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Abstract

We study whether mortality responds non-linearly and asymmetrically to unemployment in the context of national economic crises. Although both the assumption of linearity and symmetry have been challenged in other domains, this has been hitherto neglected in the mortality-unemployment literature. Greece offers an ideal setting to our study as unemployment had been moderately falling for about a decade till mid-2008 when it sharply and suddenly increased as a result of a severe economic crisis. Contrary to previous literature, our results from regional panel data estimates (1999q1-2013q4) indicate a countercyclical behaviour of total mortality and a further deteriorating crisis effect. We provide robust evidence that mortality is both non-linear and asymmetric, which suggests that the effect on the number of deaths changes for very high values of unemployment and depends on its direction. Both non-linearity and asymmetry are driven by those above 65 years old. Our findings have important methodological implications and suggest that empirical investigations on fluctuations, recessions and mortality should consider possible non-linear and asymmetric behaviours.

Keywords: Mortality; Unemployment; Crisis; Non-linearity; Asymmetry; Greece

JEL classification: I10; E32; J60

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1. Introduction

The empirical literature on the relationship between mortality and unemployment has typically revolved around the assumptions of linearity and symmetry (Ruhm 2000; Ruhm 2007; Ruhm 2015). Under linearity, mortality responses are assumed to be equal regardless of the level of unemployment and under symmetry these responses are independent of the direction in which unemployment changes. Several economic applications outside the health domain have challenged these assumptions on both theoretical and empirical grounds. Neftçi (1984) provided evidence that unemployment, like most major economic time series, exhibits an asymmetric behaviour with sudden jumps and lower drops. His findings were confirmed by a number of other studies (Brunner 1997; Rothman 1991) leading McQueen and Thorley (1993) to argue that empirical results assuming symmetrically behaving macroeconomic indicators should be interpreted with caution. A more recent stream of research analyses whether these behavioural characteristics of the economy affect the relationship of economic indicators with other variables. For example, using US panel data, Mocan and Bali (2010) unravelled asymmetric unemployment effects on criminal activity but found no evidence of non-linearities.

In this paper we argue that, in the context of national crises, it is important to consider both the direction and the level of unemployment when studying its associations with mortality for a number of reasons. Asymmetrically behaving business cycles may shape the expectations and beliefs of individuals regarding the economy in a differentiated way (Neftçi 1984). Household budget allocation decisions can be different during recessionary and non-recessionary periods. Consequently, health expenditure and food consumption that affect overall and cause-specific mortality may respond in an analogous way. Moreover, policy reforms and decisions depend on the phase of the business cycle, e.g. health budget and unemployment benefits can be slowly increasing during good times but they could be suddenly and severely cut while in recession. In addition, lifestyle choices adopted during positive economic climates could be hard to change when recessions hit in a sharp and unexpected way. Harris and Gonzalez Lopez-Valcarcel (2008) provided evidence of asymmetric properties in health behaviours with respect to information received by peers. They showed that the presence of one non-smoking sibling in the family reduces a young person’s probability to smoke by 4% while the presence of a smoking sibling implies an 8% increase in the same probability. Finally, allocation decisions between work and leisure based on the opportunity cost of time also depend on the state of the economy. Intertemporal substitution suggests that individuals respond to transitory economic conditions by deferring time-intensive health investments or adoption of alternative life style choices (Ruhm 2000). As leisure time becomes less costly during economic downturns and a recession deepens and becomes more long-lasting, then individuals could adjust their health behaviours.

Despite the bulk of evidence with respect to the mortality implications of unemployment, the issues of non-linearity and asymmetry remain largely unexplored, especially in the context of national economic crises. Ruhm (2016) showed that severe national recessions appear to have a large and protective effect on overall mortality in the US beyond the association with unemployment fluctuations. Bonamore et al. (2015) provided evidence of a U-shaped relationship using regional data from 23 European countries for the period 2000-2012. However, their models did not consider possible asymmetries and did not control for recessionary periods or countries in recession. Hence, any autonomous crisis effects beyond the relationship with unemployment were not disentangled from their results. Moreover, each economic crisis contains its own idiosyncratic elements in terms of individual behaviours, social norms and institutions (Ruhm 2016).[1] Wu and Cheng (2010) using time series data from the US for the period 1951-2005 provided evidence of asymmetric suicide cycles but symmetric overall mortality, arguing that most causes of mortality are not directly chosen by individuals, therefore one cannot expect them to respond asymmetrically to economic fluctuations.

In this paper we explore how mortality responds to unemployment in the context of a severe national crisis. Greece offers an ideal setting for our investigation. Since the beginning of the 2008 financial crisis, unemployment skyrocketed to unprecedented levels, the highest among all European countries. In early 2010, a series of tough austerity measures were taken, after the country's deficit approached 16% of GDP. In the years that followed, and as the financial situation was getting worse, Greece signed three Memoranda of Understanding in order to secure financial support from the International Monetary Fund, the European Union and the European Central Bank. The loans were conditional on the implementation of specific reforms in a number of sectors, including pensions, health systems and the labour market.

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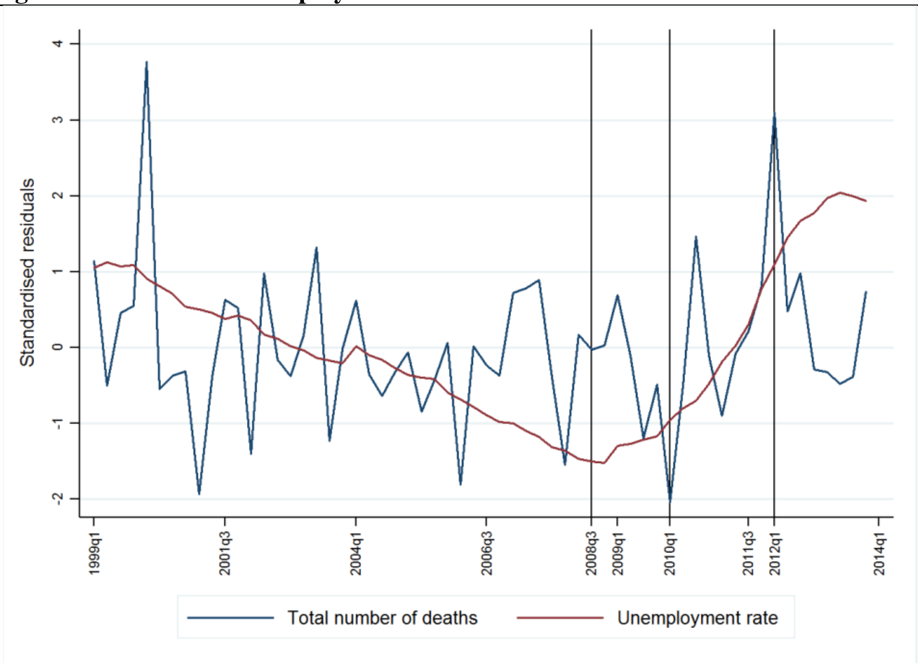
[1] For example, the breakup of the Soviet Union was followed by a severe drop in life expectancy, partially due to declines in alcohol prices (Brainerd and Cutler 2005). On the other hand, the 2008 Icelandic banking crisis was followed by persistent health enhancing behaviours linked to the increased prices of alcohol and cigarettes (Ásgeirsdóttir et al. 2014; Ásgeirsdóttir et al. 2016).

Figure 1 displays the evolution of overall mortality and unemployment in Greece over the total period of investigation. It indicates a possible asymmetric behaviour of unemployment with a slow drop for about a decade followed by a sudden jump in 2008 from a national average of 7.8% to 27.5% in 2013 (EL.STAT. 2015). Unemployment and mortality move together over time; they both have a downward trend before the crisis, which reverses suddenly after 2008q3. However, after 2012, and when unemployment reaches its highest values, the two variables seem to follow different directions. Unemployment continues to increase while mortality starts falling. This latter observation may indicate a non-linear relationship between the two variables.

Figure 1. Deaths and unemployment in Greece



Source: Hellenic Statistical Authority (EL.STAT).
Notes: Population weighted residuals for unemployment rate and total death count are obtained from weighted regressions on time trends, regional and time fixed effects. They are collapsed by quarter and standardized to zero means and unit standard deviations. Vertical lines indicate the beginning of the economic crisis (2008q3) and the fiscal consolidation (2010q1, 2012q1) periods.

In order to investigate the mortality implications of unemployment and the national crisis we use quarterly regional panel data for the period 1991q1-2013q4. Contrary to previous literature we find that mortality is countercyclical and the crisis has had an overall deteriorating effect. Relaxing the linearity assumption reveals that for very high levels of unemployment observed towards the end of our sample period, the relationship between unemployment and mortality becomes negative. The hypothesis of a symmetric relationship is also rejected for total and a series of cause-specific deaths. Both asymmetry and non-linearity seem to be driven predominantly by those above 65 years of age. Although the underlying mechanisms driving the results cannot be identified with aggregated data, we discuss possible explanations and implications. Our study contributes to the literature by being the first one to examine the implications of economic fluctuations within a national crisis context on mortality departing from the typically adopted linear and symmetric framework.

The remainder of the paper is structured as follows. Section 2 outlines the empirical methodology. Section 3 presents the data. Section 4 discusses the results and Section 5 concludes.

2. Empirical methodology

The literature employs regional panel data methods to estimate the relationship between mortality and economic conditions. The effect of unemployment is assumed to be linear, symmetric and it is identified through conditional within-area variation (Ruhm 2000; 2007; 2015). Health effects of national crises are captured by recessionary period indicators but without controlling for year fixed effects since the latter would absorb any country-wide effects (Ruhm 2016).

We begin our investigation by estimating some baseline mortality equations in order to provide some first empirical evidence for Greece. However, given the rapid increase in the unemployment rate during the crisis period, we relax the assumption of a linear relationship between mortality and unemployment and introduce a quadratic unemployment term. Hence the relationship between the two variables is allowed to depend on the level of unemployment, indicating the existence of possible nonlinearities. In order to avoid transforming the dependent variable, especially when there are cells with zero death counts for certain subgroups, we estimate negative binomial regression analogues of the following model specification:[2]

$$m_{rt} = \alpha_r + \beta_1 U_{rt} + \beta_2 U_{rt}^2 + \gamma^k X_{rt}^k + T_{rt} + \zeta^\tau N_t^\tau + \delta t + u_{rt} \quad (1)$$

where m_{rt} is the death count observed in the *r*-th region during period *t*. General economic conditions are proxied by the regional unemployment rate U_{rt}, *k* controls for the size and the demographic composition of the local population are contained in the *X* vector, α are region fixed effects controlling for time-invariant disparities across regions (e.g. lifestyle differences, geographical isolation) and *T* are regional linear time

[2] Typically, logged death rates per 100,000 population are used as dependent variables. However, this has been shown to lead in biased OLS estimates (Silva and Tenreyro 2006). Miller (2009) and Mocan and Bali (2010) have used Poisson and negative binomial models instead.

trends controlling for unobservable time-varying confounders. N_t^{τ} is a set of τ indicators regarding the recessionary period and two subsequent sub-periods. More specifically, there is a post-2008q3 binary variable indicating the crisis period, i.e. when the national and regional unemployment rates started to rise, a post-2010q1 indicator indicating the period when some fiscal consolidation measures began being implemented (e.g. public sector pay cuts) and a post-2012q1 indicator when further austerity measures were introduced (e.g. legislative reduction of the national minimum wage by 32%, substantial restructuring of the labour relations framework). The estimated coefficients of these indicators will signify any mortality effects of the national recession beyond those expected from unemployment fluctuations. Given that our sample period can be split into two distinct sub-periods, a non-recessionary and a recessionary one, and in the absence of year fixed effects due to the introduction of the period-specific indicators, we include a general time trend (in linear and quadratic form) so the coefficients of interest can be estimated net of the fact that mortality can be declining or growing over time (depending on the sign and magnitude of $\hat{\delta}$) for reasons that are common across regions and unrelated to the other variables.

In this framework the association between mortality and economic conditions is given by $\vartheta m_{rt}/\vartheta U_{rt} = \hat{\beta}_1 + 2\hat{\beta}_2 U_{rt}$ and it is evaluated at the mean and across the unemployment rate distribution. Since unemployment is used as an indicator of economic activity this should not indicate that deaths are caused from job loss or transition from employment to unemployment.[3] They are only indicative about whether mortality is procyclical ($\vartheta m_{rt}/\vartheta U_{rt} < 0$), countercyclical ($\vartheta m_{rt}/\vartheta U_{rt} > 0$) or unrelated to transitory changes in local economic conditions. The signs and magnitudes of $\hat{\beta}_1$ and $\hat{\beta}_2$ will also determine the shape of this relationship. Overall, a positive relationship between the total death count and unemployment should be expected as the two variables seem to evolve together (Figure 1). However, mortality is trending downwards when very high values of unemployment are observed towards the end of the period, suggesting that a reversed sign could be detected.

Apart from linearity, we also relax the symmetry assumption by allowing the conditional mean count of deaths to follow two different paths, depending on the change (increase or decrease) in unemployment, i.e. on whether the Greek economy is in a recession or not, i.e. following Mocan and Bali (2010):

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[3] Using administrative data, Sullivan and von Wachter (2009) estimated increased mortality rates for individuals who lost their job.

$$m_t = b_0 + b_1 U_t^+ + b_2 U_t^- + e_t \tag{2}$$

where $U_t^+ = \begin{cases} U_t, & U_t \geq U_{t-1} \\ 0, & U_t < U_{t-1} \end{cases}$ and $U_t^- = \begin{cases} U_t, & U_t < U_{t-1} \\ 0, & U_t \geq U_{t-1} \end{cases}$.

This implies that:

$E(m_t) = b_0 + b_1 U_t^+$ for $U_t - U_{t-1} \geq 0$

$E(m_t) = b_0 + b_2 U_t^-$ for $U_t - U_{t-1} < 0$.

Given the regional panel data used here, the empirical model exploring possible asymmetries is specified as follows:

$$m_{rt} = \alpha_r + b_1 U_{rt}^+ + b_2 U_{rt}^- + \gamma^k X_{rt}^k + T_{rt}\zeta^\tau + N_t^\tau + \delta t + \varepsilon_{rt} \tag{3}$$

According to this specification a rejection of the null hypothesis H_0: $b_1 = b_2$ would indicate that unemployment affects deaths in an asymmetric way depending on the trajectory it is moving into; downward for the period before and upward for the period during the economic crisis.[4] In further checks we examine whether the impact of a decrease and an increase in unemployment has a differentiated impact over time and whether there are any detectable period-specific non-linearities.

3. Data and descriptive statistics

Data on death counts have been provided by the Hellenic Statistical Authority (EL.STAT) under a special licence agreement. These are administrative data regarding the exact number of deaths by region, gender, age, cause and month for the period between January 1999 and December 2013. They are collected and processed through an electronic registration system of the Ministry of Interior that is automatically updated every time a vital event occurs. This minimizes the risk of a reporting or measurement error.[5] Regions follow the NUTS-II taxonomy (13 regions), age is reported in 16 categories (≤14, 15-19, 20-24… 80-85, >85) and the 56 underlying causes of death follow the 10th revision of the International Statistical

[4] Neftçi (1984) demonstrates that dividing the sample into two sub-periods (recessionary and not) and comparing estimates obtained from regressions on each separate subsample could lead to biased results. In a different context, Ruhm (2015) split his sample to demonstrate the decreasing procyclicality of mortality over time using US data for 1976-2010.

[5] We acknowledge there may be some bias in the reporting of certain mortality causes such as suicides, due to social stigma and religious reasons. Also adverse events may be underreported. However, there is no evidence that patterns in the reporting of these mortality causes has changed over the period we examine. Therefore, our analysis is not affected.

Classification of Diseases and Related Health Problems (ICD-10). We decided to focus our analysis on the most frequent causes of death in Greece and the main causes discussed in the area of economic fluctuations and mortality internationally (overall 11 causes as seen in Table 1). Regional data on quarterly unemployment and population size are publicly available from the EL.STAT. Moreover, using the Quarterly Labour Force Survey (LFS) over the period 1999q1-2013q4, we have calculated weighted shares for a number of demographic and other characteristics in order to control for the composition of the regional population, i.e. shares of females, those aged 0-19, 45-54, 55-64, 65-74 and more than 75 years old, shares of non-Greeks or EU citizens, those living in rural areas, those uninsured and those working in their family business. We have also used the LFS to calculate quarterly time series of regional populations as an alternative to the totals publicly announced by the EL.STAT. Merging all data together resulted in a balanced panel of 13 regions observed for 60 quarters.

Table 1 displays some key descriptive statistics. Demographic characteristics have evolved slowly over time. However, unemployment increased from an average of 10.5% to 16.8% during the crisis, escalating to more than 30% in some regions. Moreover, it became much more volatile; the standard deviation is 2.9 and 7.2 for the periods before and during the crisis, respectively.

Statistics on death counts are displayed in the lower panel of Table 1. Total mortality increased from a regional mean of 2,015 deaths per quarter to 2,121 deaths in the crisis subperiod. The mean difference, obtained as a marginal effect from a negative binomial regression of total deaths on a crisis indicator and regional population size, is statistically significant at the 5% level. This increase is more pronounced for females and for those over 75 years old. Total deaths are significantly lower for those below 44 years old and for those in the 65-74 years old age band. Looking at specific death causes, significantly fewer deaths associated with vehicle accidents and circulatory system diseases are observed during the crisis. At the same time, increased death counts are observed for all the other causes considered here, except for those related to mental health which have remained unchanged.

Table 1. Descriptive statistics

	Before crisis: 1999q1-2008q2				During crisis: 2008q3-2013q4				Mean
Demographics	Mean	Std.Dev	Min.	Max.	Mean	Std.Dev	Min.	Max.	difference
Unemployment rate	10.50	2.94	3.20	21.90	16.81	7.22	2.90	32.60	6.03[a]
% female	50.67	0.63	48.95	51.93	50.91	0.54	48.78	51.95	0.24[a]
% ≤19 years old	21.77	1.71	18.53	25.88	20.46	1.44	18.15	24.32	-1.31[a]
% 45-54 years old	12.76	0.63	11.60	14.23	13.57	0.60	12.39	14.86	0.79[a]
% 55-64 years old	11.27	0.76	9.54	12.65	11.94	0.64	10.55	13.29	0.64[a]
% 65-74 years old	10.17	1.45	7.64	13.34	10.23	1.10	7.62	11.89	-0.95[a]
% ≥75 years old	8.11	1.64	4.94	11.79	10.42	1.59	6.82	13.00	2.26[a]
% non-Greeks/EU	2.73	1.62	0.1	7.89	4.66	2.11	1.25	9.94	1.82[a]
% in rural areas	36.77	14.17	0.65	65.54	35.74	14.33	0.47	63.85	-0.78[a]
% uninsured	3.80	0.99	1.17	6.93	4.68	1.55	1.30	10.27	0.86[a]
% in family business	9.83	3.86	2.26	21.06	7.14	2.47	1.34	12.88	-2.80[a]
% high-school	21.36	3.12	14.81	29.59	23.93	2.30	18.61	29.89	2.50[a]
% in constructions	3.42	0.73	1.86	5.59	2.76	1.03	1.07	5.44	-0.67[a]
Death counts (ICD codes)*									
Total	2,015.1	2,108.5	503	10,292	2,121.4	2,266.9	511	10,917	66.74[b]
Males	1,054.0	1,077.6	250	5,241	1,100.1	1,151.7	258	5,499	25.74[c]
Females	961.1	1,032.0	229	5,051	1,020.4	1,116.2	213	5,418	41.17[b]
≤24 years old	28.91	33.9	1	186	20.2	23.4	0	115	-10.28[a]
25-44 years old	59.85	74.1	5	336	53.8	69.4	4	344	-8.68[a]
45-64 years old	244.1	291.8	36	1,316	250.4	303.9	40	1,347	2.74
65-74 years old	403.7	440.7	68	2,286	321.3	360.9	54	1,616	-110.05[b]
≥75 years old	1,278.6	1,283.7	314	6,448	1,475.7	1,516.6	365	7,623	170.60[a]
Suicides (54)	6.9	6.9	0	39	8.5	9.8	0	66	1.20[a]
Homicides (55)	2.2	3.4	0	23	3.1	5.4	0	29	0.67[a]
Vehicles (47)	36.2	38.3	1	201	25.7	27.8	1	153	-12.09[a]
Circulatory (25-30)	981.7	996.1	227	5,070	917.0	954.8	190	4,933	-95.28[a]
Cancer (08-14,16-17)	481.7	528.9	104	2,318	532.6	606.3	95	2,649	39.38[a]
Nervous (22)	23.5	25.0	1	121	31.5	36.1	2	189	7.20[a]
Respiratory (31-32)	156.4	190.9	23	1,254	204.8	241.1	31	1,338	50.01[a]
Digestive (33-34)	47.4	53.7	3	283	52.5	57.9	6	278	5.65[b]
Mental (21)	2.4	3.1	0	23	2.3	2.8	0	17	-0.65
Infectious (01-07)	13.7	16.8	0	127	20.7	19.8	0	103	7.92[a]
Adverse events (49)	1.5	2.5	0	16	2.1	3.5	0	25	0.67[a]
Observations		494				286			

Source: Hellenic Statistical Authority (EL.STAT) and Labour Force Survey (LFS).
Notes: [a],[b] and [c] indicate whether the differences in means (average marginal effects obtained by negative binomial regressions of each variable on a post-2008q3 crisis indicator and local population size) are statistically significant at the 1%, 5% and 10% level, respectively. [*] International Classification System of Diseases and Related Health Problems (version 10.0) codes in parentheses.

4. Results

4.1 Baseline model

Table 2 displays parameter estimates obtained from negative binomial regressions of a baseline model. The results indicate a positive and weak relationship between the number of deaths and unemployment. Controlling for time effects attenuates the estimated unemployment coefficient (column 3) indicating that a 1 percentage point rise in unemployment increases total death count by 0.18% (3.7 more deaths for a total period sample mean of 2,054). The results are similar if controls for a linear time trend and regional time trends are included (column 5). The estimated coefficient of the time trend implies that the total number of deaths get smaller by 0.31%, on average, each quarter (5.78 less deaths).

Including a quadratic time trend further deflates the unemployment coefficient, signifying that unemployment changes by one percentage point, death count changes by 0.10% (3.3 deaths) in the same direction. Specifying a quadratic function of time indicates that the number of deaths decreases by 0.27% each quarter, or 4.9 less deaths.[6] As a robustness check, in column (7) we exclude Attica, which is the largest and most densely populated region, but the results remain intact. Population weighting does not seem to play a major role either. In panel A we do not control for population size, in panel B we include the estimated population obtained from the LFS and in panel C the population size reported in the official EL.STAT regional unemployment announcements. Our estimations carry on controlling for the LFS population.

Table 2. Overall mortality regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: No control for population size							
Unemployment	.00426[a] (.00074)	.00217[c] (.00124)	.00180[c] (.00103)	.00084 (.00054)	.00159[a] (.00053)	.00102[b] (.00047)	.00104[b] (.00050)
Dispersion parameter	.00501[a] (.00024)	.00208[a] (.00025)	.00172[a] (.00017)	.00149[a] (.00013)	.00170[a] (.00047)	.00169[a] (.00013)	.00176[a] (.00013)
Panel B: LFS control for population size							
Unemployment	.00431[a] (.00073)	.00242[c] (.00130)	.00176[c] (.00097)	.00061 (.00051)	.00141[b] (.00057)	.00090[c] (.00049)	.00114[b] (.00049)
Dispersion parameter	.00491[a] (.00026)	.00205[a] (.00023)	.00170[a] (.00016)	.00148[a] (.00013)	.00169[a] (.00014)	.00168[a] (.00013)	.00176[a] (.00013)
Panel C: EL.STAT control for population size							
Unemployment	.00428[a] (.00072)	.00242[c] (.00131)	.00177[c] (.00098)	.00059 (.00051)	.00140[b] (.00057)	.00091[c] (.00049)	.00113[b] (.00048)
Dispersion parameter	.00490[a] (.00026)	.00205[a] (.00023)	.00170[a] (.00016)	.00148[a] (.00013)	.00169[a] (.00014)	.00168[a] (.00013)	.00176[a] (.00013)
Observations	780	780	780	780	780	780	Excl. Attica
Regional fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarter fixed effects	-	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	-	Yes	Yes	Yes	-	-	-
Demographics	-	-	Yes	Yes	Yes	Yes	Yes
Regional time trends	-	-	-	Yes	Yes	Yes	Yes
Linear time trend	-	-	-	-	Yes	Yes	Yes
Quadratic time trend	-	-	-	-	-	Yes	Yes

Source: Hellenic Statistical Authority (EL.STAT), Labour Force Survey (LFS).
Notes: Negative binomial regression parameter estimates. The dependent variable is the death count. Demographics include the regional shares of: females, aged ≤19, 45-54, 55-64, 65-74 and ≥75 years old, non-Greeks/EU citizens, living in rural areas, uninsured, working in their family business, secondary education graduates and construction workers. Robust standard errors clustered by region in parentheses. [a] p<.01, [b] p<.05, [c] p<.1.

[6] The estimated coefficient of the linear time trend is -0.00416 (se=0.00137). In the quadratic version the time trend coefficient is -0.00642 (se=0.00183) and the coefficient of the squared trend is 0.00004 (se=0.00002), indicating a slower decline of mortality during the crisis, as shown in an earlier descriptive work (Laliotis, Ioannidis, and Stavropoulou 2016).

The dispersion parameter is small but highly significant across all specifications justifying the choice of the negative binomial count data model over a Poisson one that comes with an equidispersion assumption.[7]

4.2 Non-linear specifications

Table 3 presents the results from estimating variants of equation (1) to provide further insights by relaxing the assumption of non-linearity. The estimated coefficient of the squared interaction term is small but significant. The results suggest that overall mortality is countercyclical and increases by 0.21% (4.26 more deaths) for every percentage point rise in unemployment. However, the relationship changes for high levels of unemployment, i.e. for more than 24%, that were first observed in late 2012. Again, excluding Attica does not cause significant changes. Some basic specification tests indicate that the unemployment coefficients are statistically different from each other and jointly significant supporting the adoption of a non-linear specification.

Table 3. Total mortality regressions: Non-linearities and the impact of recessions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Unemployment (β_1)	.00450[a] (.00147)	.00433[a] (.00154)	.00397[a] (.00134)	.00466[c] (.00241)	.00721[a] (.00176)	.00644[a] (.00246)	.00576[b] (.00257)
Unemployment squared (β_2)	-.00009[c] (.00005)	-.00008 .00005	-.00008 (.00005)	-.00010 (.00007)	-.00023[a] (.00006)	-.00020[b] (.00008)	-.00018[b] (.00009)
Post-2008q3 indicator	-	-	.00958 (.00794)	-	-	.00881 (.00737)	.00922 (.00832)
Post-2010q1 indicator	-	-	-	-.00167 (.01244)	-	.00316 (.01127)	.00784 (.01190)
Post-2012q1 indicator	-	-	-	-	.05579[a] (.01086)	.05617[a] (.00987)	.05794[a] (.01070)
$\vartheta m_{rt}/\vartheta U_{rt}$	.00210[a] (.00057)	.00227[a] (.00061)	.00205[a] (.00056)	.00215[a] (.00071)	.00137[b] (.00060)	.00122[c] (.00067)	.00121[c] (.00069)
Turning point	24.06%	26.98%	26.44%	23.84%	15.82%	15.80%	16.26%
F-test: $\beta_1 = \beta_2 = 0$, $\chi^2(2)$	15.00[a]	14.42[a]	14.35[a]	9.58[a]	17.34[a]	6.87[b]	5.26[c]
F-test: $\beta_1 = \beta_2$, $\chi^2(1)$	9.19[b]	7.72[a]	7.49[a]	3.68[c]	16.68[a]	6.84[a]	5.02[b]
F-test period indicators, $\chi^2(3)$	-	-	-	-	-	48.06[a]	52.59[a]
Observations	780	Excl. Attica	780	780	780	780	Excl. Attica
Regional fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarter fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demographics	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regional time trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: Hellenic Statistical Authority (EL.STAT), Labour Force Survey (LFS).
Notes: Negative binomial regression parameter estimates. The dependent variable is the death count. All models control for the local population size (LFS). Robust standard errors clustered by region in parentheses. [a] p<.01, [b] p<.05, [c] p<.1.

[7] We have estimated all models using OLS and Poisson estimators for various transformations of the dependent variable. Although in the case of total mortality the results are similar, there are sizable differences when considering age and cause-specific deaths. The results are available from the authors upon request.

In the remaining columns of Table 3 we examine whether the economic crisis has been associated with mortality outcomes beyond those attributed to unemployment fluctuations. Controlling for the post-2008q3 period where unemployment trended upwards does not affect the results; the estimated coefficient of the crisis indicator is positive but not significant. The same holds after controlling for the post-2010q1 period indicating the beginning of the fiscal consolidation period which has been extensively considered to have had deteriorating public health effects. However, once a post-2012q1 indicator is included, the estimated unemployment effect drops by approximately 35% indicating that a 1 percentage point rise in unemployment increases deaths by 0.14% (2.65 more deaths). Moreover the post-2012q1 period, characterized by the implementation of further austerity measures, has a statistically significant deteriorating effect. As compared to the previous period, the mean death count is increased by approximately 5.6% (114.6 more deaths). Moreover, controlling for crisis and austerity periods indicates that the countercyclical link between total deaths and unemployment could have changed sign in an earlier point of time, when unemployment increased to 16% in early 2011.[8]

Equation (1) is also estimated separately for gender, age groups and causes of death. The results are reported in Table 4. Although not statistically significant, the relationship with unemployment is greater for females but it is behaving the same way for both genders. Females are also hit harder when considering the crisis per se, as seen from the parameter estimates of the period indicators. For instance, about two thirds of the increased mean total death count in the post-2012q1 period concerned women. Unemployment does not seem to be correlated with mortality for the younger group. Also, the crisis has a largely protective effect for those below 44 years old. We find some evidence of a procyclical mortality for those 45-64 years old, however, the crisis has a deteriorating effect on them. This effect is even larger for those older than 65 years, plus a positive relationship with changes in economic conditions. It is interesting to observe that the relationship changes sign first for those over 75 years old and then for those in the 65-74 years old age band.

[8] Ideally, we would like to have quarterly time series on healthcare indicators per region. However, such data of good quality are not available. Moreover, given the centralization of the Greek healthcare system one should not expect to see a significant degree of variation across regions. Hence, including crisis period indicators is expected to adequately absorb the impacts of crisis and austerity.

Table 4. Results by gender, age and cause of death

	Males	Females	≤24 years	25-44 years	45-64 years	65-74 years	≥75 years	Suicides	Homicides
Unemployment	.00657[a] (.00238)	.00695[b] (.00282)	.01628 (.01031)	.00382 (.00968)	-.00616 (.00389)	.00705[b] (.00335)	.00972[a] (.00256)	.00416 (.02145)	.00140 (.03790)
Unemployment squared	-.00022[a] (.00008)	-.00021[b] (.00009)	-.00045 (.00031)	-.00029 (.00028)	.00009 (.00012)	-.00018[c] (.00010)	-.00031[a] (.00009)	.00038 (.00063)	-.00022 (.00113)
Post-2008q3 indicator	.01239[b] (.00619)	.00260 (.01010)	-.01063 (.02779)	-.06705[b] (.03305)	.00336 (.01471)	.01178 (.01035)	.01031 (.00767)	.07528 (.06377)	-.15721 (.13483)
Post-2010q1 indicator	-.01434 (.00882)	.02202 (.01398)	.00649 (.04742)	-.07249 (.04526)	.00997 (.01596)	-.03126[c] (.01747)	.00736 (.01259)	-.06180 (.08692)	-.29536[b] (.12028)
Post-2012q1 indicator	.04155[a] (.01105)	.07275[a] (.01088)	-.10363[b] (.04865)	-.01213 (.05072)	.02956[c] (.01541)	.04086[a] (.00999)	.06392[a] (.01334)	-.16300[b] (.08290)	-.08640 (.16986)
$\vartheta m_{rt}/\vartheta U_{rt}$	.00098 (.00068)	.00148 (.00104)	.00475 (.00436)	-.00355 (.00343)	-.00391[a] (.00111)	.00253[b] (.00104)	.00184[b] (.00076)	.01398[c] (.00780)	-.00415 (.01274)
Turning point	15.06%	16.29%	18.09%	6.65%	34.99%	20.01%	15.81%	5.43%	3.23%
F-test: $\beta_1 = \beta_2 = 0, \chi^2(2)$	7.59[b]	6.26[b]	2.49	4.97[c]	16.50[a]	6.03[b]	14.67[a]	6.80[b]	0.32
F-test: $\beta_1 = \beta_2$, $\chi^2(1)$	7.58[a]	6.34[b]	2.49	0.17	2.43	4.39[b]	14.36[a]	0.03	0.00
F-test period indicators $\chi^2(3)$	24.90[a]	45.63[a]	5.72	19.92[a]	3.70	22.51[a]	28.69[a]	4.38	8.15[b]

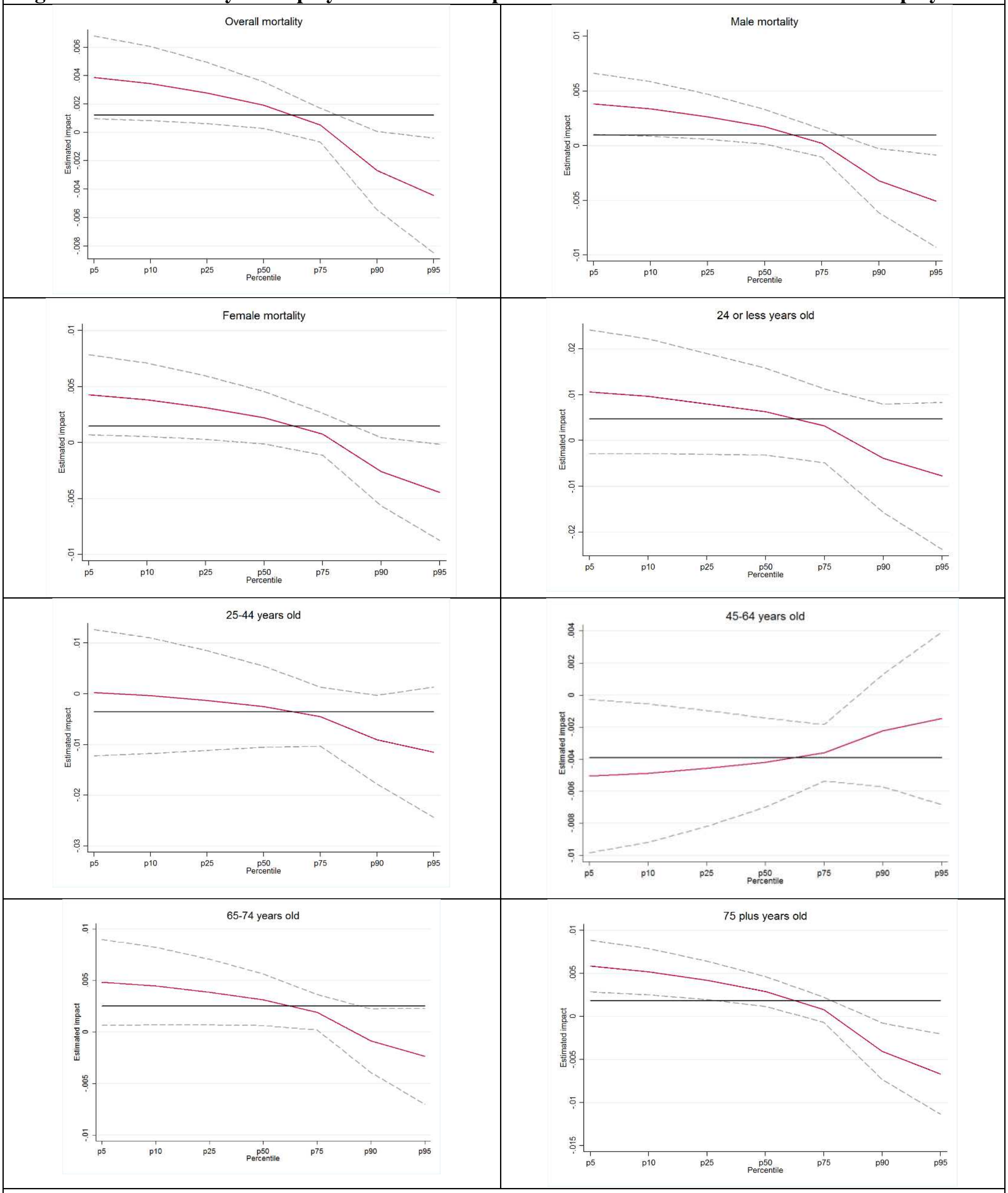
	Vehicle accidents	Circulatory system	Cancer	Nervous system	Respiratory diseases	Digestive diseases	Mental health	Infectious diseases	Adverse events
Unemployment	.00149 (.01108)	.00486[b] (.00247)	.00076 (.00228)	-.00050 (.00894)	.00638 (.00844)	.01421[c] (.00736)	.01329 (.03112)	-.00818 .01137	-.00048 (.03757)
Unemployment squared	-.00014 (.00037)	-.00017[c] (.00009)	-.00007 (.00007)	- .000031 (.00030)	-.00040 (.00024)	-.00025 (.00021)	-.00016 (.00103)	.00003 (.00025)	.00128 (.00104)
Post-2008q3 indicator	.00458 (.04286)	.01508 (.00923)	.00173 (.01162)	.02513 (.03762)	.04999 (.03116)	-.01219 (.05639)	.07260 (.11689)	.23814[a] (.05326)	.25274 (.35133)
Post-2010q1 indicator	-.08106[c] (.04711)	-.01523 (.01187)	-.03289[a] (.00902)	.02828 (.04201)	-.05704[a] (.02049)	-.03298 (.04510)	-.20673[c] (.11201)	-.24263[a] (.07909)	.12871 (.27405)
Post-2012q1 indicator	-.05514 (.09913)	.05522[b] (.02207)	.01642b (.00821)	.26807[a] (.07423)	.12688[a] (.02904)	.03175 (.04362)	-.06561 (.19116)	(.06958) .07938	-.01023 (.27906)
$\vartheta m_{rt}/\vartheta U_{rt}$	-.00214 (.00445)	.00046 (.00095)	-.00102 (.00096)	-.00129 (.00342)	-.00388 (.00263)	.00771[b] (.00300)	.00926 (.01244)	-.00750 (.00863)	.03226[c] (.01845)
Turning point	5.26%	14.16%	5.46%	8.05%	7.97%	28.04%	42.24%	152.81%	18.92%
F-test: $\beta_1 = \beta_2 = 0, \chi^2(2)$	0.42	3.91	3.44	0.17	18.67[a]	6.60[b]	0.55	0.75	7.13[b]
F-test: $\beta_1 = \beta_2$, $\chi^2(1)$	0.02	3.88[b]	0.12	0.00	0.61	3.65[c]	0.18	0.51	0.00
F-test period indicators $\chi^2(3)$	9.20[b]	8.37[b]	28.06[a]	14.99[a]	66.28[a]	1.84	3.61	20.63[a]	1.44

Source: Hellenic Statistical Authority (EL.STAT), Labour Force Survey (LFS).
Notes: Negative binomial regression parameter estimates. The dependent variable is the death count. All models are specified as in column 6 of Table 3. Robust standard errors clustered by region in parentheses. [a] p<.01, [b] p<.05, [c] p<.1.

A systematic relationship between mortality and unemployment is not supported for all death causes. The parameter estimate for suicides is positive and significant indicating that a 10 percentage point increase in unemployment is accompanied by 1.1 more suicides, although the mean level for this death cause is decreased after 2012q1 (1.2 less suicides). The post-2012q1 period also seem to have a deteriorating effect for deaths from diseases of the circulatory, nervous and respiratory systems. Deaths related to vehicular accidents, cancer and mental health conditions seem to be on a lower level since 2010q1 although they are not systematically related to transitory unemployment changes. Deaths from adverse events during medical treatment also exhibit a weak but positive relationship with economic conditions, i.e. 0.06 more deaths for each point increase of the unemployment.

Apart from the mean, we have evaluated the relationship across several points of the unemployment distribution. The results for total, gender and age specific deaths are displayed in Figure 2.

Figure 2. The mortality-unemployment relationship evaluated across the distribution of unemployment

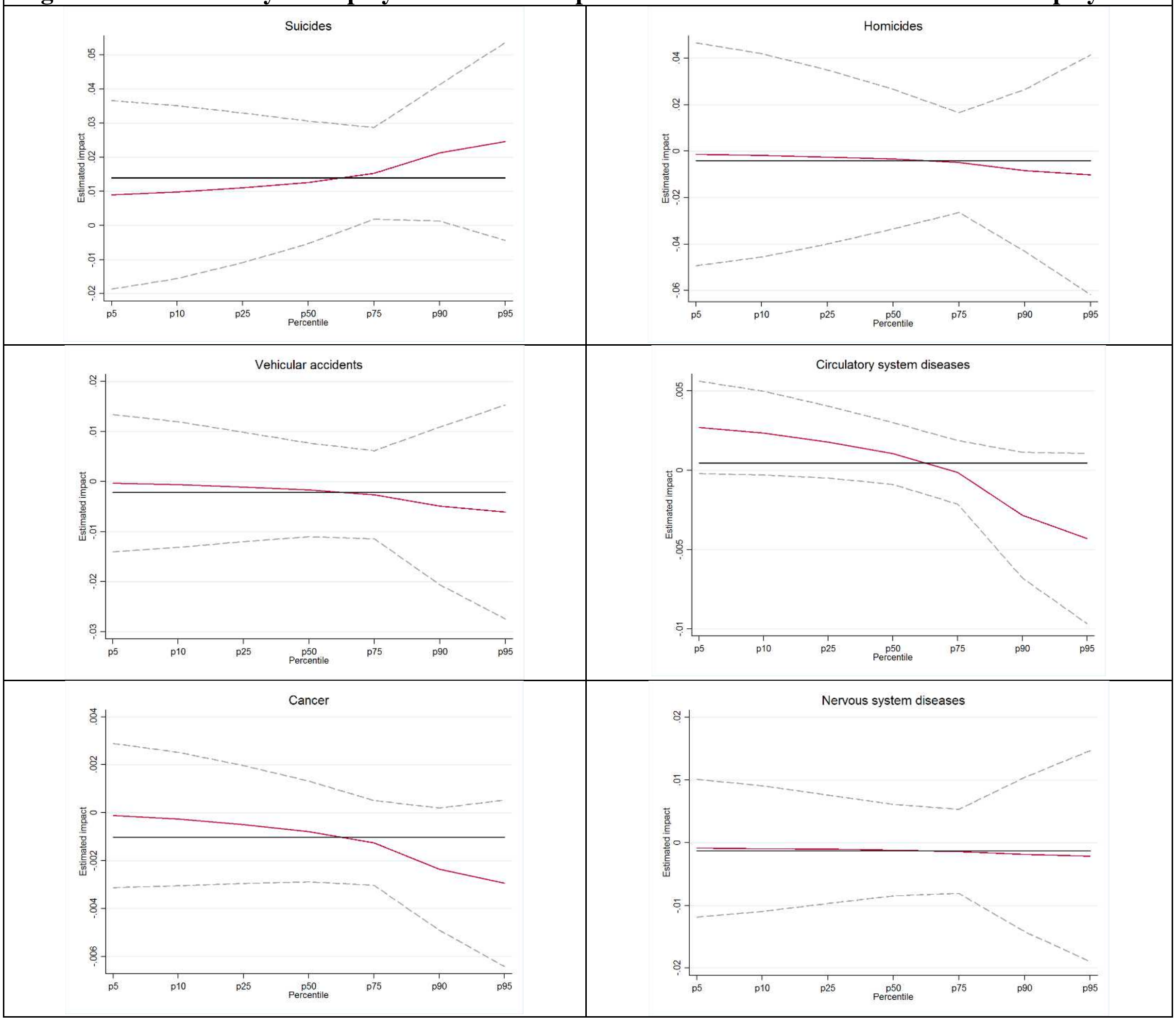


Source: Hellenic Statistical Authority (EL.STAT), Labour Force Survey (LFS).
Notes: Based on models of Table 3, column 6 and Table 4. Dashed lines indicate the 95% CIs (based on standard errors obtained via the delta method) for the estimated unemployment effect. Horizontal black lines indicate the mean unemployment effect.

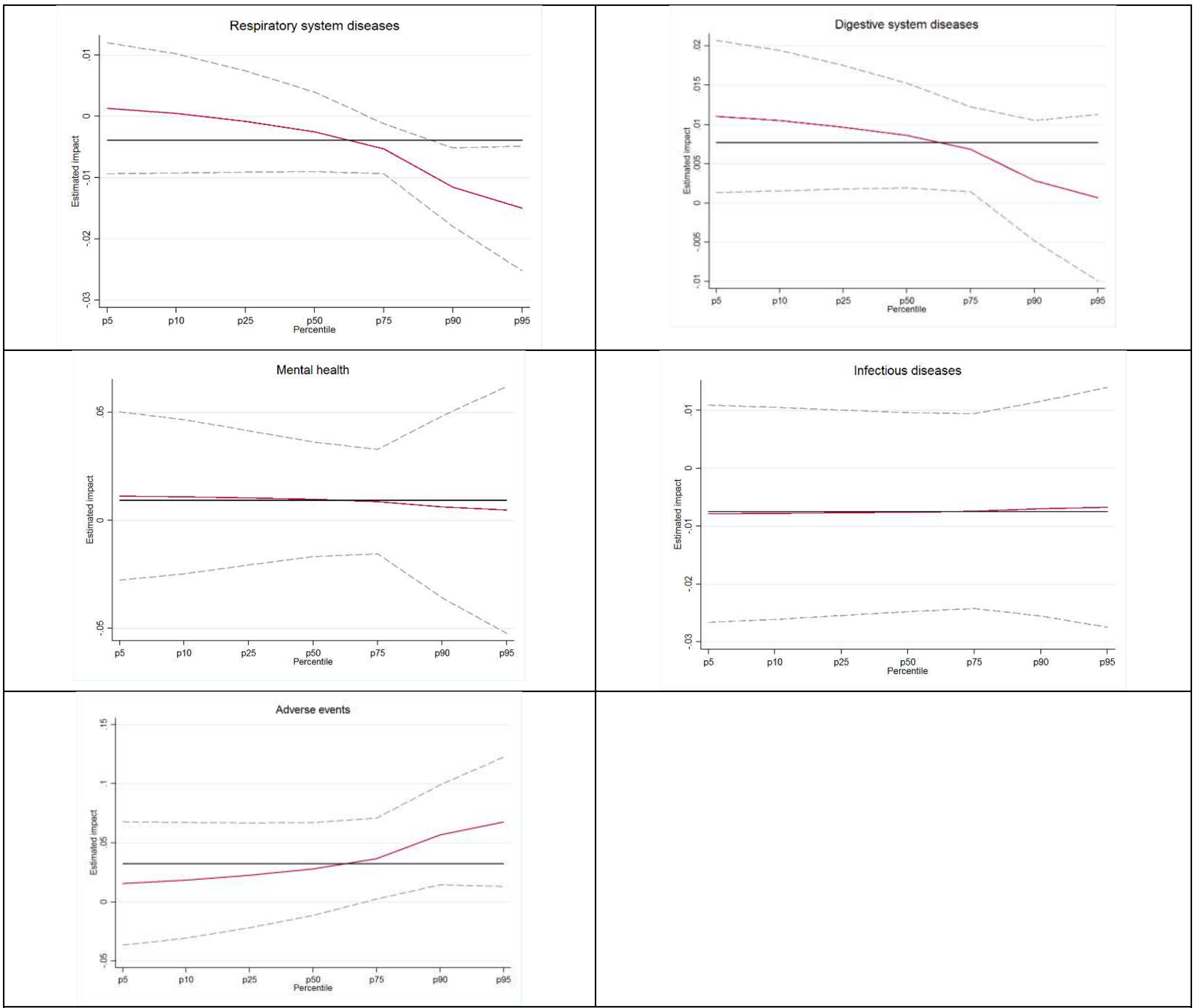
In most of the cases, the countercyclical relationship tends to change at very high values of unemployment (75th percentile) that are observed during the crisis. The procyclicality of those in the 45-64 age group becomes countercyclical as unemployment increases while the relationship is becoming more negative across the unemployment distribution for those in the 25-44 years old group but without being statistically significant.

Figure 3 displays the cause-specific graphs. Deaths from suicides become more countercyclical as unemployment increases but they are not very precisely estimated. The countercyclical mortality related to the circulatory system becomes procyclical for high levels of unemployment while deaths from cancer are almost always procyclical but not in a statistically significant way. Also, the countercyclicality of deaths from digestive diseases changes to procyclicality as the crisis deepens.[9]

Figure 3. The mortality-unemployment relationship evaluated across the distribution of unemployment



[9] We have also estimated all these models using the OLS and Poisson estimators for various transformations of the dependent variable, as in Santos Silva and Tenreyro (2006). Although the differences are small for overall mortality, they become sizeable for certain ages and certain death causes. The respective table is available upon request from the authors.



Source: Hellenic Statistical Authority (EL.STAT), Labour Force Survey (LFS).
Notes: Based on models of Table 4. Dashed lines indicate the 95% CIs (based on standard errors obtained via the delta method) for the estimated unemployment effect. Horizontal black lines indicate the mean unemployment effect.

4.3 Asymmetric specifications

The uncovered non-linear effect could be the result of an asymmetric relationship between the two variables; when unemployment escalates to higher levels, its impact on mortality may be different from when it follows a downward trend. We estimate variants of equation (3) to address this issue. Table 5 presents the results; all models account for the full set of controls. For the total death count, the estimated coefficient of U_{rt}^{-} is in line with previous estimates and indicates that before the crisis deaths decreased by 0.14% for every percentage point decrease in unemployment (2.87 less deaths). The estimated coefficient of U_{rt}^{+} signifies that a one percentage point increase in unemployment is accompanied by a 0.095% reduction in mortality (1.95 less deaths) although the result is not statistically significant. The two coefficients are statistically different from each other at the 5% level, leading to a rejection of the symmetry assumption.

The coefficients of the period indicators are significant and confirm the deteriorating health effect of the crisis and austerity periods.

Table 5. Mortality and unemployment before and during the recession

	Overall	Males	Females	≤24 years	25-44 years	45-64 years	65-74 years	≥75 years	Suicides	Homicides
During crisis (b_1)	-0.00095 (.00075)	-.00116 (.00081)	-.00078 (.00105)	.00479 (.00495)	-.00331 (.00288)	-.00324[a] (.00099)	.00013 (.00072)	-.00131 (.00095)	.02342[a] (.00759)	-.00891 (.01073)
Before crisis (b_2)	.00135[c] (.00083)	.00092 (.00074)	.00162 (.00128)	.00014 (.00446)	-.00756[b] (.00378)	-.00359[b] (.00159)	.00332[a] (.00123)	.00191[c] (.00116)	.00380 (.01008)	.00194 (.01771)
Post-2008q3 indicator	.02909[b] (.01241)	.03154[a] (.00992)	.02371 (.01517)	-.02556 (.03468)	-.08363[a] (.02826)	-.00104 (.01973)	.03570[a] (.01307)	.03948[a] (.01516)	-.04769 (.06525)	-.08983 (.16797)
Post-2010q1 indicator	.01627[b] (.00696)	-.00105 (.00639)	.03577[a] (.00923)	.01275 (.05136)	-.06789[c] (.03826)	.00531 (.01434)	-.01704 (.01507)	.02661[a] (.00893)	-.11303[c] (.06201)	-.27175[c] (.14236)
Post-2012q1 indicator	.04760[a] (.00828)	.03108 (.00902)	.06365[a] (.01132)	-.15727[a] (.05654)	-.04575 (.05203)	.03531[b] (.01641)	.03588[a] (.00928)	.05038[a] (.01131)	-.17379[c] (.09222)	-.08395 (.20605)
F-test: b_1=b_2, $\chi^2(1)$	3.89[b]	3.63[c]	2.89[c]	1.34	1.31	0.04	7.56[a]	4.11[b]	2.94[c]	0.35
F-test: b_1=$b_2 = 0$, $\chi^2(2)$	3.92	3.63	2.90	1.52	4.14	15.51[a]	8.16[b]	4.11	9.54[a]	0.79
F-test period indicators, $\chi^2(3)$	54.56[a]	17.11[a]	56.81[a]	8.73[b]	18.76[a]	4.96	21.40[a]	32.71[a]	4.76	3.74
	Vehicle accidents	Circul. system	Cancer	Nervous system	Respir. diseases	Digestive diseases	Mental health	Infect. diseases	Adverse events	
During crisis (b_1)	-.00494 (.00557)	-.00115 (.00101)	-.00287[a] (.00064)	.00344 (.00392)	-.00804[a] (.00224)	.00366 (.00389)	-.00684 (.01296)	-.00355 (.00858)	.05006[a] (.01616)	
Before crisis (b_2)	-.00026 (.00582)	.00034 (.00143)	.00061 (.00145)	-.00923[c] (.00528)	-.00361 (.00306)	.00999[a] (.00362)	.03206[c] (.01837)	-.01389 (.01067)	.02724 (.02801)	
Post-2008q3 indicator	.03356 (.05680)	.02944[a] (.01097)	.02397[b] (.00944)	-.04878 (.04977)	.08894[b] (.03716)	.03154 (.04150)	.29150[b] (.13888)	.17694[b] (.07414)	.06773 (.34469)	
Post-2010q1 indicator	-.06539 (.05982)	-.00512 (.01026)	-.02345[a] (.00775)	.00872 (.04296)	-.03206 (.02117)	-.01011 (.04994)	-.12868 (.11652)	-.25907[a] (.07096)	.02377 (.26742)	
Post-2012q1 indicator	-.05457 (.08859)	.04670[b] (.01951)	.01927[a] (.00643)	.24029[a] (.05844)	.10960[a] (.02455)	.02732 (.04283)	.00302 (.14632)	.05241 (.08429)	.01779 (.24787)	
F-test: b_1=b_2, $\chi^2(1)$	0.56	1.45	7.57[a]	6.53[b]	1.35	1.48	5.89[b]	2.59	0.87	
F-test: b_1=$b_2 = 0$, $\chi^2(2)$	0.90	2.29	28.80[a]	6.53[b]	14.38[a]	8.30[b]	5.89[b]	2.78	10.62[a]	
F-test period indicators, $\chi^2(3)$	1.98	12.94[a]	64.27[a]	23.31[a]	58.16[a]	1.44	5.38	15.19[a]	0.10	

Source: Hellenic Statistical Authority (EL.STAT) and Labour Force Survey (LFS).
Notes: Negative binomial regression parameter estimates. The dependent variable is the death count. All models control for the full set of time and region effects, regional time trends, local population size and demographics. Robust standard errors clustered by region in parentheses. [a] p<.01, [b] p<.05, [c] p<.1.

The exercise is repeated for different gender and age groups and separate death causes. There is weak evidence of asymmetry for both genders, with the effects of unemployment and the period indicators being larger for females. No asymmetries are uncovered regarding the first three age categories (the relationship is always procyclical for those aged between 25-64 years old) for which the economic crisis seems to have had a protective effect; except for a significant post-2012q1 indicator for the 45-64 year old ones. Death levels for those over 65 years old are increased during the crisis. Suicides are asymmetric and systematically related to economic conditions only in the recessionary period; there are 0.18 more suicides for every percentage point rise in unemployment, although their mean level has been reduced. Deaths from vehicular accidents seem to be trending downwards but no systematic evidence is detected. The mean number of deaths from circulatory diseases has increased, in total, during the recession: 73 more deaths for a sample mean of 958. Deaths from cancer are asymmetric and decrease as unemployment rises in the crisis period. Deaths from nervous system diseases and mental health conditions are also asymmetric while deaths due to adverse events during medical treatment increase with unemployment only during the crisis.

As an alternative specification, we examine if economic conditions exert a differentiated impact over time and if this has been changed over the period. We interacted U_{rt}^{+} and U_{rt}^{-} with a linear time trend in order to investigate the impact of unemployment as a function of time. The estimated coefficient of $(t \times U_{rt}^{-})$ was -0.00014 with a p-value of 0.133 and the coefficient of $(t \times U_{rt}^{+})$ was -0.00024 with a p-value of 0.015 but they were not statistically significant from each other indicating that the differential impact of unemployment on mortality has remain stable over time. Specifying U_{rt}^{+} and U_{rt}^{-} in a quadratic fashion confirms that deaths were countercyclical before the recession. The positive relationship is still observed for low values of unemployment in the recessionary period; the estimated coefficient of U_{rt}^{+} is 0.00423 with a *p*-value of 0.176. However, the coefficient of the squared term of U_{rt}^{+} is negative and equal to -.00017 with a *p*-value of 0.052. This confirms what is graphically depicted in Figure 1; deaths and unemployment move together until a certain time point within the crisis period but then continue in opposite trajectories.

5. Conclusions

We show that mortality in Greece is countercyclical, and behaves both asymmetrically and non-linearly to unemployment in the context of the 2008 economic crisis. Our finding on countercyclical mortality is in contrast with the majority of the economic literature in the last two decades (Ruhm 2000; Ruhm 2007; Gonzalez and Quast 2011; Tapia-Granados 2005). It is in agreement though with a few recent studies suggesting that the procyclical mortality effects may be changing. Using data from the US and investigating a period similar to the one of our analysis, Gordon and Sommers (2016) found that during 1993-2012, unemployment rates demonstrate a weak and inconsistent effect on mortality. In a model that controls for county and year fixed effects they show that a 1-unit standard deviation increase in unemployment predicts a 2.8% increase in total mortality. Their findings are similar to a recent study by Ruhm (2016) who found that mortality shifted from strongly procyclical to being weakly or unrelated to unemployment between 1976-

2010. Contrary to that latter study though that found that national crises have a protective effect on total mortality (Ruhm 2016), we provide robust evidence of a deteriorating crisis effect. Our contrasting findings may suggest that there are idiosyncratic elements and that each crisis may have different effects depending on its nature and severity. Our evidence has also policy implications highlighting the greater vulnerability of those in the elderly age groups during turbulent times.

Our study offers important methodological insights regarding the relationship between unemployment and mortality. We find robust evidence that the relationship is both asymmetric and non-linear. The sharp and sudden deterioration in the prevailing economic conditions seems to have temporarily affected the downward mortality trend in Greece during the crisis period. However as the crisis continues with persistently high unemployment levels, mortality seems to get back on its declining trajectory hence resulting in a sign change of the estimated relationship. We also show that reductions in unemployment reduce mortality more relative to unemployment increases. These important findings regarding the association between unemployment and mortality are crucial and would not have been observed without relaxing the assumptions of linearity and symmetry. On the basis of this, we argue that related studies should consider for such effects, particularly in the context of wider economic crises.

Although claims for the mechanisms that underline asymmetries and non-linearities are hard to establish, our findings suggest that these are likely to be age related. Indeed, both asymmetries and non-linearities are driven by those above 65 years old, hence the interpretation cannot be related to labour force status, working conditions or the work-leisure model. As Miller et al. (2009) suggest understanding mortality patterns among the elderly is vital in understanding cyclicality and this is proven particular true in our case. A key for our interpretation is that those over 65 are the main users of the health services. Therefore the asymmetric and non-linear effects we observe may reflect similar trends in the way healthcare services responded to the crisis. As argued in earlier studies, the Greek health system faced significant structural problems long before the crisis hit yet little had been done largely due to lack of political will and inertia (Mossialos, Allin, and Davaki 2005; Davaki and Mossialos 2005; Economou 2010). Yet, and in response to the crisis a number of policy reforms were introduced during a short time period, even if they had been on the table for decades (Economou, 2015). The lack of regional data on indicators such as health expenditure does not allow us to test further health system related factors. Future research on this area could shed more light on the impact of crises on the health of the population.

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