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PROCYCLICAL MORTALITY AND THE "MIGRATION BIAS": AN INVESTIGATION ON THE UNITED STATES AND FINLAND

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Abstract — Empirical investigations in past decades have repeatedly found mortality oscillations in parallel with economic upturns and downturns, so that death rates tend to deviate from trend upward in expansions, and downward in recessions. However, this pattern looks counterintuitive, and some researchers have considered that it is unproven. Recently it has been proposed that procyclical mortality, even in high-income countries, (a) would be observable just in some countries and periods, for instance not in Finland; and (b) it is just a statistical artifact due to a *migration bias,* i.e., unregistered migration leading to overestimation of death rates in areas or periods of expansion. This investigation provides evidence of procyclical mortality in USA and Finland in the period since 1950 to the present and shows procyclicality of national death rates, indexed by life expectancy at birth, and national death *counts*. These results make the "migration bias" an implausible explanation of procyclical mortality which on the other hand is shown to be present both in Finland and the USA. The link of mortality oscillations to the economy is clearly stronger in USA than in Finland, but in both countries procyclical mortality is observable, particularly in working-age population.

INTRODUCTION

Excepting wars and other periods of social or political calamity like the 1990s in Eastern Europe and the countries of the old USSR (1, 2), mortality rates usually decline every year and show declining long-term trends almost without exception in all countries since available statistics exist. However, since the early 20th century all through recent years, authors such as Dorothy Thomas (3, 4), Joe Eyer (5), Christopher Ruhm (6-8) and many others (9-16) observed in market economies that mortality oscillated over the long-term trend with upturns and downturns associated with those of the economy at large. The term "procyclical mortality" refers to these observed deviations of mortality rates from its long-term declining trend, rising above trend during expansions, falling below trend during recessions. Procyclical

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mortality has been found in many high-income countries (11, 15, 17, 18) and some medium-income countries (12, 13), but it has been never fully accepted as an empirical regularity, it is rather a disputed hypothesis (19). For many investigators, procyclical mortality looks suspicious as it suggests that population health would benefit from economic decay rather than from economic growth, which usually involves prosperity because of expanding income (both capital and labor income, i.e., profits and wages, are procyclical) (20). Thus, a number of researchers in public health and other disciplines questioned or rejected the hypothesis as unproven (21, 22), others said that procyclical mortality is restricted to traffic mortality (23), and even others, like Harvey Brenner, reframed it, so that upturns of mortality during expansions would be lagged effects of the previous recession (24) (of course, as business cycles are irregular, this explanation is kind of ludicrous, as most of what Brenner produced).

Underlying the disagreements and controversies on the procyclical oscillation of mortality rates there are some common misunderstandings that frequently appear in the investigations on the effects of macroeconomic change on death rates.

First it is often thought, though usually is not explicitly stated, that the procyclical character of mortality implies a causal link between rising unemployment rates (or whatever economic indicator is used as proxy for economic conditions) and declining death rates. This is obviously a mistake, because proving that mortality tends to increase when unemployment rates decline is only a way to show that mortality tends to decrease *when the economy decelerates*. Any other indicator of the business cycle, say, declining sales of sulfuric acid, probably would do (and, obviously, declining sales of sulfuric acid have in causal terms nothing to do with mortality). We are dealing here with a similar case to that posed by the fact that a drop in the barometer is a predictor, but not a cause, of bad weather.

Second, because researchers have often started from the view that in modelling death rates for instance as a function of unemployment rates they were looking for a causal relationship, they thought they had to include in the model potential confounders, or third variables. Thus, Ruhm included in his models the percentage of the state population with given levels of educational attainment, and the proportion being classified as Black or Hispanic (6), while Economou included indicators of smoking and drinking, levels of atmospheric pollution, and dietary habits (25), under the consideration that "confounding factors mediate in the economic conditions/unemployment-mortality relationship" so that, “in order to reveal the true effects of economic conditions or unemployment on mortality, the mediating confounding factors should be controlled for.” Now, the proportions of people with different educational attainment or pertaining to different ethnic groups change only slowly and therefore is very unlikely that they be associated to relatively sudden changes in unemployment and mortality. Thus, including them in the model only represents an extra trending variable which will not significantly change the results for the covariates that vary at business-cycle frequencies. However, levels of smoking or atmospheric pollution change quickly and their changes are associated with the business cycle, indeed they are some of the factors that have been invoked as intermediate variables in the pathway leading from changes in the economy to changes in mortality. Therefore, including them in the model as Economou proposes is like investigating the effects of smoking on lung function adjusting by the level of nicotine in blood.

A third misunderstanding in the investigation on the relation between macroeconomic conditions and health is the idea that investigating that relation by analyzing the time series relation between one series of national death rates and one series of an economic indicator is not a proper thing to do and it is indeed inferior to using panel data, as “any lengthy time series may contain omitted variables that are spuriously correlated with economic conditions and have a causal effect on health” (26) (p. 175). However, considering a country and its subunits, the information provided by national death rates is just a summary of the information provided by the death rates of the subunits, and the conclusions obtained from a panel analysis of the subunits (6, 14, 27) must be substantially the same conclusions obtained from the analysis of the whole nation (28), if the analysis is properly done.

Recently it has been proposed that procyclical mortality is just a fallacious inference due to the so-called *migration bias* derived from panel model analyses. This idea can be explained as follows. Let be a nation subdivided into subunits i, so that $D_{i,t}$ and $P_{i,t}$ are respectively the annual deaths and the mid-year population of the subunits during year t, so that $M_{i,t} = D_{i,t} / P_{i,t}$ is the real mortality rate of subunit i on year t. Since $D_{i,t}$ and $P_{i,t}$ cannot be directly counted, they need to be estimated from death registries and census data, so that $m_{i,t}$, $d_{i,t}$ and $p_{i,t}$ are respectively the estimates of $M_{i,t}$, $D_{i,t}$ and $P_{i,t}$. In a country with a proper system of vital and demographic statistics, because of unregistered deaths we can assume that $d_{i,t}$ will somewhat underestimate $D_{i,t}$, but the number of unregistered deaths will be tiny compared with the number of total deaths, so we can assume that $d_{i,t} = D_{i,t}$. Now, is $p_{i,t}$ a proper estimate of $P_{i,t}$? People are continuously changing residence and the only solid information about population numbers is that provided by censuses in which population is counted, usually at 10-year intervals. Thus, we can assume that for census years $p_{i,t} = P_{i,t}$ because the census counts properly the population. However, intercensal estimates of population are usually done by linear interpolation, so that, for example, if censuses occurred at year t and t+10, then the estimated population at year t + 5 is $p_{i,t+5} = (P_{i,t} + P_{i,t+10})/2$. Now, what the migration-bias theory states is that intercensal estimates of population will be systematically biased because unregistered internal migration from other parts of the country, so that in years and subunits undergoing economic expansion $p_{i,t} < P_{i,t}$, the greater the difference the stronger is the expansion, while in years and subunits of recession $p_{i,t} > P_{i,t}$, so that the stronger is the recession, the greater is the difference, because migration occurs from regions of stagnant economy (say Pennsylvania) toward areas of economic boom (say North Dakota). The consequence would be that in areas or periods of expansionary economy there would be systematic underestimation of population and overestimation of death rates, $M_{i,t} < m_{i,t}$, while in areas or periods of recessionary economy there would be overestimation of population and underestimation of death rates, $M_{i,t} > m_{i,t}$ (29). We will see later that despite the theoretical reasons in its favor, the hypothesis of procyclical mortality does not hold versus the empirical evidence.

Another form of negation of the hypothesis that procyclical mortality is a regularity observable in modern market economies is to transform it in a kind of peculiarity, so that it would be observable only in some economies and some periods. Studies in which the procyclical oscillation of mortality was initially found used data from the United States and Britain (3-6, 28) , but procyclical mortality has been also found in other nations of Europe and also European countries analyzed as a panel (10, 17, 18, 30-32), as well as in Canada (33), several Latin American countries (12, 13), and Japan (15, 34). Against an emerging consensus that procyclical mortality in market economies is a regularity during the 20th century and recent decades, so that studies departing from this pattern would be probably flawed because of specific reasons (26), the view has been recently proposed that procyclical mortality is not observable for instance in Finland (35).

This investigation uses data from the United States and Finland to provide evidence on the procyclical fluctuation of mortality in both countries in the period since 1950 to recent years. Furthermore, by using series at the national level rather than at the level of subnational units, and by demonstrating the procyclicality of death *counts* rather than death *rates*, evidence is found that shows the implausibility of the "migration bias" as a mechanism to generate an artifactual procyclical oscillation. On the other hand, it is shown that the link of mortality rates with the oscillations of the economy appears in Finland much weaker than in the United States, but the procyclical oscillation of mortality is detectable in both countries.

DATA AND METHODS

USA and Finland's data on life expectancy at birth and death counts are from the Human Mortality Database (36). To avoid the inclusion of war periods, the investigated data series start in 1950 and extend to recent years. This period of about 65 years covers several business cycles in both countries, with recessions in Figure 1 clearly marked by rising unemployment. The early 1990s economic crisis in Finland, when the country fully lost a major receptor of its exports, the USSR, and its unemployment rate rose to 18%, and the Great Recession of the late 2000s, when unemployment increased to 10% in the USA, were particularly severe recessions.

Since the annual number of deaths and births are small compared with the size of the population, year-to-year relative changes in total or age-specific population size are also small and population changes slowly. Annual counts of deaths are more volatile. Thus, for instance, the coefficient of variation of annual deaths at ages 15-24 in Finland in the period 1950-2013 was 105.9% while the that of the corresponding population was just 11.5%.

Figure 2 (upper panels) shows the annual deaths at ages 15-64 in Finland and the United States. The thin line is a long term-trend computed with the Hodrick-Prescott (HP) filter, which reveals for instance that annual deaths at ages 15-64 in Finland were above trend in 1990 and below trend in the early 1980s.

If the procyclical oscillation of mortality rates is present in a given population, then annual death counts should also oscillate procyclically over and above long-term trends. These long-term trends would be due to demographic changes in population (e.g., aging) and secular changes in population health (e.g., decreasing deaths at young ages and increasing deaths due to cancer because of population aging).

If, as suggested by Arthi et al. (29) because internal migration population is underestimated during expansions or in areas of expanding economy and for identical reason is overestimated during recessions and in areas of decaying economy, then a spurious procyclical oscillation of mortality would be observed in investigations using panel data with different regions of a country. However, since internal migration does not affect the national death counts, if a procyclical oscillation is observed in them, then the "migration bias" would not be at all a credible explanation of procyclical mortality.

Transfer functions, which are the one-series analogous to multiple-series panel regression models were computed to estimate the extent that a change in macroeconomic conditions is associated with a change in life expectancy or death counts. Cross correlations between series detrended with a non-linear method (the Hodrick-Prescot filter) were also computed, as previous research has shown that non-linear methods may be more efficient to elucidate macroeconomic effects on mortality (27).

Results

Transfer models, that is, regressions in which the change in a mortality-based demographic indicator (life expectancy at birth, e_0 in demographic notation, or death counts in different population subgroups) was modeled as a function of the change in a macroeconomic indicator—the unemployment rate or GDP—at lag 0, lags 0 and 1, or lags 0, 1 and 3, revealed that excepting isolated cases the change in GDP has no statistically significant associations at any of the investigated lags with the change in demographic indicators in the United States or Finland in the period of study (results not shown). Contrarily, the change in the unemployment rate reveals many significant associations with demographic indicators at lag 0, though not at lags 1 or 2. Table 1 shows the results of transfer models in which the explanatory covariate is the change in the unemployment rate at lag zero. For the United States, the unemployment rate shows highly significant associations with total and sex-specific life expectancy at birth as well as death counts for males and females at all investigated ages in the period

1950-2014. Considering the period 1970-2013, the levels of statistical significance are lower and indeed the associations with the unemployment rate are no longer significant for several age groups.

Quite different is the case of Finland, where Table 1 shows that, at lag zero, no significant associations appear between the change in unemployment and the change in demographic variables in the period 1950-2014 in transfer models (we neither detect any significant associations st lags 1 and 2, results not shown); in the restricted period 1970-2014 the association of the change in unemployment with the change in a death count is only significant for males at ages 15-64 and marginally significant for the whole population at that age.

If these results were considered in isolation, it might be concluded that the evidence of a procyclical oscillation of mortality, while quite strong for the United States, is flimsy for Finland. But this is not confirmed by other statistical procedures as it will be shown presently.

When both economic indicators and demographic indicators are detrended with the Hodrick-Prescott filter, the correlations of e_0, as well as female e_0, male e_0 and many specific death counts with economic indicators are statistically significant, which indicates that both in the United States and Finland mortality oscillated procyclically, rising over and above trend in expansions and falling in recessions. That is proved by negative correlations of detrended GDP with e_0, positive correlation of the unemployment rate (UR) with e_0, and negative correlations of the UR with death counts. Tables 2 to 5 show that in both Finland and USA, detrended e_0 for the whole population as well as for males and females is negatively correlated with detrended UR, and positively correlated with detrended GDP. In absolute value the correlations are much stronger with UR, but still, the pattern of negative correlations of e_0 with detrended GDP and positive correlations of e_0 with detrended UR indicates that e_0 tends to rise above trend when the UR rises because the GDP growth is slowing down. Tables 2 to 5 show that this pattern is observable both in the general sample 1950-2013 and the more recent years 1980-2013 and is also robust to selection of smoothing parameter for the Hodrick-Prescott filter. The two values of the smoothing parameter, $\gamma = 100$ and $\gamma = 6.25$, used in this investigation, are the two extremes of the range of values proposed in econometric literature to detrend annual data.

In Finland the correlations of detrended e_0 with detrended UR are weaker than in the USA and they are only marginally significant, for the entire population and the male population, in the sample 1950-

2013; they become however strongly significant in the sample 1980-2013 (Table 3), in which they are as well positive, indicating procyclical mortality.

The oscillations over trend of annual counts of deaths for large groups of population (Tables 2 to 4) and for smaller age-strata (Tables 5 and 6) are with very few exceptions positive with detrended GDP and negative with detrended UR, which is further evidence that annual deaths oscillate procyclically in most age strata. If death counts evolved independently of the economy, we would expect more or less half of the signs positive and half negative both for GDP and UR, not the pattern of systematic negative correlations of detrended death counts with UR and positive correlations of death counts with GDP.

Weaker correlations show that generally the oscillation of death counts is less linked to the economy, procyclically, for females than for males, and mortality appears also less procyclical in Finland than in the United States. Thus, as shown in Table 2, in 1950-2013 the correlation of detrended e_0 with detrended UR is 0.37 in USA (a highly significant correlation) and 0.23 in Finland (a marginally significant correlation). However, specific demographic groups depart from the pattern of stronger correlations of mortality with the economy in USA than in Finland. Thus, for instance, the correlation of detrended deaths at ages 15-64 with the unemployment rate (Figure 2, bottom panels) is -0.27 in USA (significant at the lowest level of standard significance, Table 1) and –0.36 in Finland (highly significant).

Discussion

Overall these results show that death counts, not only death rates, oscillate procyclically both in Finland and USA, though the link between the economy and general mortality, as indexed by e_0 or total deaths, appears weaker in Finland. A procyclical oscillation of mortality observable at the national level and not only for mortality rates or mortality-based indicators like e_0 but also for death counts, is not consistent with the hypothesis of a "migration bias" that would generate the observation of procyclical mortality as just a statistical artifact due to people moving between different regions of the country. Our results confirm the frequent finding of procyclical mortality as more evident in male deaths, and show that procyclical mortality is particularly observable in young individuals, which fits previous results (6, 27) and is not consistent with the view that procyclical mortality is a phenomenon mainly or exclusively observable in the elderly population (37). Annual death counts at ages 15-24 appear very procyclical both in Finland and USA. Indeed, the link between the death count of young adults and the expansions of the economy seems to have been substantially intensified in the past three decades in Finland (Tables 5, 6 and 7). Traffic deaths which are highly responsive to economic conditions (6) and form a large proportion of deaths at ages 15-24 are caused by car crashes and traffic and transportation injuries in general.

When $\gamma = 6.25$ is used as HP parameter to detrend the series, the correlations between detrended death counts or e_0 values with economic indicators are in general substantively weaker than when $\gamma = 100$ is used. Though there have been tough arguments in the econometric literature on what is the appropriate parameter for the HP filter using annual data, it seems that $\gamma = 6.25$ produces a trend that eliminates too much of the business-cycle fluctuation in any variable [ref (38), Appendix]. That is illustrated by Figure 1 where the deviation of unemployment from trend during the recession of the early 1990s in Finland when $\gamma = 6.25$ is used produces a detrended UR which is only slightly over trend, in spite that the UR was at the time over 15 percentage points above its historical average during the previous three decades.

As it was already said, taken in isolation the results of transfer-function models could be interpreted as supporting the view that mortality does not show a procyclical oscillation in Finland. Contrarily, as it has been shown here, correlations of non-linearly detrended economic indicators with similarly detrended mortality-based indicators suggest that is not the case, as they show that indeed mortality deviates from the non-linear trend of the HP filter in the opposite direction to the unemployment rate. That is substantial evidence of a procyclical oscillation of mortality in Finland. A statistical method or an experiment which does not reveal a given phenomenon or effect do not necessarily mean the phenomenon is not present, it can be just that the experiment or the procedure were not appropriate to detect that specific phenomenon or effect.

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Table 1. Estimates of the change in demographic indicators associated with an increase of one-percentage point in the unemployment rate, USA and Finland

Dependent variable	Effect estimate	St. error	Effect estimate	St. error
	USA 1950-2013		Finland 1950-2013	
e_0	0.07***	0.02	0.01	0.03
e_0 males	0.08***	0.02	0.02	0.04
e_0 females	0.07**	0.02	0.01	0.03
Deaths at specific ages				
All ages	-10260.7**	3542.9	33.0	123.8
15-64	-2664.6*	1122.5	-49.7	36.5
25-54	-1443.4*	661.1	1.9	21.3
65+	-7302.4*	2930.1	79.7	96.4
Males	-4753.8**	1776.4	-4.7	65.7
15-64	-1953.3*	757.0	-41.7	27.9
25-54	-1039.7*	462.0	0.1	16.9
65+	-2593.9*	1286.4	34.0	45.5
Females	-5506.9**	1928.1	37.8	67.6
15-64	-711.3†	414.8	-7.9	13.3
25-54	-403.7†	239.1	1.8	7.6
65+	-4708.6**	1738.6	45.7	59.4
	USA 1970-2013		Finland 1970-2013	
e_0	0.05*	0.02	0.02	0.02
e_0 males	0.05*	0.02	0.03	0.02
e_0 females	0.06*	0.02	0.01	0.03
Deaths at specific ages				
All ages	-9166.5†	4636.5	13.7	119.8
15-64	-1252.4	1345.8	-58.0†	30.1
25-54	-1119.7	912.7	-6.6	19.8
65+	-7566.5†	4048.2	80.7	108.5
Males	-3213.1	2128.9	-19.0	58.5
15-64	-944.9	929.0	-48.7*	22.0
25-54	-796.0	661.5	-6.6	16.1
65+	-2067.4	1634.1	34.1	52.1
Females	-5953.4*	2679.6	32.7	71.6
15-64	-307.5	482.9	-9.3	13.1
25-54	-323.7	307.0	0.0	7.7
65+	-5499.1*	2500.2	46.5	66.9

*** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$, † $P < 0.1$.

Table 2. Correlations of life expectancy at birth (e_0) or death counts (for specific demographic groups) with "the economy"—as indexed by the real gross domestic product (GDP) or the unemployment rate (UR). All correlations computed after detrending both series with the Hodrick-Prescott filter with a smoothing parameter γ = 100. The series extend 1950-2013, so that *n* is 64

	United States		Finland	
Variable	GDP	UR	GDP	UR
e_0	-0.23†	0.37**	-0.15	0.23†
e_0 males	-0.21†	0.38**	-0.18	0.24†
e_0 females	-0.23†	0.32**	-0.07	0.18
Deaths at specific ages				
All ages	0.21†	-0.29*	-0.01	-0.11
15-64	0.17	-0.27*	0.32**	-0.36**
25-54	0.04	-0.15	0.18	-0.23†
65+	0.18	-0.23†	-0.19	0.06
Males	0.17	-0.28*	0.03	-0.13
Males 15-64	0.16	-0.28*	0.34**	-0.37**
Males 25-54	0.04	-0.13	0.18	-0.22†
Males 65+	0.10	-0.18	-0.28*	0.15
Females	0.23†	-0.27*	-0.04	-0.07
Females 15-64	0.16	-0.23†	0.22†	-0.27*
Females 25-54	0.05	-0.17	0.12	-0.18
Females 65+	0.22†	-0.25*	-0.10	-0.01

*** $P < 0.001$, **$P < 0.01$, *$P < 0.05$, †$P < 0.1$, under the assumption of negligible autocorrelation of the series. However detrended series have autocorrelations varying in a very wide range, from as low as 0.03 for detrended Finish deaths to 0.75 for detrended Finish unemployment rate. All autocorrelations were positive except the one corresponding to deaths of males aged 65+ which was -0.12.

Table 3. Correlations as in table 2. Series 1980-2013 for all variables, i.e., *n* = 34 for all correlations

	United States		Finland	
Variable	GDP	UR	GDP	UR
e_0	-0.30†	0.39*	-0.29†	0.48**
e_0 males	-0.20	0.29	-0.39*	0.55***
e_0 females	-0.39*	0.45**	-0.08	0.27
Deaths at specific ages				
All ages	0.20	-0.29†	-0.03	-0.13
15-64	0.11	-0.11	0.57***	-0.60***
25-54	-0.03	-0.02	0.32†	-0.44**
65†	0.15	-0.25	-0.25	0.11
Males	0.09	-0.22	0.07	-0.24
Males 15-64	0.07	-0.09	0.58***	-0.62***
Males 25-54	-0.03	-0.02	0.34*	-0.46**
Males 65†	0.03	-0.16	-0.31†	0.16
Females	0.26	-0.32+	-0.1	-0.02
Females 15-64	0.20	-0.15	0.36*	-0.38*
Females 25-54	-0.01	-0.05	0.15	-0.23
Females 65+	0.22	-0.29†	-0.17	0.06

*** $P < 0.001$, **$P < 0.01$, *$P < 0.05$, †$P < 0.1$.

Table 4. Correlations as in Table 1 but using the Hodrick-Prescott filter with a smoothing parameter γ = 6.25. Series 1950-2013 for all variables (*n* = 63 for all correlations)

	United States		Finland	
Variable	GDP	UR	GDP	UR
e_0	-0.24†	0.44***	-0.02	0.06
e_0 males	-0.25†	0.46***	-0.03	0.09
e_0 females	-0.22†	0.40**	0.01	0.01
Deaths at specific ages				
All ages	0.26*	-0.38**	-0.05	0.04
15-64	0.15	-0.38**	0.05	-0.11
25-54	0.06	-0.27*	0.05	-0.11
65+	0.28*	-0.33**	-0.09	0.08
Males	0.24†	-0.38**	-0.08	-0.01
Males 15-64	0.20	-0.4**	0.10	-0.16
Males 25-54	0.10	-0.27*	0.05	-0.11
Males 65+	0.23†	-0.29*	-0.17	0.07
Females	0.27*	-0.37**	-0.02	0.07
Females 15-64	0.05	-0.29*	-0.06	0.03
Females 25-54	-0.04	-0.22†	0.02	-0.06
Females 65+	0.30*	-0.35**	-0.01	0.07

*** *P* < 0.001, ***P* < 0.01, **P* < 0.05, †*P* < 0.1. Detrended series have autocorrelations varying in a very wide range around zero, from as low as -0.48 for deaths of Finish males aged 65+ to as high as 0.49 for the Finish unemployment rate. It must be noted that while positive autocorrelations tend to generate spurious statistical significance, negative autocorrelations tend to dampen or eliminate statistical significance.

Table 5. Correlations as in table 1. Series 1980-2013 for all variables (*n* = 34 for all correlations) now using the Hodrick-Prescott filter with a smoothing parameter γ = 6.25

	United States		Finland	
Variable	GDP	UR	GDP	UR
e_0	-0.26	0.36*	-0.08	0.22
e_0 males	-0.24	0.33†	-0.14	0.35*
e_0 females	-0.28	0.38*	0.02	0.01
Deaths at specific ages				
All ages	0.25	-0.31†	-0.05	0.04
15-64	0.06	-0.2	0.17	-0.33†
25-54	-0.01	-0.12	0.14	-0.31†
65+	0.27	-0.29	-0.09	0.13
Males	0.21	-0.26	-0.07	-0.08
Males 15-64	0.11	-0.22	0.27	-0.45**
Males 25-54	0.04	-0.15	0.18	-0.37*
Males 65+	0.20	-0.20	-0.18	0.10
Females	0.28	-0.33†	-0.02	0.13
Females 15-64	-0.07	-0.11	-0.09	0.09
Females 25-54	-0.15	-0.04	-0.01	-0.02
Females 65+	0.3†	-0.33†	-0.01	0.13

*** P < 0.001, **P < 0.01, *P < 0.05, †P < 0.1.

Table 6. Correlations of death counts for small age groups with "the economy"—as indexed by the real gross domestic product (GDP) or the unemployment rate (UR). All correlations computed with series detrended with the Hodrick-Prescott filter applied with a smoothing parameter γ = 100. Series 1980-2015 for all variables (n = 36)

	United States		Finland	
Age group	GDP	UR	GDP	UR
0-4	0.42*	-0.31†	0.20	-0.37*
5-14	0.12	-0.26	-0.06	-0.03
15-24	0.45**	-0.42*	0.39*	-0.53**
25-34	-0.09	-0.12	-0.08	0.08
35-44	0.12	-0.11	0.21	-0.41*
45-54	-0.06	0.04	0.10	-0.10
55-64	0.26	-0.09	0.21	-0.21
65-74	-0.12	-0.02	-0.41*	0.32†
75-84	0.46**	-0.36*	0.19	-0.35*
85-94	0.17	-0.23	-0.16	0.13
95†	0.23	-0.29†	-0.20	0.27

*** $P < 0.001$, **$P < 0.01$, *$P < 0.05$, †$P < 0.1$.

Table 7. Correlations of death counts for small age groups with "the economy"—as indexed by the real gross domestic product (GDP) or the unemployment rate (UR). All correlations computed with series detrended by using the Hodrick-Prescott filter with a smoothing parameter γ = 6.25. Series 1980-2015 for all variables (n = 36)

	United States		Finland	
Age group	GDP	UR	GDP	UR
0-4	0.39*	-0.41*	-0.08	-0.32†
5-14	0.10	-0.16	-0.09	-0.09
15-24	0.18	-0.33†	0.21	-0.29†
25-34	-0.11	-0.13	-0.04	0.10
35-44	-0.14	-0.03	0.08	-0.23
45-54	-0.26	0.08	-0.07	0.12
55-64	0.00	-0.09	0.12	0.29†
65-74	0.07	-0.10	-0.22	0.09
75-84	0.26	-0.32†	-0.10	0.04
85-94	0.03†	-0.35*	0.04	0.12
95+	0.28	-0.31†	0.04	0.15

*** $P < 0.001$, **$P < 0.01$, *$P < 0.05$, †$P < 0.1$.

Figure 1. Unemployment rate (thin line with dots) as percentage of the labor force, USA and Finland, 1950-2013. The dotted and dashed thick lines are Hodrick-Prescott trends computed respectively with smoothing parameters γ = 100 and γ = 6.25. Note how γ = 6.25 (dashed line) produces a trend that follows more closely than the filter with γ = 100 (dotted line) the oscillations of the original series

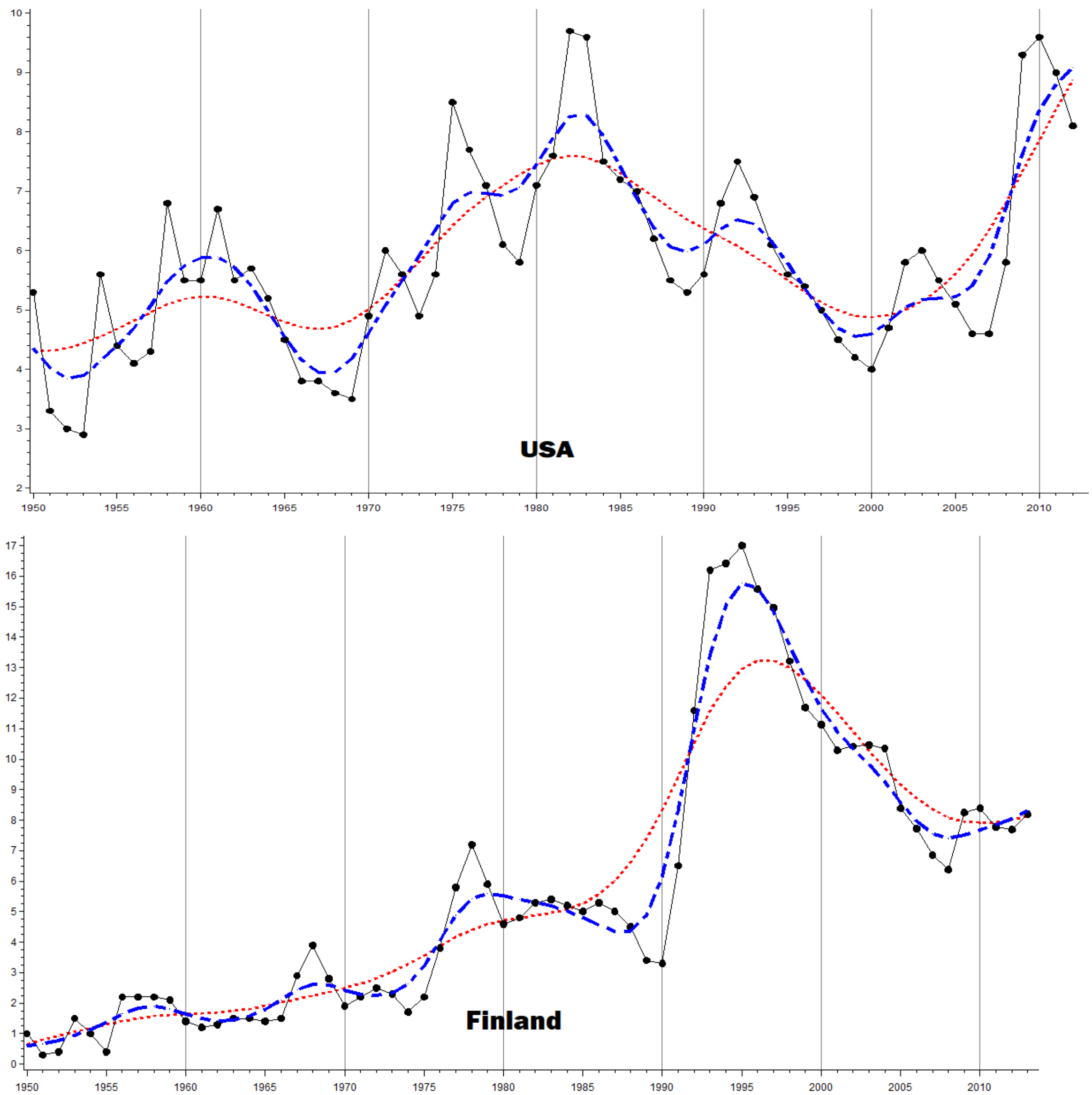

Figure 2. Plots of annual deaths at ages 15-24 and the unemployment rate, in levels and detrended with the Hodrick-Prescott filter. Finland and USA, 1950-2013