.661	22.092	8.310	31.192	48.391	0.289	21.077	17.624
p-value	0.139	0.041	0	0.008	0	0	0.596	0	0

Appendix 8:

Estimated form of the cause-specific mortality-unemployment relationship


Log(CVD)
Log(Accidents)
Log(Vehicle Accidents)
Log(Cirrhosis)
Log(Homicide Rate)
Unemployment Rate (in %)
observed data
Polinomyal Fractional
Linear
Linear in Ln(E)
Quadratic in Ln(E)

Appendix



Year
1980
1985
1990
1995
2000
2005
2010
11
10
9
8
7
6
Averange Consumption of Alcohol (in Logs)
2.6
2.4
2.2
2
1.8
Year
Unemployment rate
Log(Alcohol Consumption)