

The Impact of the Great Recession on Mortality: A Dynamic Factor Analysis

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Abstract

We use a dynamic factor time series model to estimate the national mortality impact of the Great Recession. In aggregate, the Great Recession *reduced* the average annual, age-adjusted mortality rate by about 2 percent, with effects persisting for at least a decade. In a calibrated model of the welfare effects of the estimated impacts of the Great Recession on consumption and mortality, we find that the welfare gain from the estimated mortality decline is quantitatively significant relative to the welfare loss from the estimated consumption decline. The estimated mortality decline is also quantitatively close to prior mortality estimates using cross-sectional variation in the severity of the Great Recession, implying limited general equilibrium effects of the Great Recession on mortality. More broadly, our findings suggest that prior evidence from local labor markets that recessions are good for health can be extrapolated to the likely mortality consequences of nationwide recessions.

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1 Introduction

Are recessions good for health? Perhaps surprisingly, the answer appears to be yes. A large literature in health economics has documented that mortality is pro-cyclical: deaths tend to rise in expansions and fall in downturns. However, much of the evidence behind this conclusion is based on the relationship between mortality and fluctuations in local labor market conditions both within the United States (e.g., Ruhm, 2000; Miller et al., 2009; Stevens et al., 2015; Finkelstein et al., 2025) and within other high-income countries (e.g., Neumayer, 2004; Granados, 2005; Buchmueller et al., 2007; Ariizumi and Schirle, 2012). This local variation helps address many of the confounding problems that plagued earlier, national time-series analyses, where estimates were often sensitive to time periods, controls, and the choice of macroeconomic and health measures (Ruhm, 2012). But the same features that make designs using local labor market variation credible also limit the questions they can answer. By differencing out national shocks, these studies cannot estimate the full effect of a nationwide recession. Local estimates may miss spillovers across labor markets, changes in national wealth or financial conditions, federal policy responses, and other general-equilibrium forces that affect all places at once. As a result, evidence that mortality falls when there is a local labor market recession does not, by itself, establish that nationwide recessions are “good for health.”

This distinction is central in empirical macroeconomics, where recent papers have emphasized that using regional variation to estimate the effects of national shocks may not recover the aggregate effects of these shocks. Examples include estimates of the effects of fiscal stimulus (Nakamura and Steinsson, 2014), labor demand shocks (Beraja, Hurst, and Ospina, 2019), and trade shocks (Adão et al., forthcoming; Rodríguez-Clare et al., 2026). Formally, this reflects a “missing intercept” problem: cross-sectional estimates identify relative effects but omit general-equilibrium responses common to all units (Wolf, 2023).

In this paper, we bring this “local-versus-national” question to the study of recessions and mortality, examining the aggregate mortality impacts of the 2007-2009 Great Recession. There is existing evidence that areas of the U.S. that were harder hit economically by the Great Recession experienced mortality declines relative to areas that were less hard hit (Finkelstein et al., 2025). However, when it occurred, the Great Recession represented the largest contraction in the U.S. economy since the Great Depression, producing substantial, aggregate declines in asset prices, income, and earnings (e.g., Hur, 2018; Peterman and Sommer, 2019; Glover et al., 2020; Menno and Oliviero, 2020). As a result, evidence from variation in the impact of the Great Recession across local labor markets may not apply to the aggregate, national impact of the Great Recession. Such evidence would not, for example, account for potential cross-area spillovers from employment

declines in one labor market on mortality in other labor markets, nor for any aggregate effects of the Great Recession on mortality, for example through the stock market collapse and/or the monetary policy response to the Great Recession. How this large aggregate shock affected mortality nationwide thus remains an open empirical question.

We begin by presenting descriptive time series evidence on mortality over about a half-century. We show that there is a visible decline in mortality relative to trend at the time of the Great Recession. The qualitative pattern of the observed mortality path from 2006 to 2016 can be predicted from the time series relationship between mortality and unemployment from 1969 through 2005. However, the unemployment rate is an imperfect proxy for economic conditions in general, and in particular during the Great Recession. The 2006-16 unemployment time series, for example, masks the possibility that the economy was already displaying signs of weakness prior to 2008 (Mian and Sufi, 2010), as well as the subsequent sluggish recovery (Yagan, 2019).

In the main analysis of the paper, therefore, we augment the dynamic factor, time series model of Stock and Watson (2012) – which is trained on 132 different economic indicators from 1959 through 2005 – to include mortality, and use the resulting estimates to predict the impact of the Great Recession on mortality from 2007 through 2016. We impose the exclusion restriction that these economic indicators may influence mortality but that mortality does not influence them. Our estimates imply that the Great Recession reduced the cyclical component of age-adjusted mortality by 1.8 percent on average over these 10 years, with reduced mortality relative to trend persisting at least through the end of our 10-year analysis period. To put this estimate in perspective, on average between 1965 and 2000, age-adjusted mortality declined by 1 to 1.5 percent per year (Cutler and Meara, 2004); the Great Recession-induced aggregate mortality decline is therefore equivalent to about 1.5 years of secular reductions in mortality.

As another benchmark, we use the predictions from the dynamic factor model for both consumption and mortality during the Great Recession to calibrate the welfare consequences of the Great Recession without and with accounting for endogenous mortality. This analysis is in the spirit of other work in macroeconomics that incorporates health into welfare comparisons across countries and that incorporates secular improvements in health into welfare analyses of economic growth within and across countries (e.g., Nordhaus, 2002; Becker et al., 2005; Murphy and Topel, 2006; Hall and Jones, 2007; Jones and Klenow, 2016; Jones, 2016; Brouillette et al., 2025). Incorporating our mortality estimates has a quantitatively important, offsetting impact on our estimates of the welfare losses from the Great Recession relative to what would be implied by our estimates of its consumption effects alone. For example, for a 55-year-old, endogenous mortality reduces the welfare cost of the Great Recession by about 20 percent. At older ages where consumption effects

of the Great Recession may be limited, the Great Recession may even be welfare increasing once we account for endogenous mortality.

In the final part of the paper, we compare our estimates of the aggregate impact of the Great Recession to recent estimates based on spatial variation in local exposure to the same recession (Finkelstein et al., 2025), as well as to estimates of the impact of other local labor market fluctuations on mortality (Ruhm, 2000). This allows us to shed light on whether the Great Recession’s aggregate mortality effects are amplified, attenuated, or largely unchanged by the general-equilibrium forces absent from local designs. We find that estimates of the mortality impact of the Great Recession are similar – both quantitatively and in terms of their time path – whether they are estimated based on local area or national variation in economic conditions. This suggests that there are limited cross-market spillovers, as well as limited mortality impacts of Great-Recession-induced national declines in wealth and investment income above and beyond the income effects on local labor markets. As we discuss below, this finding is consistent with a large body of evidence in health economics that consistently finds limited effects of income or wealth on mortality over similar time horizons.

Taken together, our results provide new evidence that mortality is pro-cyclical at the national, aggregate level. At first blush, this may appear counter-intuitive, especially given the existing evidence that individuals who lose their job due to plant closures or mass layoffs experience increased mortality both in the U.S. (e.g., Sullivan and von Wachter, 2009) and in other high-income countries (e.g., Browning and Heinesen, 2012; Bloemen et al., 2018; Amorim et al., forthcoming). However, these findings are not inconsistent. Indeed, the evidence from local labor markets suggests that pro-cyclical mortality may stem from the *external* benefits of a slack economy, such as improvements in the quality of elder care (Stevens et al., 2015) and reductions in air pollution (Chay and Greenstone, 2003; Heutel and Ruhm, 2016; Finkelstein et al., 2025).

Our paper contributes to the large, empirical literature on the relationship between the economy and health. As noted earlier, most of this literature is based on local labor market variation, which may not capture general equilibrium effects of aggregate, national recessions. However, there are some important exceptions. Edwards (2009) and Egan et al. (2014) document that aggregate mortality is pro-cyclical, rising during booms and falling during recessions, in the United States over the 20th century.² In contrast to these findings, Drautzburg et al. (2026) use aggregate demand shocks from the macroeconomics literature and find that self-reported health worsens for prime-age individuals during periods of reduced aggregate demand. More broadly, there is a large empirical

²There is also evidence of pro-cyclical mortality in the U.S. time series from 1870 to 1920 (Ogburn and Thomas, 1922), from 1972 to 1991 (Ruhm, 2000, Figure 1), and from 1969 to 2019 (Finkelstein et al., 2025, Appendix Figure 5).

literature on the nuanced relationship between income and health. We discuss this literature in more detail in Section 6.3 below in the context of interpreting our findings.

In addition, our comparison of the results from the dynamic factor time series model of the Great Recession with those leveraging cross-regional variation in its intensity relates to a growing literature on whether and when analyses of regional shocks and outcomes can inform estimates of aggregate national shocks (e.g., Chodorow-Reich, 2020; Guren et al., 2021; Auerbach et al., 2024). One strand of this literature estimates cross-regional effects and maps them to aggregate outcomes via structural models (e.g., Nakamura and Steinsson, 2014; Beraja, Fuster, et al., 2019; Adão et al., forthcoming). The ‘demand equivalence’ approach, developed by Wolf (2023), instead provides conditions under which household-level and time-series evidence can be combined to produce a reliable estimate of aggregate effects.³ In this paper, we pursue a third approach: directly comparing estimates produced by local labor market variation and time series national variation in the economy, and interpreting any differences as indicative of the nature of general equilibrium effects of the Great Recession that are not captured by the local labor market approach. Overall, we find a limited role for these general equilibrium effects of recessions on mortality.

The rest of the paper proceeds as follows. Section 2 presents motivating descriptive patterns on mortality over a half century and on the time series relationship between unemployment and mortality. Section 3 describes the data and estimation of the dynamic factor model, and Section 4 presents its results. Section 5 uses the dynamic factor model estimates of the impact of the Great Recession on consumption and mortality to examine how the welfare implications of the Great Recession from its consumption impacts alone are affected by also incorporating its mortality impacts. Section 6 compares the estimates of the impact of the Great Recession on mortality from the dynamic factor model to those based on cross-sectional variation in the severity of the Great Recession, and discusses our findings in light of what is known about the impacts of income and of economic shocks on health. Section 7 provides a brief conclusion.

2 National Mortality Time Series: Data and Descriptive Patterns

2.1 Mortality Data and Decomposition

Data. We obtain information on age-specific deaths from the National Center for Health Statistics (NCHS) individual-level death data from 1969 through 2016. These data include the exact date of death (day, month, and year), allowing us to measure age-specific quarterly death counts.

³In a related approach, Matthes et al. (2025) jointly estimate cross-regional and aggregate effects via a Bayesian framework.

We combine the age-specific death counts with yearly, national population data by age bin starting in 1969 from the Surveillance, Epidemiology, and End Results Program (SEER) to form national age-adjusted quarterly mortality rates. Specifically, we calculate the age-adjusted mortality rate in a given quarter by averaging over the mortality rate in each of 19 age bins and weighting each age bin by the national share of the population in that age bin in 2000.⁴ We focus on age-adjusted mortality rates so that our analysis is not affected by changes over time in the age composition of the population.

A challenge is that the SEER population data are at the yearly level, while we wish to analyze quarterly data on mortality rates. We therefore linearly interpolate between yearly age-bin population estimates to create population estimates at the start of each quarter. Since SEER data reflect population as of July 1st (NIH National Cancer Institute and Vilhuber, 2021), we calculate quarterly population as a weighted average of the current, previous, and subsequent years' populations, with the weights varying by quarter.⁵ Appendix Figure A.1 shows that our resultant quarterly estimates of age-adjusted mortality rates are consistent with yearly estimates published by the National Center for Health Statistics (NCHS).

Decomposition. We decompose mortality into the sum of a long-run trend, a seasonal (quarterly) component, and a residual term that incorporates both a cyclical component (the component of the time series that varies at business cycle frequency) and an idiosyncratic error. We parametrize this mortality decomposition via the following quarterly, time series regression:

$$\tilde{m}_t = \alpha + \sum_{k=2}^4 \beta_k \mathbb{I}_{q(t)=k} + \delta * \text{year}_{y(t)} + \epsilon_t, \quad (1)$$

where t indexes a specific quarter-year period, $q(t) \in \{1, 2, 3, 4\}$ denotes the quarter of t , and $y(t)$ denotes the calendar year of t . Here, $\tilde{m}_t$ denotes the log age-adjusted quarterly mortality rate, $\mathbb{I}_{q(t)=k}$ denotes indicators for the quarter of the year, $\text{year}_{y(t)}$ denotes a linear time trend, and the ϵ_t residuals contain both the cyclical and idiosyncratic error components. We estimate equation (1) using data from 1969-2005; the 2006-2016 period is out-of-sample.⁶

⁴The age bins are: 0, 1-4, 5-9, and then every five-year age bin up through 80-84, with a final bin for 85+.

⁵Specifically, let $y(t)$ denote the year at period t , such that $Pop_{y(t)-1}$, $Pop_{y(t)}$, and $Pop_{y(t)+1}$ denote the previous, current, and subsequent years' populations, respectively. We then define Q1 population by $0.5 \times Pop_{y(t)-1} + 0.5 \times Pop_{y(t)}$, Q2 population by $0.25 \times Pop_{y(t)-1} + 0.75 \times Pop_{y(t)}$, Q3 population by $Pop_{y(t)}$ and Q4 population by $0.25 \times Pop_{y(t)+1} + 0.75 \times Pop_{y(t)}$.

⁶We use Newey-West standard errors to account for serial correlation; following a rule proposed by Stock and Watson (2020), we set the maximum lag order of autocorrelation to 4.

2.2 Time Series Patterns

Figure 1 Panel (a) shows mortality patterns over the 1969-2016 period. The blue line shows our estimate of the long-term linear trend $\hat{\delta}$ (including the constant term $\hat{\alpha}$) based on estimating equation (1) on the 1969-2005 quarterly data and extrapolating out to 2016. Consistent with prior work (e.g., Cutler and Meara, 2004; Ma et al., 2015), we estimate that mortality declines are approximately log-linear, with an average annual decline of 1.1 percent (standard error = 0.05 percent). The black line shows the long-term trend plus the $\hat{\epsilon}_t$ residuals; in other words, the black line shows mortality rates purged of seasonal variation via the $\hat{\beta}_k$ coefficients. It indicates that the mortality rate fluctuates substantially around its long-term trend, with deviations reaching up to 5 percent. For example, mortality rates were below their long-run trend in the late 1970s and early 1980s and during the Great Recession, and above their long-run trend in the 1990s and early 2000s. These fluctuations indicate that the $\hat{\epsilon}_t$ residuals capture meaningful variation in the mortality rate, which raises the question of how much of this variation can be explained by prevailing economic conditions.

The Time Series Relationship Between Mortality and Unemployment. The literature described in the Introduction that documents pro-cyclical mortality using local labor market variation has focused on the relationship between unemployment and mortality within areas (such as states or commuting zones) over time. We therefore begin by examining how well the contemporaneous unemployment rate can predict national fluctuations in mortality relative to the deviations from trend seen in Panel (a).

To do so, we add contemporaneous unemployment to the regression in equation (1) and estimate:

$$\tilde{m}_t = \alpha' + \sum_{k=2}^4 \beta'_k \mathbb{I}_{q(t)=k} + \delta' * year_{y(t)} + \theta' * (U_t - \bar{U}) + \epsilon'_t, \quad (2)$$

where U_t denotes the contemporaneous unemployment rate (taken from the St. Louis Fed's UNRATE time series), and $\bar{U}$ denotes the unemployment rate mean across 1969-2005. Panel (b) shows the mortality path predicted by equation (2) in red. For comparability, it superimposes the blue/black time series shown in Panel (a). The unemployment rate is negatively correlated with mortality in the time series ($\hat{\theta}' = -1.39$ percent, standard error: 0.21 percent). In other words, high-unemployment periods – such as the late 1970s/early 1980s and the early 1990s – are associated with below-trend predicted mortality.⁷

⁷Appendix A shows that we observe a similar pro-cyclical mortality pattern and magnitude when running a 2-variable VAR with unemployment and mortality. In this simple VAR setup, the estimated effect of the current unemployment shock is a 0.4 percent decrease in the current mortality rate – a result quite similar in magnitude

Since our focus is on the Great Recession, Figure 1 Panel (c) zooms in on the 2003-2016 period. The large increase in unemployment between 2007 and 2009 yields lower predicted mortality rates; since the unemployment rate decreased throughout the 2010s, the model predicts mortality gradually returning to its long-run trend. The model’s predictions broadly reproduce the post-recession mortality path, in which the mortality rate is below its estimated long-run trend, especially initially, and then gradually returns to trend.

Overall, these results suggest that increases in the contemporaneous unemployment rate predict declines in the contemporaneous mortality rate relative to its long-run trend. However, the unemployment rate is an imperfect proxy for economic conditions, especially in the context of the Great Recession. The 2006-2016 unemployment time series masks both the possibility that the economy was already displaying signs of weakness prior to 2008 (Mian and Sufi, 2010) as well as the subsequent sluggish recovery; Yagan (2019), for example, finds that areas more severely affected by the Great Recession still had a lower employment-population ratio in 2015, even though by then the area unemployment rate had mostly receded to its 2006 level. A related literature indicates that job loss affects long-term employment and earnings outcomes beyond what is captured by the unemployment rate; for example, workers frequently exit the labor force and seek disability insurance benefits (Autor and Duggan, 2003) or suffer long-term human capital losses (Jarosch, 2023). Other papers, such as Hall (2015), indicate that the Great Recession induced lower investment and, consequently, a lower capital stock. This body of work indicates that economic downturns such as the Great Recession are multi-faceted and are not fully captured by the unemployment rate alone. In our main analysis, therefore, we incorporate a large set of economic indicators via a dynamic factor model, which allows for a comprehensive assessment of the relationship between economic conditions and the mortality rate.

3 Dynamic Factor Model: Data and Estimation

Dynamic Factor Models (DFMs) are a dimensionality reduction technique, such that hundreds of macroeconomic indicators are driven by a few unobserved macroeconomic “factors.” This structure relates well to workhorse macroeconomic models, such as the New Keynesian model, that feature only a handful of shocks. We employ the DFM used in Stock and Watson (2012), augmenting it to include mortality; we also extend their data to Q4 2016 and limit the factor estimation period to Q4 2005.⁸

to Ruhm (2000) and Finkelstein et al. (2025)’s estimates of the relationship between unemployment and mortality based on local area variation in the unemployment rate.

⁸We restrict the factor estimation period to Q4 2005 to allow for the possibility that economic trends related to the Great Recession began as early as 2006, as suggested by Mian and Sufi (2010). In Appendix C, we extend the

3.1 Data

Economic Data. We update the Stock and Watson (2012) dataset, comprising 200 quarterly national-level economic indicators from 1959–2012, to cover the period through 2016. These indicators include measures from 13 broad categories, such as national income and product accounts, employment and unemployment, housing starts, stock prices and wealth, interest rates, prices, and credit. Following Fernald et al. (2017), we replace indicators that were discontinued in the 2012–16 period with similar indicators.

Our treatment of these economic variables directly follows Stock and Watson (2012). We use only 132 of the 200 economic indicators to estimate the dynamic factor model, excluding top-line aggregates such as GDP and total consumption. We transform the economic indicators such that the time series become plausibly stationary; real activity variables are transformed to growth rates, while inflation, interest rates and unemployment rates are transformed to first differences. We then remove low-frequency variation from each transformed series by subtracting a long-run local mean, computed at each date as a weighted average of the surrounding 100 quarters of observations. The weights are given by a biweight kernel, which places the greatest weight on the closest quarters and smoothly tapers to zero at the edges of the window.⁹

In some of our analyses, we focus particularly on consumption, which is measured in Stock and Watson (2012) by real personal consumption expenditures (PCE). As explained in the previous paragraph, the consumption time series is transformed to log first-differences, such that each observation represents the growth rate relative to the previous quarter; we then apply the biweight filter described above to remove low-frequency variation, yielding series that fluctuate around zero. The raw PCE data are also available at the state level, which enables us to compare estimated impacts of the Great Recession on consumption from the dynamic factor model to those estimated using local-area variation in exposure to the Great Recession.

Mortality Data. We use the mortality data described in Section 2. These data also include geographic identifiers, which likewise enable us to compare estimated impacts of the Great Recession on mortality from the dynamic factor model to those estimated using local-area variation in exposure to the Great Recession. We perform a set of transformations to the mortality series that is similar to the previously described transformations of the economic series.

First, since we are interested in the cyclical component of mortality, we collect the residual mortality ($\hat{\epsilon}_t$) estimated via equation (1), which contains cyclical and idiosyncratic error components.

factor estimation period to Q3 2007 – as in the original Stock and Watson (2012) – as a robustness check.

⁹For more detail on variable transformations, see the online supplement to Stock and Watson (2012).

To separate the idiosyncratic error component from the cyclical component in these residuals, we then apply the Kalman filter to the residual time series. We apply this additional smoothing here, even though Stock and Watson (2012) did not smooth the economic variables, because the mortality time series is considerably more volatile, and first-differencing a very volatile series would introduce considerable noise.

The idea behind the Kalman filter, as employed in the time series literature (e.g., in Stock and Watson, 2016a), is to decompose the $\hat{\epsilon}_t$ residuals in equation (1) into an unobserved mortality state s_t and a noise term v_t that is assumed to be i.i.d. normally distributed. The mortality state is in turn assumed to follow an AR(1) process with i.i.d. normally distributed errors ζ_t , as in the equations below:

$$\hat{\epsilon}_t = s_t + v_t, \quad v_t \sim N(0, \sigma_v^2), \quad (3)$$

$$s_t = \phi s_{t-1} + \zeta_t, \quad \zeta_t \sim N(0, \sigma_\zeta^2) \quad (4)$$

The Kalman filter is a one-sided filter; that is, it only uses information up to time t to estimate s_t .¹⁰

Figure 2 Panel (a) displays the results. The red line displays the estimated mortality state $\hat{s}_t$; this series represents the quarterly estimates of the cyclical component of age-adjusted mortality; since the mortality outcome was specified in logs in equation (1), the y-axis values can be interpreted as the percent deviation of the age-adjusted mortality rate from its long-term trend. The black line provides a comparison to the time series of the estimated $\hat{\epsilon}_t$ residuals from equation (1). The Kalman-filtered time series (red line) retains the same profile as the residual time series (black line) but is considerably less volatile.

Finally, since economic activity is more strongly associated with changes in the cyclical component of mortality than with the component's level, we take the first-difference of this estimated cyclical component.¹¹ Specifically, we denote:

$$m_t \equiv \Delta \hat{s}_t \quad (5)$$

The resultant time series m_t is shown in Figure 2 Panel (b). The values in this figure can be interpreted as the percentage point quarter-on-quarter change in the cyclical component of the log mortality rate, so that a value of 0.25 means that the cyclical component of mortality increased by 0.25 percentage points since the last quarter (for example, from 1 percent above trend to 1.25

¹⁰The main results are robust to employing other filtering procedures such as a biweight smoother.

¹¹Similarly, the analyses of impacts of local labor market unemployment on mortality likewise consider how *changes* in the unemployment rate impact mortality (e.g., Ruhm, 2000; Finkelstein et al., 2025).

percent above trend), or equivalently that the mortality rate increased by 0.25 percent.

3.2 Estimation

The DFM's structure is represented by

$$X_t = \Lambda F_t + e_t \quad (6)$$

where $X_t = (X_{1t}, X_{2t}, \dots, X_{nt})'$ represents a vector of 132 economic indicator time series measured quarterly over the period from 1959 Q1 through 2016 Q4, F_t represents a vector containing six factors,¹² Λ represents a matrix of coefficients (called factor-loadings) and e_t represents an idiosyncratic error term. The model thus represents macroeconomic time series as a linear combination of factors plus an idiosyncratic error term. The ΛF_t term is called the common component of X_t .

Both Λ and F_t in equation (6) above must be estimated. Following Stock and Watson (2012), we jointly estimate these terms via principal components analysis (PCA), which provides a consistent estimate of F_t and Λ via an optimization problem that minimizes the sum of squared errors $(X_t - \Lambda F_t)'(X_t - \Lambda F_t)$ weighted by the covariance matrix of idiosyncratic errors. We estimate Λ first as a solution to the least squares problem and subsequently estimate F_t by projecting the loadings onto the observed data through the equation:¹³

$$\hat{F}_t^{59-05} = (\hat{\Lambda}^{59-05})' X_t^{59-05}. \quad (7)$$

Finally, to produce factors in the 2006-2016 period, we hold the 1959-2005 factor-loadings fixed and plug in the observed X_t in 2006-2016:

$$\hat{F}_t^{06-16} = (\hat{\Lambda}^{59-05})' X_t^{06-16} \quad (8)$$

Stock and Watson (2012) applied this procedure to the quarterly, time-series data on 132 economic indicators from Q1 1959 through Q3 2007. They are able to predict most of the variation in the economic indicators during the Great Recession using only six factors. These factors are not observable variables, but rather linear combinations of the underlying economic indicators that

¹²We choose six factors following Stock and Watson (2012), who base this choice on Bai and Ng (2002) tests as well as visual inspection of scree plots.

¹³For further details on the estimation procedure, see Stock and Watson (2016b). Note also that since F_t and Λ are determined jointly, the solution to the problem is not unique, as a solution to ΛF_t could also be $\Lambda H H^{-1} F_t$ for some invertible matrix H . Thus, this procedure requires an arbitrary normalization of Λ (following Stock and Watson (2012) we use $\Lambda' \Lambda = \mathbf{I}$), which implies that a particular factor does not have a specific economic meaning. Factors instead represent arbitrary linear combinations of the variables in X_t that serve as an indicator of the state of the economy.

serve as reliable indicators of the state of the economy. Using the resultant, estimated factor loadings and the subsequent aggregate time series of these six factors from Q4 2007 through Q2 2011 to predict out of sample how each of 200 economic indicators was expected to move over this period, they assess how well the predicted values track the actual movements over the Great Recession and subsequent recovery. They conclude that the factor model trained on pre-Great Recession data does a good job predicting the time series, aggregate movement of economic variables during the Great Recession. In other words, the Great Recession appears to be the result of larger shock realizations rather than a new set of shocks or factors. We are able to reproduce their results.

Incorporating Mortality. We augment the model to also estimate the relationship between economic factors and mortality during the pre-Great Recession period, and use these estimates to predict how mortality would be expected to evolve given the changes in economic factors during the Great Recession. This exercise assumes that the factor loadings for mortality did not change during the Great Recession; this may be a reasonable assumption given that Stock and Watson (2012) estimate that the factor loadings for economic indicators do not change during the Great Recession.¹⁴

Leveraging the mortality time series m_t constructed above (and shown in Figure 2 Panel (b)), we obtain factor-loadings Λ_m for mortality by running an OLS regression of the mortality time series on the economic factors over the period from 1969 to 2005 Q4:

$$m_t^{69-05} = \hat{\Lambda}_m^{69-05} \hat{F}_t^{69-05} + u_t \quad (9)$$

where $\hat{F}_t^{69-05}$ are the six factors estimated in equation (7).¹⁵ This approach imposes the exclusion restriction that the economic factors may influence mortality but mortality does not influence them.

Using the estimated factor-loadings for mortality ($\hat{\Lambda}_m^{69-05}$) from equation (9), together with the 2006-2016 factors ($\hat{F}_t^{06-16}$), we then predict the mortality rate over the 2006-2016 period:

$$\hat{m}_t^{06-16} = \hat{\Lambda}_m^{69-05} \hat{F}_t^{06-16} \quad (10)$$

The outcome from equation (10) serves as a prediction of the path of mortality rates given economic conditions during the Great Recession.

¹⁴Cheng et al. (2016) provide evidence consistent with the emergence of a new factor around the Great Recession that mostly affects financial variables. However, as we discuss in Section 4, we find that mortality is more related to real activity variables than financial variables.

¹⁵As in Section 2, we employ Newey-West standard errors. Similarly to Ludvigson and Ng (2009), we treat factors as observed and ignore estimation error; Bai and Ng (2006) show that, as long as the number of factor indicators N is sufficiently large relative to the number of time periods T ($\sqrt{T}/N \rightarrow 0$), factor estimation error is asymptotically negligible when estimating second-stage parameters.

4 Dynamic Factor Model: Results

4.1 Baseline Results

Co-Movement of Economic Factors and Mortality. Appendix Table A.1 displays the R^2 of the common component for the 13 broad economic categories, as well as the (new) R^2 for the cyclical component of the mortality rate (bottom row).¹⁶ It suggests that movements in the cyclical component of mortality can be partially explained by macroeconomic factors, with an R^2 of 0.05 over the entire sample period. While there is some variation in fit across recessions, there is no clear pattern in the fit over time. The R^2 for mortality is lower than for the economic indicators, which is not surprising: unlike the economic indicators, mortality was not used in estimating the factors; additionally, the mortality time series is more volatile than most economic indicators.

To get a better sense of which economic factors are important for mortality, we estimate the model six times: first with one factor, then with two factors, and so on. Table A.2 displays the R^2 obtained from each model; again, the bottom row shows the results for mortality. Results indicate that the first two factors, which are strongly associated with employment-related variables and housing starts, can explain most of the total variation in mortality explained by the model ($R^2 = 0.04$ for the first two factors, compared to R^2 of 0.05 for all six factors). By contrast, factors three through six, which are primarily associated with wealth-related variables such as stock prices and wealth, exchange rates, and housing prices, provide little additional explanatory power. The lack of co-movement between mortality rates on the one hand and stock prices and wealth on the other hand may help explain why we find similar impacts of the Great Recession whether we use local or national variation in its intensity.

Mortality. Figure 3 Panel (a) shows the predicted path for the cyclical component of the mortality rate based on the estimates from the DFM; Appendix Table A.3 displays associated yearly averages. We normalize results relative to 2006Q1, and calculate the predicted path of the cyclical component of mortality as the cumulative sum of predicted quarter-on-quarter changes in the cyclical component since 2006Q1. The results indicate that predicted mortality began decreasing before the official start of the recession in 2007Q4, presumably reflecting the fact that the U.S. economy began showing signs of weakness prior to the recession; for example, Mian and Sufi (2010) show declines in auto sales and house prices starting in 2006.

Overall, the model predicts that the annual cyclical component of mortality rates decreases by

¹⁶The results for the economic categories are quite similar to those in Stock and Watson (2012). The online supplement for Stock and Watson (2012) shows the correspondence between individual indicators and categories. The “Other” group contains two indicators: consumer expectations and policy uncertainty.

an average of 1.8 percent in the 2007-2016 period relative to its long-term trend. The mortality decline is evident early in 2007. The decline levels off after about 2009, remaining constant through the end of our analysis period in 2016.

The estimates from the DFM suggest that the impacts of the Great Recession on mortality are more persistent than what we find using only the contemporaneous unemployment in Figure 1. This divergence in persistence is natural, since the unemployment rate reverted to its pre-recession mean by 2015. As discussed in Section 2, however, other indicators such as the prime-age labor force participation rate did not recover. Thus, the persistence of the mortality impacts of the Great Recession from the DFM estimates highlights the importance of incorporating economic information beyond the contemporaneous unemployment rate. This advantage is reinforced by the structure of the DFM: the six estimated static factors may span a smaller number of dynamic factors,¹⁷ such that the predictive regression implicitly incorporates these dynamics rather than drawing from contemporaneous information alone.

We undertook a number of supplemental analyses. In Appendix C we show that the estimated impacts of the Great Recession on mortality in Figure 3 are robust to a number of alternative specifications. In Appendix D we extend the model to allow the predicted path of the cyclical component of mortality to vary across four broad age groups: 0-24, 25-44, 45-64, and 65+. There is evidence of mortality declines in all four age groups.

Consumption. Figure 3 Panel (b) shows the predicted path for consumption based on the estimates from the DFM; once again, we normalize results relative to 2006Q1 and display yearly averages in Appendix Table A.3. The model predicts consumption to decrease on average by 9 percent in the 2007-2016 period, relative to its long-term trend.¹⁸ The time path for the impact on consumption is similar to that for mortality: the model predicts that consumption declines start before 2007Q4 and that consumption declines level off after about 2009, remaining constant through the end of our analysis period in 2016.

4.2 Restricting to 2006-09 Structural Shocks

Before examining the implications of the preceding estimates, we consider whether they can reasonably be interpreted as reflecting the impact of the Great Recession. A potential concern with this interpretation is that we have predicted mortality changes for 2006-2016 relative to trend by

¹⁷In DFMs, it is possible that static factors F_t represent different lags of a single dynamic factor f_t ; for instance, F_{1t} and F_{2t} might represent f_t and f_{t-1} , respectively.

¹⁸Appendix Table A.4 shows common component R^2 for consumption over the 1959-2007 period; the fit is very good ($R^2=0.61$) since consumption closely co-moves with economic indicators.

using the product of the mortality factor loadings and the 2006-16 factors. As a result, our mortality predictions incorporate any shocks that hit the economy in 2006 through 2016. These include shocks in 2010-16 which may or may not be plausibly part of the Great Recession.

We therefore also explore an alternative approach in which we decompose the effect of 2006-16 shocks into 2006-09 structural shocks, which isolate shocks occurring during the turn of the housing cycle and the traditionally demarcated period known as the Great Recession, and 2010-16 structural shocks, which incorporate shocks in the post-recession period that may (or may not) be related to the Great Recession. In practice, we find that the 06-09 shocks drive most of the effects on mortality; the 2010-16 shocks have only minor effects on mortality through 2016 – with a slight mortality recovery starting in 2014.

Approach. To obtain the 2006-2009 structural shocks, we define a VAR over the six factors $\hat{F}_t$ estimated in Section 3.2. As in Stock and Watson (2012), we estimate a 4-lag VAR. For expositional ease, however, we describe the approach with a 1-lag model:

$$\hat{F}_t = \Phi \hat{F}_{t-1} + \eta_t \quad (11)$$

In the above, η_t represents factor innovations; that is, changes in factors that cannot be explained by their lags. We estimate the VAR over the 1959Q3-2005Q4 period, which produces estimates $\hat{\Phi}$. Then, given $\hat{\Phi}$, we produce estimates of the innovations $\hat{\eta}_t$ as follows:

$$\hat{\eta}_t = \hat{F}_t - \hat{\Phi} \hat{F}_{t-1} \quad (12)$$

We include the out-of-sample 2006-16 period when calculating the innovations with equation (12).

Under the assumption of invertibility, in the 2006-2009 period these innovations span the space of structural shocks that hit the economy during the Great Recession.¹⁹ Figure A.2 displays estimated innovations for all 6 factors, and the dashed lines indicate 2007Q4 and 2009Q2 (the official start and end dates of the Great Recession, per the NBER). Note that large innovations occur exactly during the Great Recession.²⁰

Equipped with the estimated structural shocks from a 4-lag VAR version of equation (12) and

¹⁹The invertibility assumption is that structural shocks can be recovered from the set of factors and their lags. A threat to this assumption is that agents may act on information that is not reflected in the system, such that innovations represent structural shocks plus a component that is observable a priori to agents but not the econometrician (Bernanke et al., 2005). Our DFM environment, however, is particularly well-suited to the invertibility assumption since the factors incorporate information from 132 macroeconomic series, including those on presumably forward-looking financial prices, such as corporate bond spreads. Forni et al. (2009) show that structural shocks are spanned by factors estimated from large cross-sections and their lags.

²⁰Between 2007 and 2009, some of the shocks are positive and others are negative. This variation is a consequence of normalization and does not contain economic content.

the DFM structure, we can decompose the effect of the structural shocks at each period starting at $t=2005Q4$ on mortality at a given period $t+h$:

$$\begin{aligned}
m_{t+h} &= \hat{\Lambda} \hat{F}_{t+h} \\
&= \hat{\Lambda} (\hat{\Phi} \hat{F}_{t+h-1} + \hat{\eta}_{t+h}) \\
&= \hat{\Lambda} (\hat{\Phi} (\hat{\Phi} \hat{F}_{t+h-2} + \hat{\eta}_{t+h-1}) + \hat{\eta}_{t+h}) \\
&= \hat{\Lambda} (\hat{\Phi}^h \hat{F}_t + \hat{\Phi}^{h-1} \hat{\eta}_{t+1} + \dots + \hat{\Phi} \hat{\eta}_{t+h-1} + \hat{\eta}_{t+h})
\end{aligned}$$

Using the above relationship, we can decompose the 2006-16 DFM-predicted path of mortality rates given economic conditions into the sum of initial conditions at time t plus a combination of structural shocks decaying at a rate informed by Φ . Specifically, denote a time window by $(t+r, t+s)$, with $0 \leq r \leq s \leq h$. In this scenario, our object of interest is the impact of structural shocks in time window $(t+r, t+s)$ on mortality in period $t+h$, which we denote θ_{t+h} . In the VAR(1) framework, this is defined as:

$$\hat{\theta}_{t+h} \equiv \hat{\Lambda} \left(\sum_{k=r}^s \hat{\Phi}^{h-k} \hat{\eta}_{t+k} \right) \quad (13)$$

Since mortality is first-differenced, we perform a cumulative sum of the $\hat{\theta}_{t+h}$ terms from 2006Q1 to time $t+h$.

Unlike our baseline analysis, this approach requires that we impose a VAR structure for the factors and that we assume invertibility. However, it also offers two potential advantages. First, we can test whether the initial conditions term $(\hat{\Phi}^h \hat{F}_t)$ meaningfully impacts the estimates in Figure 3. Second, we can isolate the effect of structural shocks for varying time windows.

Results. Figure 4 shows this object for two time window specifications (2006Q1-2009Q4 and 2006Q1-2016Q4). For comparison, it overlays the baseline result from Figure 3 in red. Comparing the 2006-2016 predicted cumulative effect generated without using the initial condition (green line) to the baseline prediction (red line), we see that, reassuringly, the initial conditions term has only a minor impact on the final prediction.

The main comparison of interest is between the estimates using the 2006-2009 shocks (yellow line) and those using the 2006-2016 shocks (green line); the underlying yearly estimates are shown in Table A.5. This comparison illustrates the consequence of interpreting 2010-2016 shocks as “part of the Great Recession” in our baseline specification. It indicates that the 2010-16 shocks have only a modest effect on mortality. For example, using only the 2006-2009 shocks, we predict a 2.0 percent

reduction in mortality in 2011 compared to a 2.4 percent reduction when we also incorporate the 2010-2016 shocks. That is, shocks in 2010-2011 only contributed to a small reduction in mortality. The specification employing 2006-16 shocks also indicates some mortality recovery starting in 2014, with an estimated 1.5 percent mortality reduction in 2016 (versus 1.9 percent for the 2006-2009 shocks specification).²¹ Overall, Table A.5 indicates that the specifications using 2006-2009 and 2006-16 structural shocks yield the same 2010-16 average effect on mortality: -2.0 percent.

In practice, we suspect that the 2010-16 shocks are at least partially related to the Great Recession via its hysteresis effects. Given the estimated pro-cyclical behavior of mortality, the small and initially negative impact of 2010-16 shocks on mortality is consistent with the sluggish economic recovery in the early 2010s, which was a period of hysteresis effects of the Great Recession. As discussed in Section 2, Yagan (2019) documents that local labor market effects of the recession persisted even after unemployment rates recovered to pre-recession levels. Furthermore, Kroft et al. (2016) indicate that the increase in the long-term unemployment rate in the Great Recession can be explained by adverse effects of a longer unemployment spell during the hiring process. These hysteresis effects then translate into a particularly slow recovery from the recession. It is therefore likely that 2010-16 shocks incorporate Great Recession-induced shocks, in addition to potentially other shocks.

5 Welfare Implications of Mortality Effects of the Great Recession

We now return to our baseline specification from Section 4.1 to assess the quantitative importance of the estimated mortality declines from the Great Recession. We do so by analyzing how, relative to considering only consumption declines, incorporating endogenous mortality affects the welfare impact of the Great Recession. As noted in the Introduction, our analysis is in the spirit of a growing body of work in macroeconomics that incorporates secular improvements in health into welfare analyses. There has been comparatively less attention, however, to incorporating cyclical fluctuations in health into welfare analysis of business cycles.²²

5.1 Model

We consider a representative agent with expected lifetime utility given by:

²¹Note that, since the model is estimated using first-differences, the 2006-2009 shocks predict lower mortality growth with effects decaying over time. Once cumulated as in Figure 4, the model predicts a permanent level change.

²²There are of course some important exceptions. Edwards (2009) finds that the utility cost of cyclical fluctuations in mortality is roughly the same magnitude as the (small) costs of business cycles estimated by Lucas (1987); Egan et al. (2014) find that business cycle fluctuations in the U.S. are considerably less severe based on their adjusted measure of GDP that accounts for the monetary cost of mortality; and Finkelstein et al. (2025) find that a direct extension of the Krebs (2007) model to include pro-cyclical mortality considerably reduces the welfare costs of business cycles.

$$U(c^\omega(t), m^\omega(t)) = \sum_{t=0}^{\infty} \beta^t S(m^\omega(t)) u(c^\omega(t)),$$

where $c^\omega(t)$ is the agent's consumption in period t and aggregate state ω , $m^\omega(t)$ is the mortality rate (allowed to vary over the life-cycle), and β is the agent's subjective discount factor. The cumulative survival rate $S(m^\omega(t)) = \prod_{\tau=0}^{t-1} (1 - m^\omega(\tau))$ is calculated using the vector of mortality rates up to time t , and life expectancy T is equal to the sum of the cumulative survival rates; i.e., $T = \sum_{t=0}^{\infty} S(m^\omega(t))$. Individuals consume $c^\omega(t)$ units of consumption every period.

As in Hall and Jones (2007), the agent gets per-period utility both from being alive and from consumption. Specifically, we assume a per-period utility function, $u(c)$, given by:

$$u(c) = b + \frac{c^{1-\gamma}}{1-\gamma}, \quad (14)$$

where b governs the willingness to pay for additional years of life. The value of a statistical life-year (VSLY) is given by $VSLY = \frac{U(c,m)/u'(c)}{T}$.

We assume that there are two aggregate states $\omega \in \{L, H\}$, where $\omega = H$ denotes the normal state (normal times), and $\omega = L$ denotes the Great Recession state. We model the Great Recession as a shock at $t = 0$ that moves the economy to state L for ten years, at which point the economy reverts back to the no-recession state $\omega = H$ until the end of an agent's life. If mortality is exogenous, then $m^H(t) = m^L(t) = m(t)$.

We define state-dependent consumption and mortality as:

$$c^\omega(t) = c^H(t) \cdot (1 + dc(t) \cdot \mathbf{1}(\omega = L))$$

$$m^\omega(t) = m^H(t) \cdot (1 + dm(t) \cdot \mathbf{1}(\omega = L))$$

where $dc(t)$ and $dm(t)$ denote the percentage declines in consumption and the mortality rate from the Great Recession ($dc(t) < 0$ and $dm(t) < 0$); they are obtained from the empirical estimates in Section 4 and may vary over time (t) to account for the dynamic effects of the Great Recession. By directly incorporating these empirical estimates, we bypass the need to make assumptions about households' income processes and consumption-savings decisions, as in Krebs (2007) and Finkelstein et al. (2025). Instead, we use the empirically estimated consumption paths which incorporate households' optimization decisions and incorporate households' partial insurance against income shocks (Blundell et al., 2008).

We define the welfare cost of the Great Recession (Δ_{GR}^{dm}) as the amount the representative agent would need to be paid, as a percentage of their average annual consumption, to be indifferent

between experiencing the Great Recession and not experiencing the Great Recession:

$$\underbrace{\sum_{t=0}^{\infty} \beta^t S(m^{\omega}(t)) u((1 + \Delta_{GR}^{dm}) c^{\omega}(t))}_{\text{Lifetime Utility with the Great Recession}} = \underbrace{\sum_{t=0}^{\infty} \beta^t S(m^H(t)) u(c^H(t))}_{\text{Lifetime Utility without the Great Recession}}. \quad (15)$$

The right-hand side of equation (15) corresponds to an individual's lifetime utility when the aggregate state is always $\omega = H$ (i.e., no recession). The left-hand side is the lifetime utility of an individual experiencing the Great Recession; specifically, they experience the aggregate state of $\omega = L$ for $0 \leq t \leq 9$ and $\omega = H$ after that. In other words, we assume that the Great Recession's effects last for only 10 years (the time period over which we estimate effects).²³ Given that we find that the Great Recession was associated with decreases in both consumption (welfare reducing) and mortality (welfare improving), the overall impact of the Great Recession on welfare depends on the strength of these two opposing effects.

In Appendix E we show that we can approximate the welfare cost of the Great Recession (Δ^{dm}) as follows:

$$\Delta^{dm} \approx \Delta - dT * \left(\frac{\text{VSLY}}{c} \right), \quad (16)$$

where Δ denotes the welfare impact of the Great Recession when mortality is exogenous (i.e., $dm(t) = 0$) and depends on the proportional consumption declines from the Great Recession, dT denotes the percentage change in life expectancy due to the Great Recession, and VSLY/c is the ratio of the value of a statistical life year to annual consumption.

Equation (16) indicates that the welfare effects of the Great Recession are approximately separable in the effects of the Great Recession on consumption (which determines Δ) and the effects of the Great Recession on mortality (which affects life expectancy via dT). The effect of the Great Recession on life expectancy is scaled by the value of a statistical life-year (VSLY) divided by annual consumption in order to be comparable to the effects of the Great Recession on consumption.

5.2 Calibration and Results.

Calibrations. We use the estimates from the DFM in Figure 3 of the consumption and mortality effects of the Great Recession to compare the welfare cost of the Great Recession based solely on consumption effects to one that also incorporates mortality effects. We use Social Security

²³A caveat to modeling the Great Recession's impact on consumption and investment as lasting only the 10 years that we directly estimated its impacts is that there is also evidence that R&D investment is pro-cyclical and fell during the Great Recession (Anzoategui et al., 2019; Barlevy, 2007). This may have adversely impacted long-run mortality rates (by slowing the rate of medical discoveries) as well as long-run consumption. This negative investment effect may be especially important given the slow recovery from the recession and its associated hysteresis effects (Yagan, 2019).

Administration mortality tables to translate the estimated percentage decline in mortality in Figure 3 Panel (a) into a predicted increase in life expectancy. We make two different assumptions when calibrating consumption declines from the Great Recession based on the estimates in Figure 3 Panel (b). First, we assume that the Great Recession lowered consumption by a constant percentage ($dc(t)$) across all age groups up to age 65, with no consumption effects at older ages. This may be a reasonable assumption since labor market activity among individuals aged 65 and older is limited; it is also broadly consistent with the evidence in Malmendier and Shen (2024), who report larger consumption responses to the Great Recession for younger compared to older cohorts (see especially their Appendix Figure B.4). Second, since the Great Recession generated declines in 65+ wealth (Glover et al., 2020) and in non-retired workers' labor income (Coile and Levine, 2011) that may translate into lowered 65+ consumption, we also calibrate the model under the assumption that 65+ consumption declines were equivalent in percentage terms to those for ages 0-64. Finally, we set $\beta = 0.96$, allow the coefficient of relative risk aversion γ to be 1.5, 2 or 2.5, and consider a range of VSLYs corresponding to 2, 5 or 8 times annual consumption. Again, Appendix E provides more details.

Results. Figure 5 shows our estimates of the welfare costs of the Great Recession by age, under the baseline assumptions of $\gamma = 2$ and VSLY of 5 times annual consumption for the two consumption specifications described in the previous section; Appendix Table A.8 shows results for other values of γ and VSLY.

Panel (a) shows the results assuming no consumption effects for 65+. With exogenous mortality, the Great Recession imposed an average welfare cost for a 35-year-old of about 3.94 percent of average annual consumption. This welfare cost initially rises with age – since older individuals have fewer years remaining, the (constant) willingness to pay in terms of annual consumption translates into a higher share of remaining lifetime consumption – but eventually declines to zero due to the lack of consumption effects at ages 65 and older. Accounting for endogenous mortality reduces the welfare cost of the Great Recession at all ages but reduces this welfare cost substantially more at older ages. For a 35-year-old, accounting for endogenous mortality reduces the welfare cost of the Great Recession by about 6 percent (from 3.94 percent of average annual consumption to 3.72 percent). However, for a 55-year-old, endogenous mortality reduces the welfare cost of the Great Recession by about 20 percent (from 4.90 percent of average annual consumption to 3.91 percent). Under the assumption of no consumption impacts after age 65, endogenous mortality causes the Great Recession to become welfare-improving starting at age 62.

Panel (b) displays welfare effects when assuming constant consumption effects across all ages,

including 65+. With exogenous mortality, the welfare cost of the GR is now always increasing in age, reaching 7.1 percent at age 75.²⁴ However, once mortality effects are included, welfare costs of the Great Recession begin to decline with age at age 55, similarly to the first specification. This declining profile in welfare costs occurs because mortality rates are higher at older ages. Therefore, most of the averted deaths from a proportional reduction in the mortality rate at all ages are among older individuals.²⁵ Eventually the increase in mortality benefits with age dominates the increase in consumption costs with age, causing the welfare costs of the Great Recession with endogenous mortality to begin to decline with age rather than rise with age as happens with exogenous mortality. Unlike Panel (a), however, the Great Recession does not become welfare improving at older ages.

6 Comparison to Estimates Using Local Labor Market Variation

In our final set of analyses, we compare the DFM estimates of the impact of the Great Recession on mortality and consumption from Section 4.1 with estimates of the impact of the Great Recession on these outcomes based on using spatial variation in the economic severity of the Great Recession across local labor markets in the U.S.

6.1 Leveraging Local Labor Market Variation

We follow the approach in Yagan (2019) and Finkelstein et al. (2025) and estimate:

$$y_{ct} = \beta_t[SHOCK_c * \mathbf{1}(Year_t)] + \alpha_c + \gamma_t + \epsilon_{ct}, \quad (17)$$

where y_{ct} is either log per-capita personal consumption expenditure or log age-adjusted mortality in area c and year t . $SHOCK_c$ is a measure of the impact of the Great Recession on area c , $\mathbf{1}(Year_t)$ is an indicator for calendar year t , α_c and γ_t are area and year fixed effects, respectively, and ϵ_{ct} is the error term. Following Yagan (2019), we parameterize the impact of the Great Recession on area c (i.e., $SHOCK_c$) as the percentage point change in area c 's unemployment rate between 2007 and 2009. The coefficients of interest are the β_t 's; they measure impacts on the outcome y_{ct} in year t across areas differentially impacted by the Great Recession. We omit the interaction with the shock variable in 2006 so that all β_t coefficients are relative to 2006. Thus β_t in equation (17)

²⁴This large effect at age 75 is natural, since the consumption effect of the GR is persistent at approximately 10 percent (as per Figure 3), and effects lasting 10 years span the majority of the average 75-year-old's remaining life-years.

²⁵Our assumption that mortality impacts of the Great Recession ($dm(t)$) are (proportionally) the same at every age is consistent with the evidence in Appendix D as well as prior analyses of local labor market variation in the impact of the Great Recession (Finkelstein et al., 2025). As a result, it has been previously observed that most of the averted deaths from recessions are at older ages (e.g., Stevens et al., 2015; Finkelstein et al., 2025).

captures the change in outcome y in area c and year t relative to the area-specific 2006 average associated with a one-percentage-point increase in the unemployment rate from 2007 to 2009 in that area.

We use the same data sources for mortality and for consumption as in the DFM, but at the yearly level and without applying the time series-specific filtering procedure described in Section 3.1. As in Finkelstein et al. (2025), we use data from 2003 through 2016, to avoid contamination from the 2001-2002 recession.

6.2 Results

Mortality. Finkelstein et al. (2025) estimated equation (17) at the commuting zone level for log age-adjusted mortality. We reproduce their result in Figure 6 Panel (a). It indicates that places that were harder hit by the Great Recession experienced mortality declines relative to places that were less hard hit. Specifically, a one-percentage-point increase in the local area unemployment rate reduced local area mortality by 0.5 percent; this effect persisted through 2016. This estimate is quite similar to prior estimates of the impact of local area unemployment on mortality based on state-year variation in the local unemployment rate that do not involve the Great Recession (e.g., Ruhm, 2000; Finkelstein et al., 2026).

Nationally, the unemployment rate increased by 4.6 percentage points between 2007 and 2009. Therefore, estimates based on local labor market variation imply that the Great Recession reduced annual mortality on average by 2.3 percent in the 2007-2016 period. This is slightly larger than the estimate from the DFM that the Great Recession reduced annual mortality by an average 1.8 percent over the 2007-2016 period (see Figure 3 Panel (a)). Thus, estimates suggest a small role for aggregate and spillover effects in the effect of the Great Recession on mortality, beyond those already captured via cross-sectional variation. The similarity across time-series and cross-sectional estimates is consistent with the DFM finding of a lack of co-movement between mortality rates on the one hand and stock prices and wealth on the other hand (see Table A.2).

We also find that the dynamics in the mortality decline are similar across cross-sectional and time-series approaches. In particular, both approaches suggest persistence in the mortality effects. They also both indicate large reductions in mortality in 2007 and 2008. That said, the time-series approach suggests a slight continued mortality decline in 2009 that is not present in the cross-sectional approach, and a slight recovery in mortality starting in late 2014, while cross-sectional estimates indicate recovery only starting in 2016. Overall, however, differences in magnitude are small.²⁶

²⁶A potential concern with this analysis is that the persistence of unemployment shocks may be very different at

Consumption. We also use equation (17) to produce new estimates of the impact of the Great Recession on consumption using the same spatial variation that was previously used for estimating mortality impacts. Here we use the state as the geographic area of analysis c rather than the commuting zone, as the state is the finest level of geography at which the personal consumption expenditures (PCE) data are available; mortality estimates are very similar whether the CZ or state is used as the unit of analysis (Finkelstein et al., 2025).

Figure 6 Panel (b) shows the results. Places that were harder hit by the Great Recession experienced declines in consumption relative to places that were less hard hit. Once again, this effect persists until at least 2016. A one-percentage-point increase in local area unemployment between 2007 and 2009 reduces average annual consumption by 1.38 percent (standard error = 0.32 percent) over the 2007–2016 period. Scaled by the national increase in the unemployment rate between 2007 and 2009, this implies that the Great Recession reduced annual consumption by 6.3 percent on average from 2007 through 2016. This is somewhat smaller than the DFM estimate of an average annual 9 percent decline in consumption from the Great Recession in the 2007-2016 period (Figure 3). Moreover, unlike the mortality response, the dynamics of the consumption response are also different across the two specifications: DFM estimates indicate a steep decline by 2009, while cross-sectional estimates in Figure 6 suggest a more gradual decline through 2012.

6.3 Discussion

The DFM estimates of the nationwide effect of the Great Recession on mortality are broadly similar to previous estimates using local, cross-sectional variation. Both approaches suggest that the Great Recession was “good for health.” In this section, we discuss how to interpret the nationwide estimates and their similarity to the local (cross-sectional) mortality estimates in light of the existing literature estimating the effects of income, job loss, and recessions on health outcomes.

Although there is a well-documented negative cross-sectional relationship between income and mortality in many countries and time periods (see, e.g., Cutler et al., 2006; Costa, 2015; Chetty et al., 2016; Cutler et al., 2016), economists have long argued that this relationship does not primarily reflect the causal effect of income on health (see, e.g., Deaton, 2002). Consistent with this view, both experimental and quasi-experimental estimates from a wide range of income shocks – including stimulus payments (Gross and Tobacman, 2014), lottery prizes (Cesarini et al., 2016), bequests (Kim and Ruhm, 2012), and cash transfers (Miller et al., 2024) – generally find small or null effects of income on health and mortality. Indeed, there is even evidence that the receipt

the regional level and the national level, making comparisons of the mortality impulse responses difficult to interpret. In practice, however, as we discuss in Appendix C.2, the persistence of the Great Recession’s unemployment effects is similar at the regional and national level.

of cash transfers may be bad for health and mortality in the short run by increasing risky drug and alcohol use (see, e.g., Dobkin and Puller, 2007; Evans and Moore, 2012; Gross and Tobacman, 2014; Andersson et al., 2015; Chorniy et al., 2025).

This existing literature is useful for interpreting the similarity between the nationwide (aggregate) estimates and the local (cross-sectional) estimates of the effect of the Great Recession on mortality. In principle, this similarity admits two possible explanations: either the Great Recession had limited general equilibrium effects on income, or those effects on income did not translate into changes in mortality. Our read of the evidence points to the latter interpretation. We find evidence consistent with general equilibrium effects of the Great Recession on income; recall that estimates using cross-regional variation indicate an average 6.3 percent consumption decline over 2007-2016 from the Great Recession, which is only about 70 percent of the 9 percent decline in consumption estimated by the DFM.²⁷ However, the existing literature finds limited mortality benefits across a wide range of positive income shocks, covering small (stimulus payments), medium-sized (cash transfers and bequests) and large shocks (lottery winnings). We therefore conclude that our finding that local and national estimates of the impact of the Great Recession on mortality are broadly similar is consistent with existing evidence of limited effects of income and wealth on mortality at business-cycle horizons.

An open question is *why* both local area and national estimates indicate that the Great Recession reduced mortality. As mentioned in the introduction, health economists have suggested a number of potential explanations for pro-cyclical mortality. In particular, given evidence that about three-quarters of the deaths averted by recessions are among the elderly (Stevens et al., 2015; Finkelstein et al., 2025), explanations have focused particularly on externalities from a recession such as improvements in the quality of elder care (Stevens et al., 2015) and reductions in air pollution (Chay and Greenstone, 2003; Heutel and Ruhm, 2016; Finkelstein et al., 2025).

There is also reason to suspect heterogeneous effects of recessions across types of local labor market declines. In particular, Finkelstein et al. (2026) find that even in the Great Recession, local area declines in manufacturing employment are associated with increased mortality, while local area declines in non-manufacturing employment (which make up the bulk of the Great Recession-induced employment declines) have the opposite-signed mortality effect. Opposite-signed mortality impacts of local labor market declines in manufacturing and non-manufacturing employment can reconcile the evidence of pro-cyclical health with the evidence that mortality increases in communities exposed to job loss from trade (e.g., Autor et al., 2019; Pierce and Schott, 2020; Noghanibehambari and Fletcher, 2026; Finkelstein et al., 2026), as well as the evidence discussed in the Introduction

²⁷In Appendix B we show that we obtain similar estimates if we analyze income instead of consumption.

that individuals who lose their job from plant closings and mass layoffs experience increased mortality. Unlike recessions, most of the job loss from these mortality-increasing shocks is concentrated in the manufacturing sector. If the macroeconomic demand shocks studied by Drautzburg et al. (2026) affect different sectors than recessions, this may also explain their findings of counter-cyclical health.²⁸

7 Conclusion

In this paper, we estimate the national, aggregate mortality impact of the Great Recession. A mortality decline relative to trend is visible during the Great Recession in simple time series analysis. Estimates from a dynamic factor, time series model indicate that the Great Recession reduced the average annual age-adjusted mortality rate by about 2 percent, with effects persisting for at least a decade. When compared to the dynamic factor model’s estimates of the impact of the Great Recession on consumption, accounting for endogenous mortality is quantitatively important for calibration of the overall welfare consequences of the Great Recession; for example, it reduces the welfare cost of the Great Recession for an average 55-year-old by 20 percent. These findings contribute to a growing body of evidence that incorporating the welfare consequences of health changes can be consequential for macroeconomic analyses (e.g., Murphy and Topel, 2006; Jones, 2016).

The quantitative estimates from the dynamic factor model are very similar to estimates based on local area variation in exposure. The similarity of the estimates suggests limited cross-market mortality spillovers as well as limited mortality impacts of Great Recession-induced national declines in wealth and investment income. This finding is consistent with an existing literature in health economics which consistently finds minimal effects of income and wealth on mortality in the short run.

More broadly, these findings suggest that, in assessing the mortality consequences of various economic shocks, it may be “safe” to ignore potential general equilibrium adjustments, as they are unlikely to affect mortality. For example, in international trade, studies using local area variation have found increases in mortality both from the China Shock (e.g., Autor et al., 2019; Pierce and Schott, 2020; Finkelstein et al., 2026) and from NAFTA (e.g., Finkelstein et al., 2026; Noghanibehambari and Fletcher, 2026). Our findings provide a potential justification for aggregating these local area estimates as a way of reliably estimating the national, aggregate effect on mortality when a model-based estimate of the aggregate effect is not available.

²⁸Consistent with this hypothesis, Drautzburg et al. (2026) note that for some, but not all, of the demand shocks they study, there is evidence of pro-cyclical mortality.

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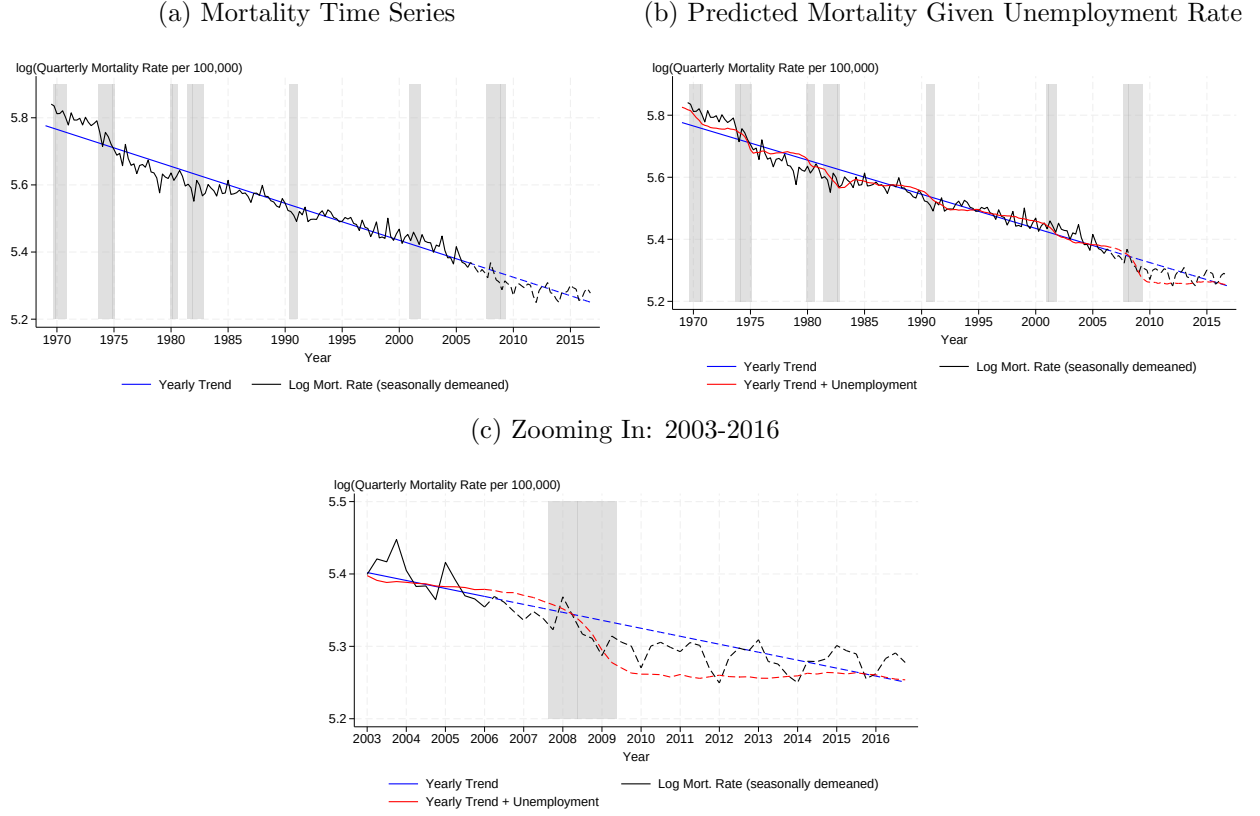
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Figures

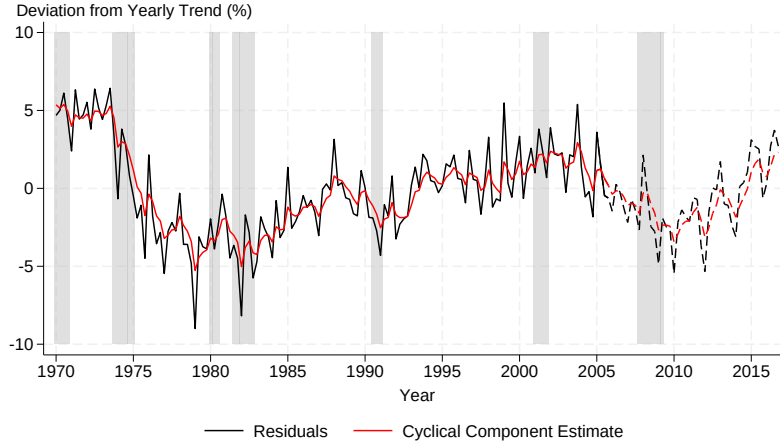
Figure 1: Mortality Time Series and Its Relationship to the Unemployment Rate



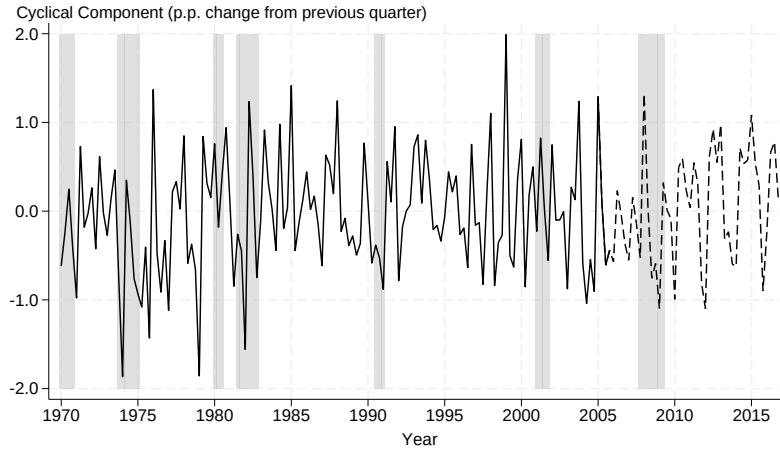
Notes: Figures show log age-adjusted mortality rates. In all panels, the black line displays the log age-adjusted mortality rate time series, demeaned of quarterly intercepts by subtracting $\hat{\beta}_k \mathbf{1}_{q(t)=k}$ from equation (1), and the blue line shows our estimate of the long-term linear trend ($\hat{\alpha} + \hat{\delta} * year_{y(t)}$) from estimating equation (1). The red line in Panels (b) and (c) shows predicted mortality based on the long-term linear trend and unemployment ($\hat{\alpha}' + \hat{\delta}' * year_{y(t)} + \hat{\theta}' * (U_t - \bar{U})$) from estimating equation (2). Equations (1) and (2) are each estimated with data from 1969 through 2005; we stop in 2005 to avoid look-ahead bias issues. Post-2006 estimates are dashed to reflect that the 2006-16 period is out-of-sample. Recessions are shaded in gray. We employ Newey-West heteroskedasticity and autocorrelation robust standard errors.

Figure 2: Mortality Time Series Transformations

(a) Mortality Residual (Cyclical + Error Components)



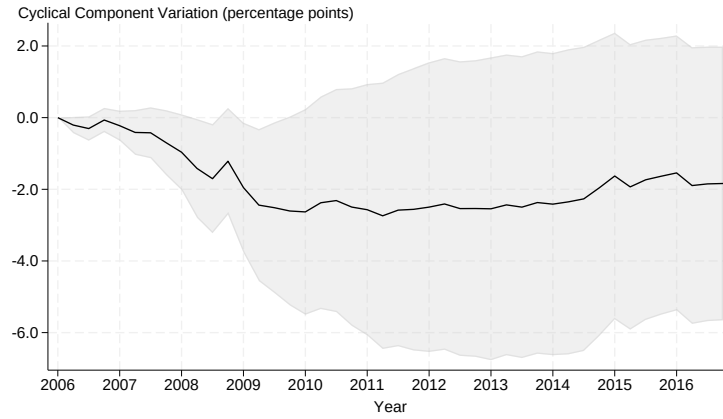
(b) First Difference of Mortality Cyclical Component



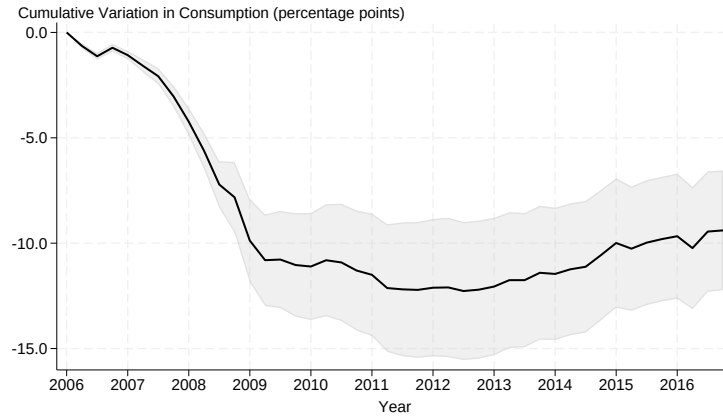
Notes: In Panel (a), the black line displays estimates $\hat{\epsilon}_t$ from equation (1), reflecting percent deviations from the long-term trend; the red line displays the cyclical component $\hat{s}_t$ estimated from equation (3), which removes the noise component via Kalman filtering. Panel (b) displays the first difference of the cyclical component of the mortality rate (i.e., $m_t \equiv \Delta \hat{s}_t$ from equation (5)); y-axis values reflect the percentage point quarter-on-quarter change in the cyclical component of the mortality rate. For example, a value of 0.25 means that the cyclical component increased by 0.25 percentage points since the last period. All estimates utilize data from 1969 through 2005; we stop in 2005 to avoid look-ahead bias issues. Post-2006 estimates are dashed to reflect that the 2006-16 period is out-of-sample. Recessions shaded in gray.

Figure 3: Predicted Response Relative to 2006Q1

(a) Mortality

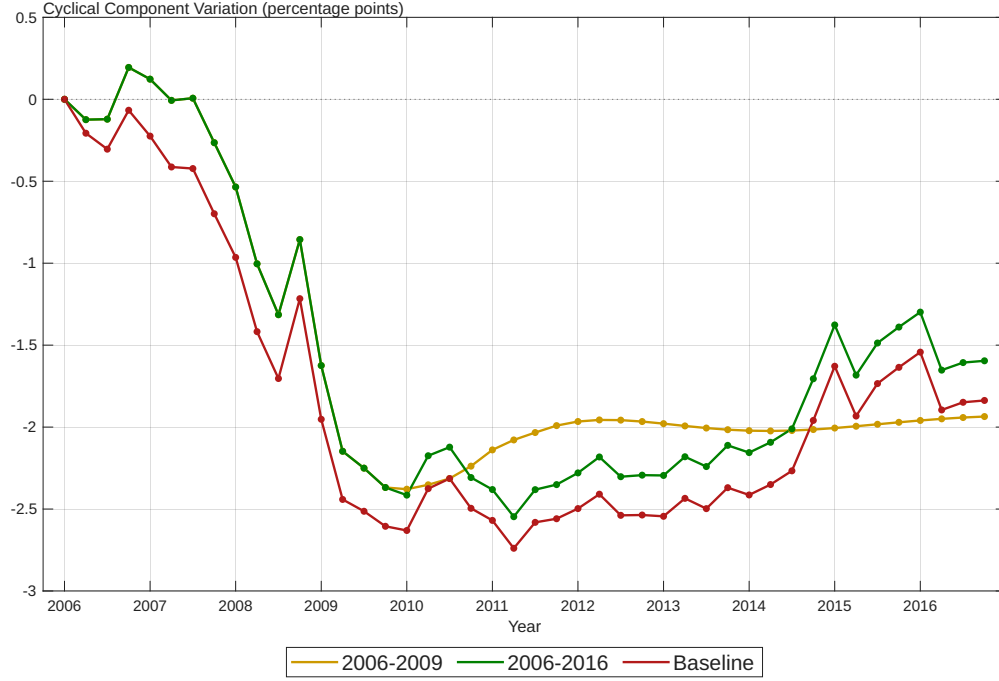


(b) Consumption



Notes: Figure displays the predicted response of the cyclical component of mortality (Panel (a)) and consumption (PCE, Panel (b)), relative to 2006Q1 (2006Q1 component set to zero), given a time series of economic factors and factor loadings estimated by the DFM as specified in equation (10) for mortality. Y-axis values represent the predicted level of the indicator relative to 2006Q1, which is defined as the cumulative sum of quarter-on-quarter changes since 2006Q1 (as estimated by the DFM). Shaded area represents the 95 percent confidence interval, employing Newey-West autocorrelation robust standard errors in the factor-loading estimation step.

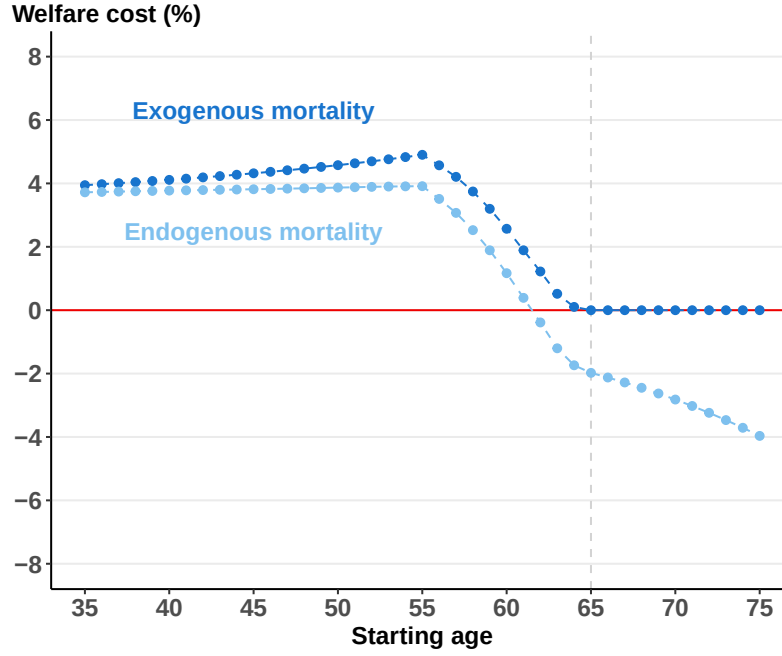
Figure 4: Predicted Mortality Response Relative to 2006Q1 Given Factor Structural Shocks



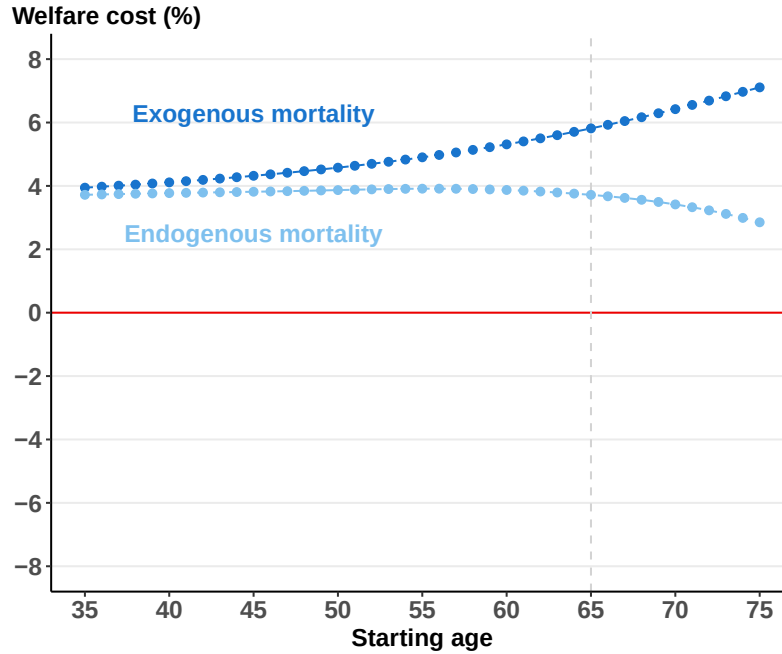
Notes: Figure displays the predicted path of the mortality cyclical component in 2006-16 as explained in Section 4.2 “Restricting to 2006-09 Structural Shocks.” Estimates represent the cumulated $\hat{\theta}_{t+h}$ (defined in equation (13)) for each $t+h$ in the 2006Q1-2016Q4 period. The green line indicates predicted mortality employing structural shocks to DFM factors in 2006-16, the yellow line employs shocks in 2006-09, and the red line represents the baseline DFM prediction in Figure 3, which incorporates 2006-16 structural shocks plus an initial conditions term. Innovations are obtained using coefficients from a 4-lag VAR of factors estimated in the 1959Q3-2005Q4 period.

Figure 5: Welfare Costs of the Great Recession by Age

(a) Baseline (No 65+ Consumption Declines)

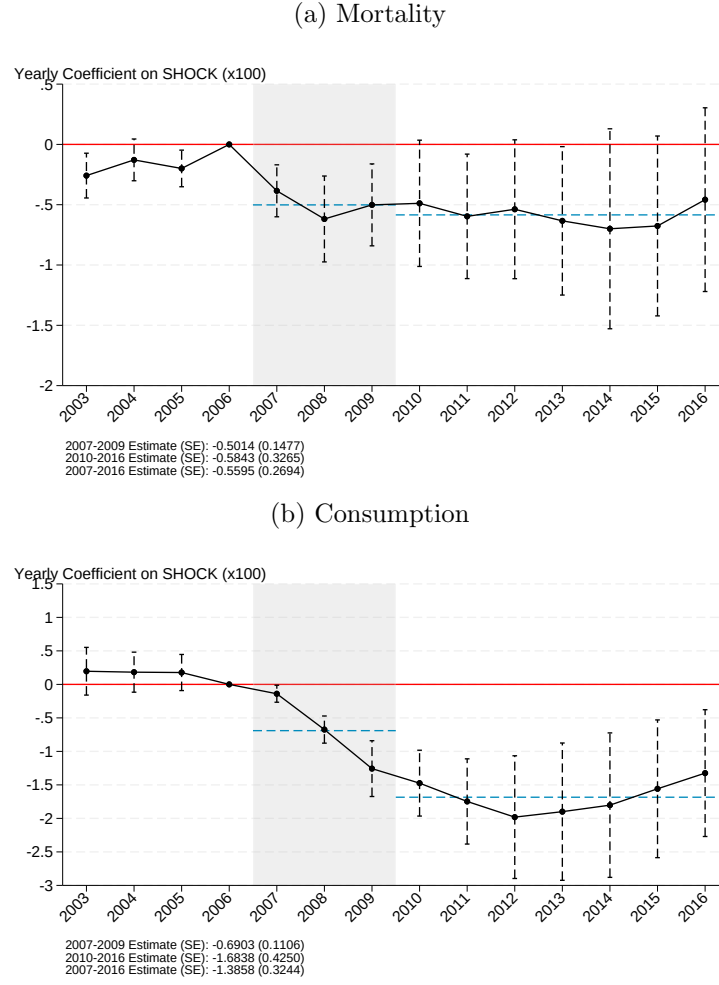


(b) Including 65+ Consumption Declines



Notes: Figure displays the welfare cost of recessions, based on equation (25), at various ages under exogenous and endogenous mortality. This welfare cost is the amount the individual would need to be paid to accept the stochastic aggregate state relative to an otherwise similar economy that stays in the non-recession state for all time periods, measured as a percentage of average annual consumption. Panel (a) displays results from a specification in which 65+ consumption is not affected by the Great Recession, while Panel (b) displays results assuming 65+ consumption declines by the same percentage as consumption among individuals aged 0-64. These estimates assume $\gamma = 2$, $\beta = 0.96$, and b corresponding to a VSLY of \$250k for 35-year-old individuals.

Figure 6: Impact of Great Recession Unemployment Shock on Mortality and Consumption



Notes: This figure displays the yearly coefficients β_t from equation (17), where the outcomes y_{st} in Panels (a) and (b) are log mortality rate and log per-capita personal consumption expenditures (PCE), respectively. Panel (a) and Panel (b) results are based on CZ-level and state-level regressions, respectively. $SHOCK_s$ is the 2007-2009 change in the CZ (state) unemployment rate. Horizontal blue dashed lines indicate the point estimate for the average of coefficients from 2007-2009 and 2010-2016. These estimates (and corresponding standard errors) are reported in the lower left-hand corner. Coefficients, standard errors, and confidence intervals are multiplied by 100 throughout for ease of interpretation. Standard errors are clustered at the CZ level in Panel (a) and state level in Panel (b), and dashed vertical lines indicate 95 percent confidence intervals on each coefficient. Panel (a) is taken directly from Figure III in Finkelstein et al. (2025). N=741 CZs (Panel (a)) and N=50 states plus DC (Panel (b)).

Online Appendix for “The Impact of the Great Recession on Mortality: A Dynamic Factor Analysis”

A Unemployment/Mortality VAR

An alternative way to benchmark the relationship between quarterly unemployment and mortality is via a simple, two-variable vector autoregression over the 1969-2016 period with four lags. Unemployment enters the VAR in levels as in Angeletos et al. (2020). Mortality is specified as in equation (5), namely as the first-difference of the cyclical component, which removes a yearly trend, quarterly intercepts and noise via a one-sided Kalman filter.²⁹ We identify the system by imposing a Cholesky decomposition, by which we assume that shocks to mortality do not contemporaneously affect unemployment. Since our estimation period did not contain any major health events that contemporaneously affected the economy (e.g., pandemics), this is likely a reasonable assumption for this exercise.

Given the Cholesky identification restriction, we compute the impulse response functions from a one percentage point increase in unemployment; results are shown in Figure A.3. The unemployment IRF (Panel (a)) is hump-shaped: a one percentage point increase in quarterly unemployment is associated with a two-percentage-point increase in unemployment after one year, which then declines toward zero after about four years. Panel (b) indicates that the estimated effect of the unemployment shock on mortality is contemporaneous, with a 0.4 percent decrease in the mortality rate – a result quite similar in magnitude to the estimates in Ruhm (2000) and Finkelstein et al. (2025). Similarly to unemployment, the effect on the mortality level (Panel (c)) peaks a year after the shock at 0.9 percent and slowly declines to zero after 3-4 years, as unemployment returns to trend. Overall, the IRFs produced by this exercise suggest a contemporaneous relationship between unemployment and mortality, with magnitudes similar to those from cross-sectional exercises.

B Income Analysis

We explore the impact of the Great Recession on income. Income is defined as total personal income from the Current Population Survey (CPS); this variable (which is not used by Stock and Watson, 2012) is available only at the yearly level and we therefore do not use it for estimating the DFM.³⁰ We construct a national income time series as the average real CPS income (deflated using CPI)

²⁹Implied VAR impulse responses are similar whether mortality is specified in first differences or in levels.

³⁰The CPS income definition is holistic, including all individual income except tax refunds and capital gains, thus including wages, business income, unemployment insurance, Social Security benefits and dividends. For a full description of the income variable, see https://cps.ipums.org/cps-action/variables/INCTOT#codes_section

across survey respondents in a given year for individuals 25 and older, weighting observations such that the sample is representative of the U.S. population. We then perform the same transformations to the time series as for consumption in Section 3.1: we first transform the time series to log first-differences and then apply a biweight filter to remove low-frequency variation.

Since our income measure is yearly, we average quarterly factors within a year and regress income on these yearly factors to produce factor loadings, following a procedure equivalent to the one for mortality explained in Section 3.2; income estimates are therefore yearly instead of quarterly. Figure A.4 displays the predicted change in income around the Great Recession as estimated by the DFM, and Table A.3 displays point estimates. The overall predicted impact on income is similar in magnitude to the estimated impact on consumption, with a persistent decline averaging 9.3 percent in the 2007-2016 period. However, the decline in income is estimated to be slightly more gradual than the decline in consumption, leveling off only around 2011.

As in Section 6, we then compare DFM predictions of the impact of the Great Recession on income with estimates based on using cross-state variation in the economic severity of the Great Recession. Figure A.5 shows the results from estimating equation (17) using state-level CPS income as the outcome variable. Estimates indicate that places harder hit by the recession experienced declines in income that persisted until at least 2016. A percentage point increase in unemployment between 2007 and 2009 is associated with an average 1.34 percent decline in income (SE: 0.30 percent) over the 2007–2016 period – again similar to the estimate for consumption (Figure 6). Given that the Great Recession increased average local area unemployment by 4.6 percentage points between 2007 and 2009, results suggest a 6.2 percent decrease in income across states. This is 30 percent smaller than the DFM estimate of an average annual 9 percent decline in income from the Great Recession in the 2007-2016 period (Figure A.4), suggesting that general equilibrium feedback effects further depressed income during the recession. The estimated impacts on income from both approaches are similar to those for consumption, suggesting limited consumption smoothing in response to the Great Recession.

C Robustness Analysis

C.1 Alternative DFM Specifications

We explore the robustness of the estimated mortality impacts of the Great Recession in Figure 3 to a number of alternative specifications. First, since we estimate the relationship between economic conditions and mortality using 1959-2005 data, we are implicitly assuming that this relationship is stable over this period, which may not be realistic. We therefore explore a variation of the model

with a break in factor loadings; the results indicate similar impacts of the Great Recession on mortality. Second, we explore changes to the factor estimation period.

Break in Factor Loadings.

Our baseline model assumes that factor loadings are constant over the 1959-2005 period. Stock and Watson (2012) investigate this assumption and argue that, for economic outcomes, there were no breaks in factor loadings during the Great Recession. However, Ruhm (2015) estimates that the relationship between mortality and unemployment rates changed in the late twentieth century. Thus, as a robustness check we predict the mortality path around the Great Recession while allowing for a break in mortality factor loadings Λ_m in 1984.³¹

We obtain factor-loadings similarly to equation (9) but allow for a break in factor-loadings in 1984, as indicated by equation (18) below:

$$m_t^{69-05} = \hat{\Lambda}_{1m}^{69-05} \hat{F}_t^{69-05} + \hat{\Lambda}_{2m}^{69-05} (\hat{F}_t^{69-05} * \mathbf{1}(Year_t \geq 1984)) \quad (18)$$

In the above, factor loadings for pre-1984 and post-1984 mortality are represented by $\hat{\Lambda}_{1m}$ and $\hat{\Lambda}_{1m} + \hat{\Lambda}_{2m}$, respectively. Given factor loadings, we then predict mortality in the 2006-2016 period similarly to equation (10):

$$\hat{m}_t^{06-16} = (\hat{\Lambda}_{1m}^{69-05} + \hat{\Lambda}_{2m}^{69-05}) \hat{F}_t^{06-16} \quad (19)$$

Figure A.7 Panel (a) displays the predicted path of mortality relative to 2006Q1, calculated similarly to the main measure in Figure 3. We see that the model with breaks predicts a larger decrease in mortality of around 3 percent by 2009, a similar magnitude to the model without breaks, but then converges to the baseline estimate by 2016.

Different Factor Estimation Sample Period.

In our baseline specification, we estimate factors using economic indicators over the 1959Q3–2005Q4 period. This approach deviates slightly from Stock and Watson (2012), who estimate factors through 2007Q3, but it allows us to treat the 2006Q1–2007Q3 period as “out-of-sample” for our predictive analysis. To ensure that our results are not driven by this specific choice of estimation window, we perform a robustness check in which we follow the original Stock and Watson (2012)

³¹We choose 1984 as the break point following Stock and Watson (2012). Furthermore, data-driven approaches in the literature generally find breaks in factor loadings in the early 80s (Stock and Watson, 2009; Breitung and Eickmeier, 2011; Chen et al., 2014), consistent with the second oil shock and the Great Moderation. The downside of allowing for breaks in factor loadings in 1984 is that there were only 2 recessions between 1984 and the Great Recession, such that evidence is limited.

methodology and estimate the factors using the full pre-Great-Recession sample period of 1959Q3–2007Q3.

Figure A.7 Panel (b) displays the predicted response of the cyclical component of mortality under this alternative specification compared to our baseline. Results are similar but slightly smaller in magnitude (2.0 percent reduction by 2009) relative to the main specification.

C.2 Cross-Regional and National Shock Persistence

A potential concern when comparing cross-regional and time-series estimates is that the Great Recession’s unemployment shock may have followed different paths at the regional and national levels. That is, differences in unemployment across regions deriving from the Great Recession may have persisted for longer than the shock to the national unemployment rate. In this scenario, mortality impulse responses detected from cross-regional and time-series approaches would not be directly comparable, since they would trace out responses to shocks with different profiles.

To investigate whether this concern is valid, we apply the cross-regional setup in equation (17) with the CZ-level unemployment rate as the outcome y_{ct} and compare the estimated cross-regional impulse response to the national change in unemployment rates. Since β_t in equation (17) represents the effect of a one percentage point change in the 2007–2009 local unemployment rate, we scale coefficients and standard errors by 4.6 – the national unemployment percentage point change between 2007 and 2009. Figure A.8 displays results; the black line displays the scaled impulse response estimated by the cross-regional approach, and the red line displays the national unemployment rate relative to 2006. Point estimates reveal similar dynamics across cross-regional and national unemployment shocks, indicating that the persistence of the Great Recession’s effect across regions is similar to the persistence of the national shock.

D Mortality Effects by Age

This section describes results of our heterogeneity analysis that explores differences in the mortality effects of the Great Recession by age. Figure A.6 shows the predicted path for the cyclical component of mortality across four age groups, and Appendix Table A.6 displays the associated yearly averages.

There is evidence of mortality impacts in all four broad age groups. We cannot reject that these estimates are the same. Similarly to the cross-sectional analysis in Finkelstein et al. (2025), the point estimates indicate larger percent reductions in mortality for younger cohorts: a persistent and gradual decline in the under-25 and 25–44 mortality reaching approximately nine and eight

percent by 2016, respectively. By contrast, 65+ mortality is predicted to decline by 2.7 percent in 2009 and by 0.9 percent by 2016. Naturally, since most deaths occur in the 65+ group, estimates for the 65+ age group are similar in magnitude to the results for age-adjusted mortality in Figure 3. The smallest percent reduction is in the 45-64 (“late middle age”) group. This could possibly come from “offsetting” mortality increases from job displacement (which could be disproportionately concentrated among high-tenure workers in this age group).

While the dynamic estimates are imprecise, the results in Figure A.6 suggest some heterogeneity in persistence in the effects across age groups: 65+ mortality effects are less persistent, while effects on under-65 mortality build up over time. This divergence in persistence between under-65 and over-65 mortality could suggest that the mechanisms affecting these age groups’ mortality are different. For the under 65 group, the health economics literature has emphasized a behavioral adjustment channel: newly unemployed individuals may reduce smoking and drinking, exercise more, and face less work-related stress (Ruhm, 2000). Such behavioral changes would only affect mortality slowly and with a lag, which is consistent with the slow-building declines in Figure A.6. Meanwhile, 65+ mortality may be affected by mechanisms that contemporaneously affect mortality, such as reductions in air pollution (Finkelstein et al., 2025). We reiterate that the baseline mortality rate for ages 45 and under is much lower than the mortality rate for the older age groups, such that mortality gains from these age groups represent a small share of the effect of recessions on mortality.

E Welfare Analysis of the Great Recession.

E.1 Model

The representative agent’s expected lifetime utility is given by:

$$U(c^\omega(t), m^\omega(t)) = \sum_{t=0}^{\infty} \beta^t S(m^\omega(t)) u(c^\omega(t)), \quad (20)$$

where $c^\omega(t)$ is the agent’s consumption in period t and aggregate state ω , $m^\omega(t)$ is the mortality rate (allowed to vary over the life-cycle), and β is the agent’s subjective discount factor. The cumulative survival rate $S(m^\omega(t)) = \prod_{\tau=0}^{t-1} (1 - m^\omega(\tau))$ is calculated using the vector of mortality rates up to time t , and life expectancy T is equal to the sum of the cumulative survival rates, i.e., $T = \sum_{t=0}^{\infty} S(m^\omega(t))$. Individuals are endowed with $c^\omega(t)$ units of consumption every period and entirely consume their endowment.

The per-period utility function $u(c)$ follows Hall and Jones (2007) and is given by:

$$u(c) = b + \frac{c^{1-\gamma}}{1-\gamma}, \quad (21)$$

where b governs the willingness to pay for additional years of life. The value of a statistical life-year (VSLY) is given by:

$$\text{VSLY} = \frac{U(c, m)/u'(c)}{T} \quad (22)$$

After substituting in the definitions for $U(c, m)$, $u'(c)$ and T , the equation above implies an age-specific value of b as a function of VSLY.

We assume that there are two aggregate states $\omega \in \{L, H\}$, where $\omega = H$ denotes the normal state (no recession) and $\omega = L$ denotes the Great Recession state. We model the Great Recession as a shock at $t = 0$ that moves the economy to state L for ten years, at which point the economy reverts back to the no-recession state $\omega = H$ until the end of an agent's life. If mortality is exogenous, then $m^H(t) = m^L(t) = m(t)$.

To incorporate the impact of the Great Recession, we define state-dependent consumption and mortality as:

$$c^\omega(t) = c^H(t) \cdot (1 + dc(t) \cdot \mathbf{1}(\omega = L)) \quad (23)$$

$$m^\omega(t) = m^H(t) \cdot (1 + dm(t) \cdot \mathbf{1}(\omega = L)) \quad (24)$$

where $dc(t)$ and $dm(t)$ denote the percentage declines in consumption and the mortality rate from the Great Recession ($dc(t) < 0$ and $dm(t) < 0$). We define the welfare cost of the Great Recession (Δ_{GR}^{dm}) as the amount an individual would need to be paid, as a percentage of their average annual consumption, to be indifferent between experiencing the Great Recession and experiencing an otherwise similar economy which does not experience the Great Recession:

$$\underbrace{\sum_{t=0}^{\infty} \beta^t S(m^\omega(t)) u((1 + \Delta_{GR}^{dm}) c^\omega(t))}_{\text{Lifetime Utility with Great Recession}} = \underbrace{\sum_{t=0}^{\infty} \beta^t S(m^H(t)) u(c^H(t))}_{\text{Lifetime Utility without Great Recession}} \quad (25)$$

The right-hand side of equation (25) corresponds to an individual's lifetime utility when the aggregate state is always $\omega = H$ (no recession). The left-hand side is the lifetime utility of an individual experiencing the Great Recession, which is modeled as experiencing the aggregate state of $\omega = L$ for $0 \leq t \leq 9$ and $\omega = H$ after that. Given that we find that the Great Recession was associated with decreases in both consumption (welfare reducing) and mortality (welfare improving), the overall impact of the Great Recession on welfare depends on the strength of these two effects.

E.2 Derivation of Approximation Formula.

In this subsection we derive the approximation formula for Δ_{GR}^{dm} in the limiting case of $\beta = 1$. We define $u(c) \equiv \tilde{u}(c) + b$.

First, we derive the welfare cost of the Great Recession when mortality is exogenous (i.e., when $dm = 0$ so that the Great Recession only affects consumption, not mortality). We define Δ as the welfare cost which solves the following expression:

$$\sum_{t=0}^{\infty} S(m^H(t))(\tilde{u}((1 + \Delta)c^\omega(t)) + b) = \sum_{t=0}^{\infty} S(m^H(t))(\tilde{u}(c^H(t)) + b)$$

Since survival is the same on both sides, the b terms cancel:

$$\sum_{t=0}^{\infty} S(m^H(t))\tilde{u}((1 + \Delta)c^\omega(t)) = \sum_{t=0}^{\infty} S(m^H(t))\tilde{u}(c^H(t)).$$

Using the homogeneity of $\tilde{u}(c)$,

$$(1 + \Delta)^{1-\gamma} \sum_{t=0}^{\infty} S(m^H(t))\tilde{u}(c^\omega(t)) = \sum_{t=0}^{\infty} S(m^H(t))\tilde{u}(c^H(t)).$$

Therefore,

$$(1 + \Delta)^{1-\gamma} = \frac{\sum_{t=0}^{\infty} S(m^H(t))\tilde{u}(c^H(t))}{\sum_{t=0}^{\infty} S(m^H(t))\tilde{u}(c^\omega(t))}.$$

Taking a first-order approximation of the last equation above around $(\Delta = 0)$ gives the following:

$$\begin{aligned} 1 + (1 - \gamma)\Delta &\approx \frac{\sum_{t=0}^{\infty} S(m^H(t))\tilde{u}(c^H(t))}{\sum_{t=0}^{\infty} S(m^H(t))\tilde{u}(c^\omega(t))} \\ \Delta &\approx \frac{1}{1 - \gamma} \left(\frac{\sum_{t=0}^{\infty} S(m^H(t))\tilde{u}(c^H(t))}{\sum_{t=0}^{\infty} S(m^H(t))\tilde{u}(c^\omega(t))} - 1 \right) \end{aligned}$$

Now we return to the definition of $\Delta_{GR}^{dm=0}$ above and allow the Great Recession to affect mortality:

$$\begin{aligned} \sum_{t=0}^{\infty} S(m^\omega(t))(\tilde{u}((1 + \Delta_{GR}^{dm})c^\omega(t)) + b) &= \sum_{t=0}^{\infty} S(m^H(t))(\tilde{u}(c^H(t)) + b) \\ \sum_{t=0}^{\infty} S(m^\omega(t))\tilde{u}((1 + \Delta_{GR}^{dm})c^\omega(t)) + \sum_{t=0}^{\infty} S(m^\omega(t))b &= \sum_{t=0}^{\infty} S(m^H(t))\tilde{u}(c^H(t)) + \sum_{t=0}^{\infty} S(m^H(t))b \end{aligned}$$

We define $T \equiv \sum_{t=0}^{\infty} S(m^\omega(t))$, $T^H \equiv \sum_{t=0}^{\infty} S(m^H(t))$, and we simplify and re-arrange as

follows:

$$\begin{aligned}
\sum_{t=0}^{\infty} S(m^{\omega}(t))\tilde{u}((1 + \Delta_{GR}^{dm})c^{\omega}(t)) + (T - T^H) * b &= \sum_{t=0}^{\infty} S(m^H(t))\tilde{u}(c^H(t)) \\
(1 + \Delta_{GR}^{dm})^{1-\gamma} \sum_{t=0}^{\infty} S(m^{\omega}(t))\tilde{u}(c^{\omega}(t)) + (T - T^H) * b &= \sum_{t=0}^{\infty} S(m^H(t))\tilde{u}(c^H(t)) \\
(1 + \Delta_{GR}^{dm})^{1-\gamma} &= \frac{\sum_{t=0}^{\infty} S(m^H(t))\tilde{u}(c^H(t)) - (T - T^H) * b}{\sum_{t=0}^{\infty} S(m^{\omega}(t))\tilde{u}(c^{\omega}(t))}
\end{aligned}$$

Now define $dT \equiv (T - T^H)/T^H$ and take a first-order approximation around $\Delta_{GR}^{dm} = 0$ and use the additional approximations ($(dT)^2 \approx 0$), $dT * \Delta_{GR}^{dm=0} \approx 0$, and $\frac{\sum_{t=0}^{\infty} S(m^H(t))\tilde{u}(c^{\omega}(t))}{\sum_{t=0}^{\infty} S(m^{\omega}(t))\tilde{u}(c^{\omega}(t))} \approx (1 - dT)$:

$$\begin{aligned}
1 + (1 - \gamma)\Delta_{GR}^{dm} &\approx \frac{\sum_{t=0}^{\infty} S(m^H(t))\tilde{u}(c^H(t)) - (T - T^H) * b}{\sum_{t=0}^{\infty} S(m^{\omega}(t))\tilde{u}(c^{\omega}(t))} \\
(1 - \gamma)\Delta_{GR}^{dm} &\approx \frac{\sum_{t=0}^{\infty} S(m^H(t))\tilde{u}(c^H(t)) - (T - T^H) * b}{\sum_{t=0}^{\infty} S(m^{\omega}(t))\tilde{u}(c^{\omega}(t))} - 1 \\
(1 - \gamma)\Delta_{GR}^{dm} &\approx (1 + (1 - \gamma)\Delta) * (1 - dT) - dT * b/\tilde{u}(c^H) * (1 - dT) - 1 \\
(1 - \gamma)\Delta_{GR}^{dm} &\approx (1 - \gamma)\Delta - dT - dT * b/\tilde{u}(c^H)
\end{aligned}$$

This gives the approximation formula in the main text using the fact that $VSLY/c = b/\tilde{u}(c)/(1 - \gamma) + 1/(1 - \gamma)$:

$$\boxed{\Delta_{GR}^{dm} \approx \Delta - dT \left(\frac{VSLY}{c} \right)}$$

E.3 Calibration.

Percentage Change in Life Expectancy, dT . We calibrate age-specific, unisex mortality rates for mortality in “normal” times (the $m^H(t)$ matrix) based on the 2007 SSA mortality tables,³² and set $m^H(t) = 1$ starting at age 100. Since the data are quarterly, we take the quarterly mean within each year. We set 2006 as the base year ($t = 0$ in the model) and subtract the 2006 value, such that values represent declines in consumption relative to 2006 (and relative to a long-term trend). To transform the estimates of proportional mortality declines from the Great Recession from Figure 3 into implied percentage increases in life expectancy (dT), we use the age-specific mortality rates from the 2007 SSA mortality tables and assume, consistent with the evidence from Finkelstein et al.

³²The SSA reports mortality tables separately for men and women, available at <https://www.ssa.gov/oact/HistEst/PerLifeTables/2022/PerLifeTables2022.html>. We calculate the unisex mortality rate as the population-weighted average mortality rate using data from 2007. Specifically, for age a , male mortality rate $m^m(a)$, female mortality rate $m^f(a)$, and a male population share $s^m(a)$ we calculate $m(a) = s^m(a) * m^m(a) + (1 - s^m(a)) * m^f(a)$.

(2025), that the Great Recession lowered the mortality rate by a constant percentage across all age groups. Together with the fact that the mortality rate is higher for older ages, this result implies that recessions produce larger absolute and percentage gains in life expectancy (dT) at older ages (see Appendix Table A.7).

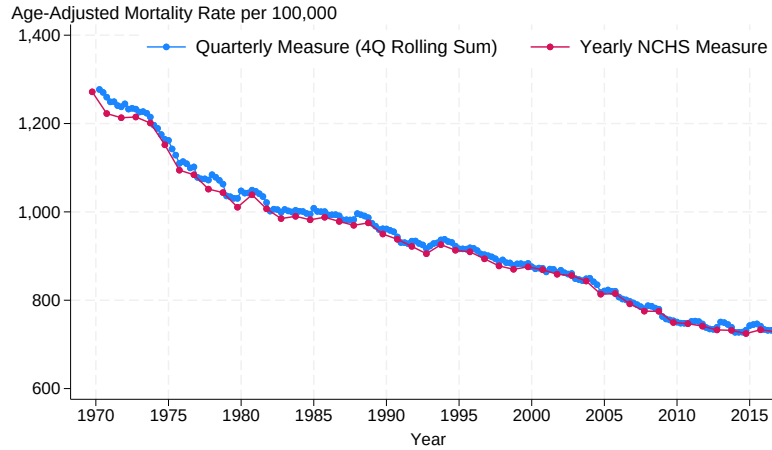
Percentage Change in Consumption, dc . We normalize $c^H(t) = 1$. For consumption, we provide two specifications. First, we assume, consistent with the evidence in Malmendier and Shen (2024), that the Great Recession lowered consumption by a constant percentage across all age groups up to age 65, with no consumption effects at older ages. However, while retirees are shielded from direct labor market impacts from the Great Recession, it is possible that the recession generated declines in 65+ wealth (Glover et al., 2020) and in non-retired workers' labor income that translate into lowered 65+ consumption. For example, Coile and Levine (2011) find that job losses related to the Great Recession forced near-retirees to claim Social Security benefits early, reducing their flow of Social Security income for the remainder of their lives. Thus, as the second specification, we assume that 65+ consumption declines were equivalent in percentage terms to those for ages 0-64; Appendix Figure A.9 displays consumption paths by starting age at $t = 0$ for both specifications.

Value of a Statistical Life Year, VSLY. We follow Hall and Jones (2007) by parameterizing b in equation (21) to match a given VSLY for 35-year-olds. Specifically, we calibrate values of b to match VSLY values of 2, 5, and 8 times average annual consumption for 35-year-olds. Consumption is normalized to 1 above; if yearly consumption were \$50k, then the three VSLY values we consider (2, 5, and 8) would correspond to VSLYs of \$100k, \$250k and \$400k, respectively. The high end of this range is based on several different sources described in Kniesner and Viscusi (2019). The low end of the range follows the \$100k VSLY assumption used by, e.g., Cutler (2005) and Cutler et al. (2022), and is also similar to the baseline VSLY in Hall and Jones (2007).

Risk Aversion. We report results for a range of risk-aversion parameters (γ), allowing values of $\gamma = 1.5, 2$ and 2.5 .

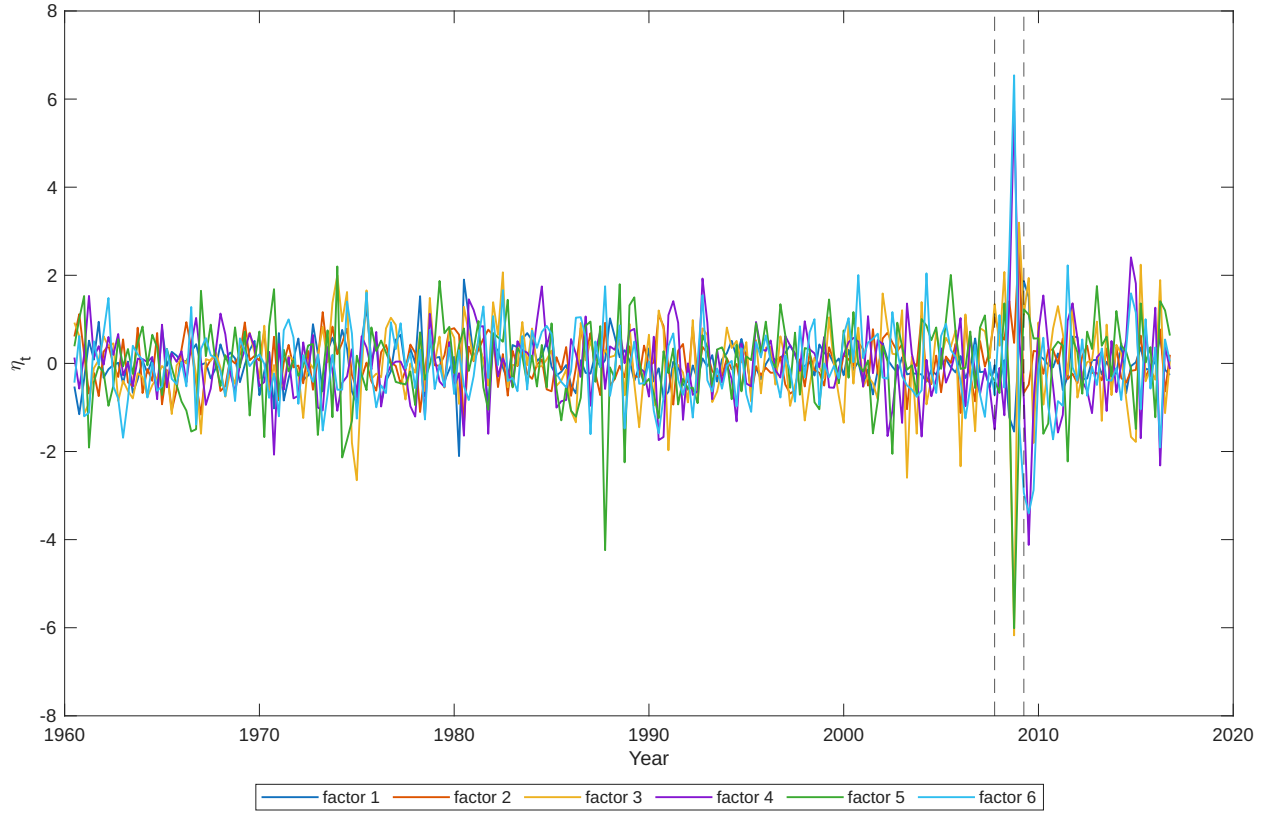
F Appendix Figures and Tables

Figure A.1: NCHS Yearly vs. Rolling Quarterly Mortality Measures



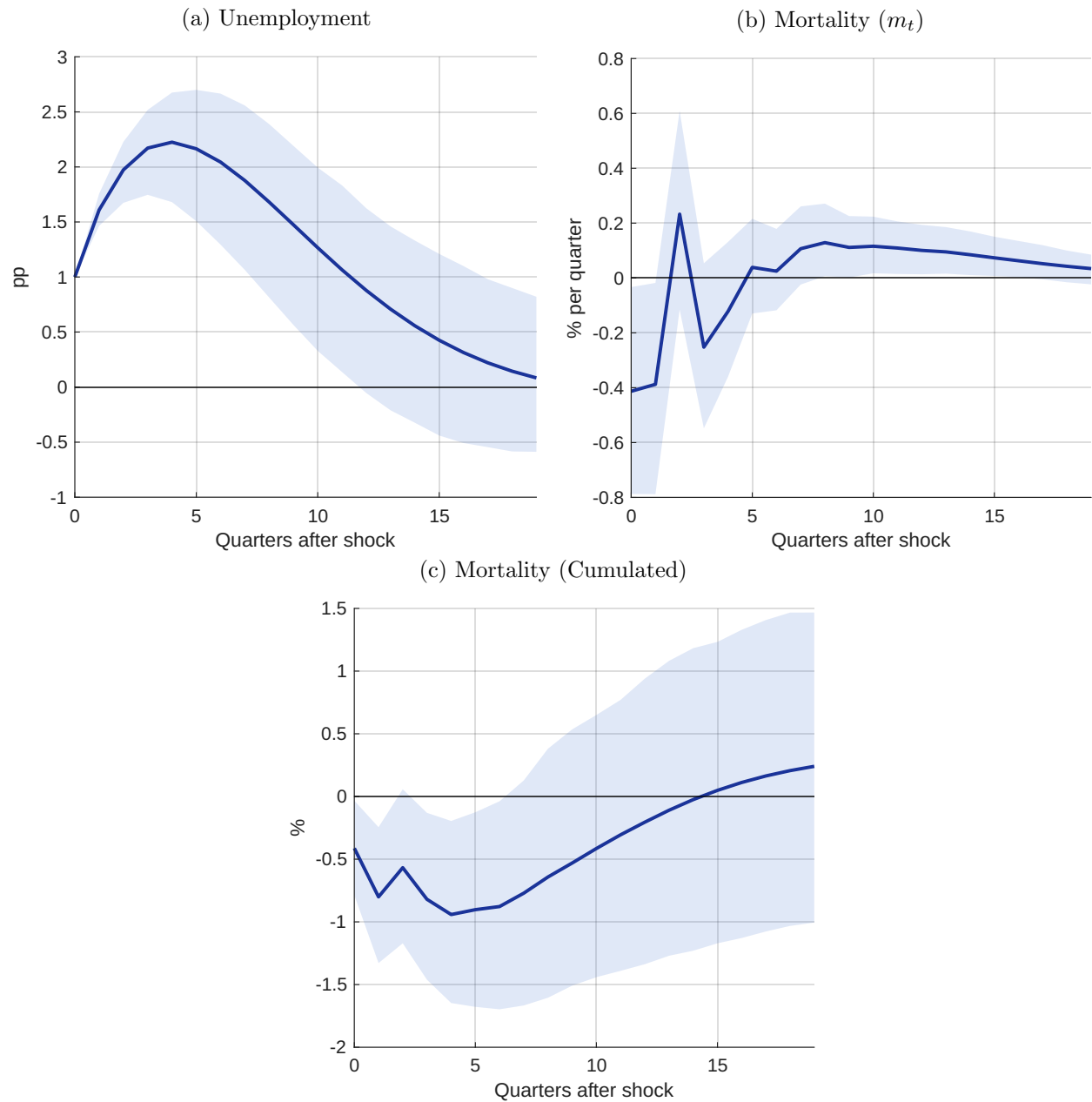
Notes: Figure displays the age-adjusted mortality rate as per our constructed quarterly measure (in blue) and per yearly NCHS published data (in red). Both mortality measures are per 100,000 U.S. 2000 standard population, which is constructed by weighting mortality rates within an age bin by the national share of the population in that age bin in 2000. The yearly measure is obtained from NCHS, available at <https://www.cdc.gov/nchs/data-visualization/mortality-trends/index.htm>. We construct the quarterly measure using NCHS individual-level mortality data and yearly SEER population data, as described in Section 2.1. For purposes of comparison with the yearly measure, the quarterly mortality rate measure is shown as a rolling sum of the previous four quarterly observations to create a measure over the past 12 months.

Figure A.2: Estimated Factor Innovations in 1960-2016



Notes: Figure displays factor innovations obtained via a 4-lag VAR of factors in the 1959Q3-2005Q4 period, as indicated in equation (12). 2006-16 factors are constructed using time series indicators and their factor loadings. 2006-16 innovations are obtained using coefficients from the 4-lag VAR of factors estimated in the 1959-2005 period. Dashed lines indicate 2007Q4 and 2009Q2 (the official start and end dates of the Great Recession, per the NBER).

Figure A.3: Quarterly Impulse Response Functions to a One Percentage Point Unemployment Shock



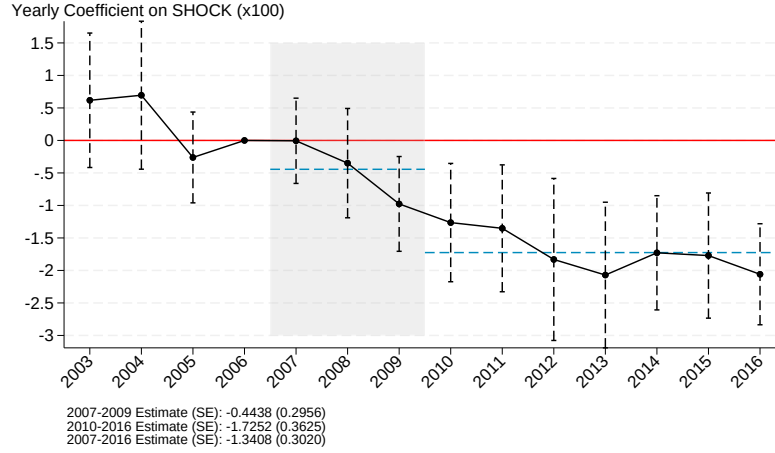
Notes: Figure displays the impulse response functions to a one percentage point increase in quarterly unemployment, estimated via the VAR system described in Appendix A. The VAR is specified over the 1969-2016 period with 4 lags. In Panel (b), mortality is defined as in equation (5) as the first-difference of the mortality cyclical component, which removes a yearly trend, quarterly intercepts, and noise via a one-sided Kalman filter. Panel (c) displays estimates of the effect on the mortality level, by cumulating effects displayed in Panel (b).

Figure A.4: Predicted Response of Income Around the Great Recession (Relative to 2006)



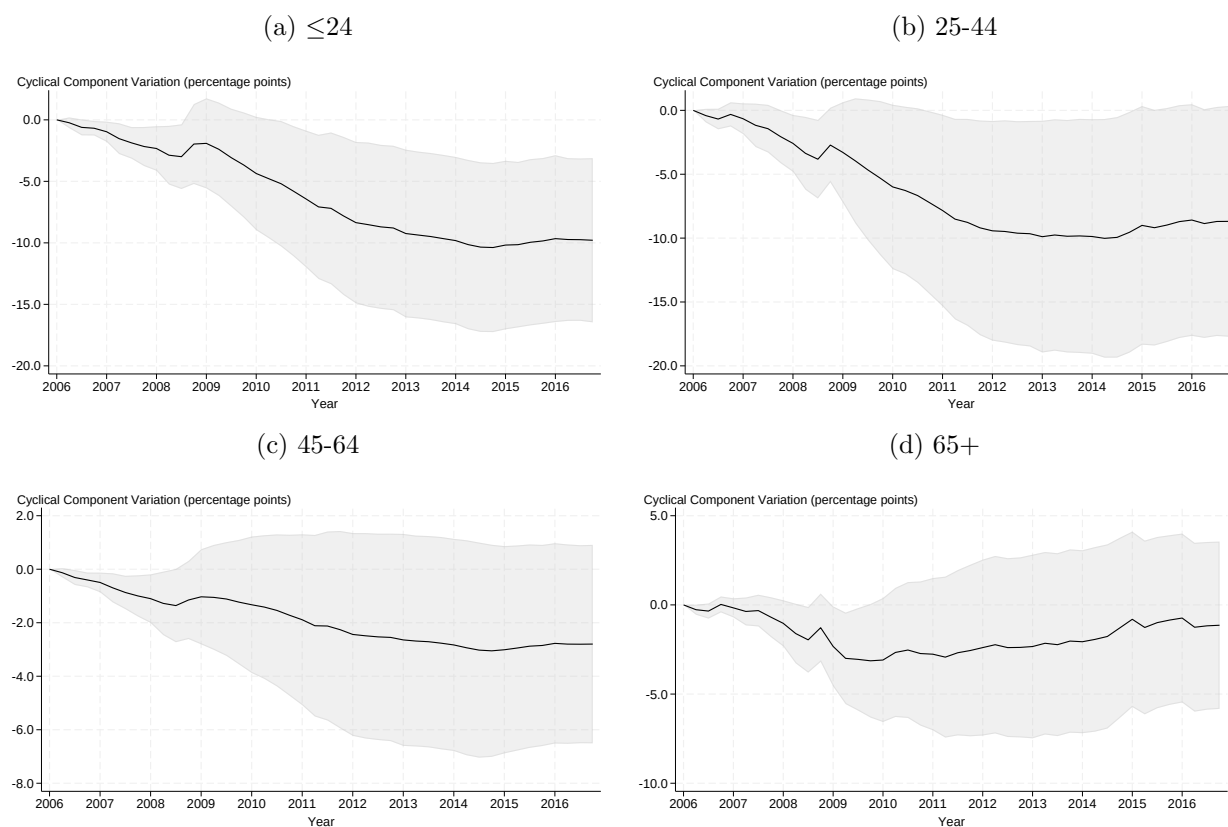
Notes: Figure displays the predicted response of income (obtained from CPS), relative to 2006 (2006 component set to zero), given a time series of economic factors and factor loadings estimated by the DFM as specified in equation (10) for mortality. Y-axis values represent the predicted level of the indicator relative to 2006, which is defined as the cumulative sum of year-on-year changes since 2006 (as estimated by the DFM). Shaded area represents the 95 percent confidence interval, employing Newey-West autocorrelation robust standard errors in the breaks in factor loadings estimation step. The income measure is yearly, such that we average out factors within a year and regress income on yearly factors to produce factor loadings.

Figure A.5: Local Impact of Great Recession Unemployment Shock on Income



Notes: Figure displays the yearly coefficients β_t from equation (17), where the outcome y_{st} is log total personal income (CPS). $SHOCK_s$ is the 2007-2009 change in the state unemployment rate. Horizontal blue dashed lines indicate the point estimate for the average of coefficients from 2007-2009 and 2010-2016. These estimates (and corresponding standard errors) are reported in the lower left-hand corner. Coefficients, standard errors, and confidence intervals are multiplied by 100 throughout for ease of interpretation. Standard errors are clustered at the state level, and dashed vertical lines indicate 95 percent confidence intervals on each coefficient. N=50 states plus DC.

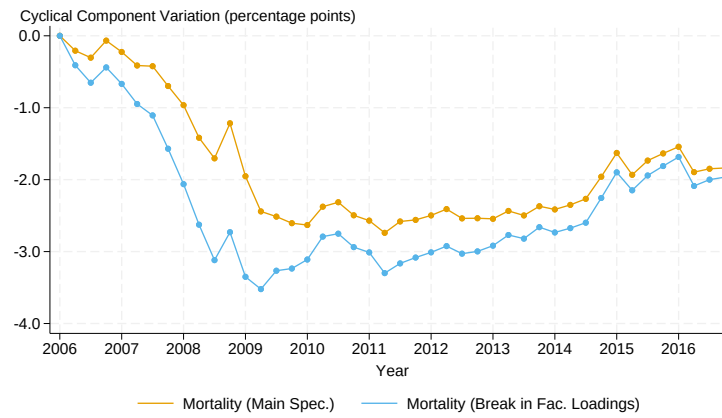
Figure A.6: Predicted Response of Mortality Cyclical Component Around the Great Recession (Relative to 2006Q1), by Age Group



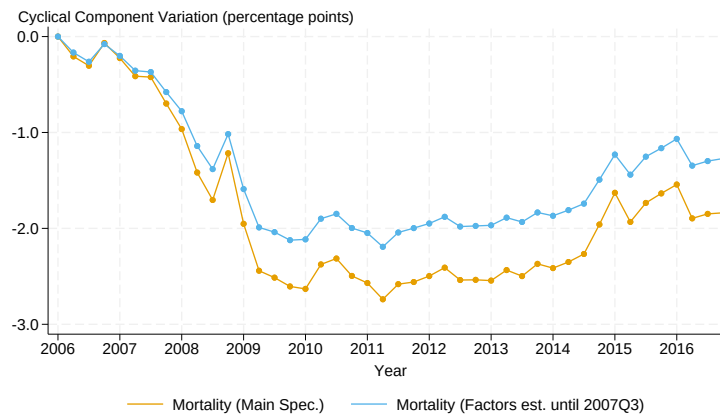
Notes: Figure displays the predicted response of the cyclical component of mortality, relative to 2006Q1 (2006Q1 component set to zero) for four age groups, given a time series of economic factors and factor loadings estimated by the DFM as specified in equation (10) for mortality. Y-axis values represent the predicted level of the indicator relative to 2006Q1, which is defined as the cumulative sum of quarter-on-quarter changes since 2006Q1 (as estimated by the DFM). Shaded area represents the 95 percent confidence interval, employing Newey-West autocorrelation robust standard errors in the factor-loading estimation step.

Figure A.7: Predicted Response of Mortality Cyclical Component Around the Great Recession (Relative to 2006Q1) - Robustness Checks

(a) Break in Mortality Factor Loadings

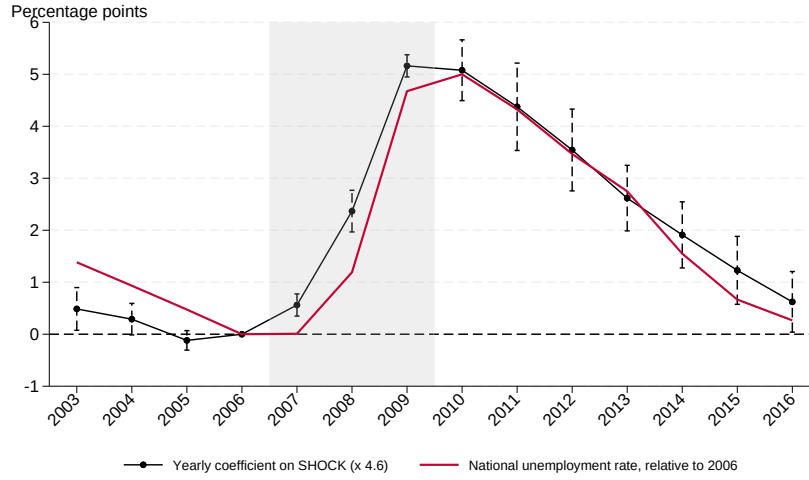


(b) Varying Factor Estimation Period



Notes: Figure displays the predicted response of the cyclical component of mortality, relative to 2006Q1 (2006Q1 component set to zero), given a time series of economic factors and factor loadings estimated by the DFM. Y-axis values represent the predicted level of the cyclical component relative to 2006Q1, which is defined as the cumulative sum of quarter-on-quarter changes in the cyclical component since 2006Q1 (as estimated by the DFM). Orange line refers to the main mortality specification, as per Figure 3 Panel (a). Panel (a) also shows mortality predicted with a break in factor loadings in 1984, as per equation (19). Panel (b) shows results using different factor estimation periods (ending in 2005Q4 and 2007Q3).

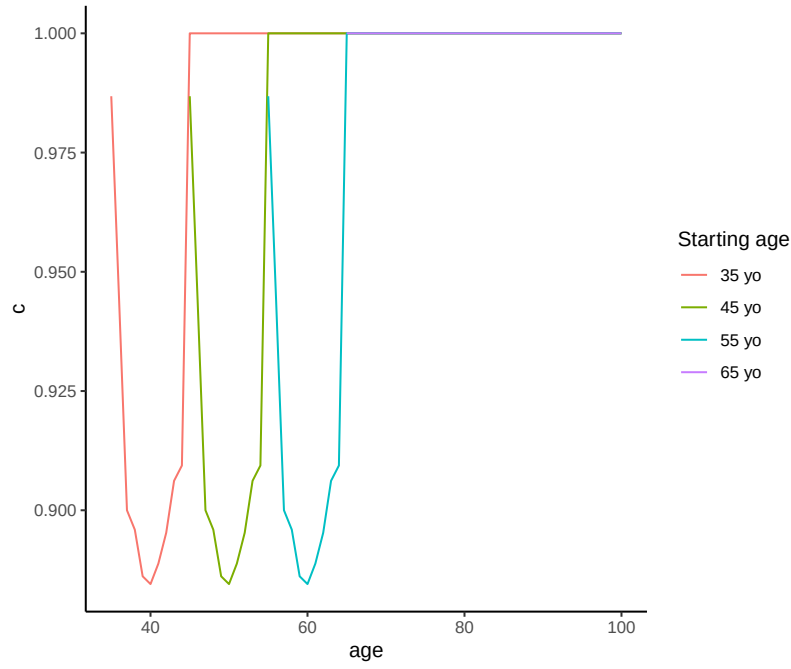
Figure A.8: Cross-Regional vs. National Unemployment Shock Persistence



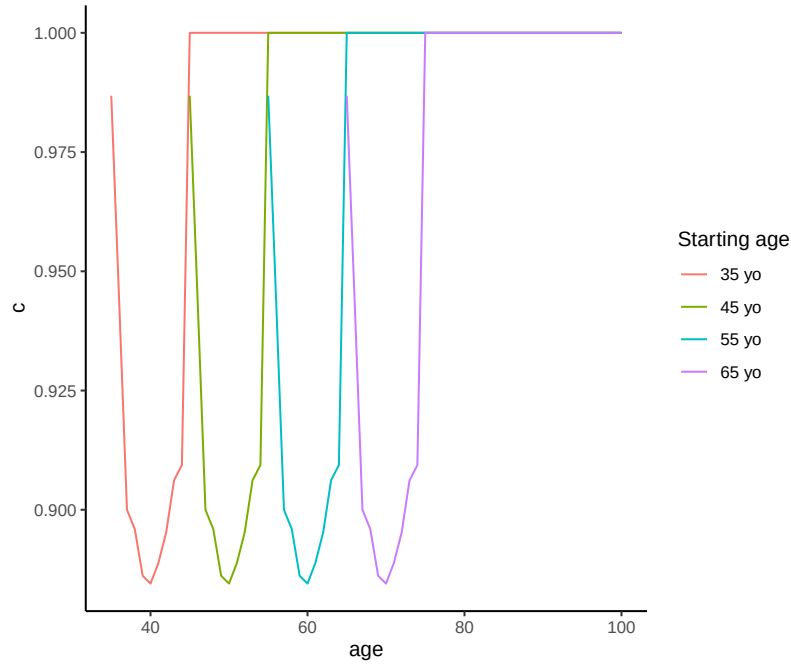
Notes: Figure displays a black line containing yearly coefficients β_t from equation (17), where the outcome y_{ct} is the CZ-level unemployment rate. Red line displays the national unemployment rate relative to 2006. Coefficients and standard errors are multiplied by 4.6 (the 2007-09 national unemployment rate change), such that cross-regional and national shocks are on the same scale. $SHOCK_c$ is the 2007-2009 change in the CZ unemployment rate. Standard errors are clustered at the CZ level, and dashed vertical lines indicate 95 percent confidence intervals on each coefficient. $N = 741$ CZs.

Figure A.9: Consumption Paths by Age

(a) Baseline (No 65+ Consumption Declines)



(b) 65+ Consumption Declines



Notes: Figure displays the path of consumption after the Great Recession shock by age at the time of the shock, as per the model in Appendix E. Panel (a) displays results from a specification in which 65+ consumption is not affected by the Great Recession, while Panel (b) displays results assuming 65+ consumption declines by the same percentage as consumption among individuals aged 0-64. Baseline $c^H(t) = 1$, and the Great Recession consumption shock is determined by DFM estimates, as per Figure 3 Panel (b).

Table A.1: R^2 's of Regressing Factors on Economic Data and Mortality

Series Category	N	Computed over 15 quarters starting at indicated cyclical peak									
		1959-2007Q3	1984-2007Q3	1960Q2	1969Q4	1973Q4	1980Q1	1981Q3	1990Q3	2001Q1	2007Q4
National income and product accounts	21	0.54	0.40	0.55	0.48	0.59	0.62	0.61	0.63	0.50	0.53
Industrial production	13	0.71	0.60	0.75	0.76	0.87	0.83	0.80	0.65	0.47	0.75
Employment and unemployment	46	0.62	0.48	0.65	0.67	0.77	0.79	0.82	0.58	0.63	0.73
Housing starts	8	0.39	0.19	0.08	0.24	0.54	0.45	0.45	0.39	-0.07	0.31
Inventories, orders, and sales	8	0.50	0.28	0.39	0.55	0.74	0.52	0.61	0.39	0.38	0.52
Prices	39	0.15	0.04	0.03	0.15	0.38	0.19	0.10	0.02	0.09	0.23
Earnings and productivity	13	0.37	0.24	0.50	0.37	0.35	0.32	0.13	0.33	0.31	-0.27
Interest Rates	18	0.42	0.29	-0.13	0.42	0.29	0.48	0.45	0.19	-0.02	-0.38
Money and Credit	11	0.46	0.29	0.23	0.56	0.50	0.65	0.66	0.41	0.14	-0.07
Stock Prices and Wealth	11	0.46	0.50	-0.03	0.60	0.69	0.55	0.61	0.34	0.38	0.69
Housing Prices	3	0.69	0.69	.	.	.	0.50	0.30	0.59	0.73	0.56
Exchange Rates	6	0.54	0.64	-1.87	0.48	0.62	0.52	0.69	0.73	0.66	0.36
Other	2	0.44	0.44	-0.21	0.12	0.86	0.90	0.90	0.57	-0.70	0.19
Mortality Rate	1	0.05	0.03	.	-0.21	0.25	0.02	0.09	0.05	0.07	-0.12

Notes: Each column represents R^2 's of the common components for each series category, computed over two time-period sub-samples (1959-2007 and 1984-2007) and 15-quarter periods after each U.S. postwar cyclical peak. Values correspond to the median R^2 of the common component across indicators in each category. $R^2 = 1 - (\sum_t \hat{e}_{it}^2) / (\sum_t X_{it}^2)$, with $\hat{e}_t = X_t - \hat{\Lambda} \hat{F}_t$ given by the factor-model estimated in the 1959-2007 period. Note that R^2 in this definition cannot exceed one (since both numerator and denominator in the fraction must be positive) but can be negative if $\sum_t \hat{e}_{it}^2 > \sum_t X_{it}^2$. Each column represents a different set of t 's. The mortality rate represents the cyclical component of the log age-adjusted mortality rate, as per the data section.

Table A.2: R^2 by Number of Factors

Series Category	N	1 Factor	2 Factors	3 Factors	4 Factors	5 Factors	6 Factors
National income and product accounts	21	.28	.42	.48	.51	.53	.54
Industrial production	13	.36	.53	.63	.64	.68	.71
Employment and unemployment	46	.49	.55	.57	.6	.61	.62
Housing starts	8	.01	.25	.26	.28	.28	.39
Inventories, orders, and sales	8	.22	.45	.45	.45	.46	.5
Prices	39	.02	.05	.1	.11	.15	.15
Earnings and productivity	13	.01	.14	.27	.33	.35	.37
Interest Rates	18	.13	.28	.34	.37	.4	.42
Money and Credit	11	.13	.33	.4	.44	.44	.46
Stock Prices and Wealth	11	.04	.14	.3	.33	.45	.46
Housing Prices	3	.1	.11	.17	.53	.52	.69
Exchange Rates	6	0	.01	.06	.21	.32	.54
Other	2	.01	.19	.19	.23	.44	.44
Mortality Rate	1	.02	.04	.04	.04	.05	.05

Notes: Table displays the R^2 obtained by separately running a model with one through six factors. R^2 is determined in the 1959-2007 period, equivalently to the first column of Table A.1.

Table A.3: Yearly Predicted Response of Mortality, Consumption, and Income Around the Great Recession (Relative to 2006)

Year	Mortality		Consumption		Income	
	Response Relative to 2006 (%) (1)	Average Response since 2006 (%) (2)	Response Relative to 2006 (%) (3)	Average Response since 2006 (%) (4)	Response Relative to 2006 (%) (5)	Average Response since 2006 (%) (6)
2007	-0.3	-0.3	-1.3	-1.3	-2.4	-2.4
2008	-1.2	-0.7	-5.6	-3.5	-2.4	-2.4
2009	-2.2	-1.2	-10.0	-5.6	-7.1	-4.0
2010	-2.3	-1.5	-10.4	-6.8	-9.8	-5.4
2011	-2.5	-1.7	-11.4	-7.7	-12.3	-6.8
2012	-2.4	-1.8	-11.5	-8.4	-12.8	-7.8
2013	-2.3	-1.9	-11.1	-8.8	-13.0	-8.6
2014	-2.1	-1.9	-10.5	-9.0	-12.2	-9.0
2015	-1.6	-1.9	-9.4	-9.0	-10.8	-9.2
2016	-1.6	-1.8	-9.1	-9.0	-10.3	-9.3

Notes: Table displays the predicted response of mortality, consumption, and income relative to 2006 (2006 component set to zero), given a time series of economic factors and factor loadings estimated by the DFM. Columns (1), (3), and (5) display the predicted level of mortality, consumption, and income relative to 2006, defined as the cumulative sum of quarter-on-quarter changes since 2006 (as estimated by the DFM). Columns (2), (4), and (6) display the response averaged over years since 2006. Mortality, consumption, and income are defined as per Section 3.1.

Table A.4: R^2 's of Regressing Factors on Economic Data and Mortality, Selected Series

Series	Computed over 15 quarters starting at indicated cyclical peak														
	1959-2007Q3	1984-2007Q3	1960Q2	1969Q4	1973Q4	1980Q1	1981Q3	1990Q3	2001Q1	2007Q4					
GDP	0.72	0.60	0.82	0.75	0.83	0.77	0.83	0.75	0.61	0.49					
Consumption (total)	0.61	0.43	0.55	0.74	0.63	0.81	0.69	0.74	0.21	0.48					
Consumption (services)	0.32	0.19	0.27	0.48	-0.08	0.61	0.47	0.41	0.22	0.58					
Nonresidential fixed investment	0.65	0.56	0.61	0.80	0.91	0.62	0.61	0.52	0.67	0.86					
Industrial production (total)	0.85	0.74	0.88	0.87	0.94	0.93	0.95	0.82	0.69	0.94					
Industrial production (automobiles)	0.56	0.18	0.54	0.58	0.71	0.67	0.41	0.56	-0.37	0.63					
Nonfarm employment	0.92	0.91	0.93	0.94	0.94	0.95	0.98	0.94	0.91	0.91					
Unemployment rate	0.85	0.74	0.79	0.89	0.96	0.92	0.89	0.73	0.83	0.89					
Short-term unemployment rate	0.82	0.70	0.83	0.88	0.91	0.88	0.84	0.83	0.77	0.71					
Long-term unemployment rate	0.59	0.55	0.56	0.53	0.64	0.73	0.71	0.41	0.59	0.64					
Housing starts	0.56	0.32	0.28	0.61	0.83	0.76	0.75	0.58	0.06	0.46					
OFHEO house price index	0.45	0.42	.	.	.	0.50	0.30	0.59	0.41	0.56					
PCE inflation	0.47	0.49	0.20	0.62	0.62	0.43	0.36	0.49	0.57	0.79					
PCE gas and energy inflation	0.37	0.46	-0.55	-1.22	-0.35	0.17	0.20	0.52	0.49	0.72					
Federal funds rate	0.45	0.40	-0.13	0.52	0.54	0.46	0.38	0.69	0.29	-1.76					
Real monetary base	0.16	0.08	0.14	0.41	0.28	0.61	0.61	-0.09	-0.28	-0.04					
Real commercial and industrial loans	0.43	0.51	0.55	0.48	0.50	-1.05	-0.77	0.72	0.55	0.50					
TED Spread	0.53	0.01	0.25	-0.14	0.74	0.80	0.75	-0.03	-0.32	0.75					
Gilchrist-Zakrajsek spread	0.50	0.49	.	.	0.83	0.06	0.54	0.60	0.64	0.85					
S&P 500	0.68	0.67	0.71	0.60	0.86	0.55	0.69	0.17	0.82	0.80					
VIX	0.46	0.47	.	0.48	0.71	-0.78	-0.74	0.56	0.74	0.81					
SLOOS lending standards	0.59	0.13	.	.	0.60	0.80	0.70	0.41	-1.46	0.45					
Household net worth-disposable income ratio	0.10	0.06	-0.03	0.67	0.40	0.78	0.09	0.34	0.19	0.30					
Household liabilities	0.53	0.43	-0.19	0.75	0.92	0.74	0.67	0.66	0.30	0.75					
Mortality Rate	0.05	0.03	.	-0.21	0.25	0.02	0.09	0.05	0.07	-0.12					

Notes: Each column represents R^2 's of the common components for selected individual economic and mortality indicators, computed over two time-period sub-samples (1959-2007 and 1984-2007) and 15-quarter periods after each U.S. postwar cyclical peak. R^2 is defined as in Table A.1. Each column represents a different set of t 's. The mortality rate represents the cyclical component of the log age-adjusted mortality rate, as per Section 3.1.

Table A.5: Yearly Predicted Response of Mortality Around the Great Recession (Relative to 2006)

	Using 2006-2009 Structural Shocks	Using 2006-2016 Structural Shocks
	(1)	(2)
2007	0.0	0.0
2008	-0.9	-0.9
2009	-2.1	-2.1
2010	-2.3	-2.2
2011	-2.0	-2.4
2012	-1.9	-2.2
2013	-2.0	-2.2
2014	-2.0	-2.0
2015	-2.0	-1.5
2016	-1.9	-1.5
2007-16 Average	-1.7	-1.7
2010-16 Average	-2.0	-2.0

Notes: Table displays the predicted response of mortality relative to 2006 (2006 component set to zero), given a time series of structural shocks derived from a 4-lag VAR of economic factors estimated by a dynamic factor model (obtained as per Section 4.2). Columns (1) and (2) use shocks occurring in 2006Q1-2009Q4 and in 2006Q1-2016Q4, respectively.

Table A.6: Yearly Predicted Response of Mortality Cyclical Component Around the Great Recession (Relative to 2006Q1), by Age Group

Year	Age Group Mortality Response (%)			
	≤ 24	25-44	45-64	65+
2007	-1.2	-1.0	-0.6	-0.2
2008	-2.2	-2.8	-1.0	-1.3
2009	-2.4	-3.9	-0.9	-2.7
2010	-4.7	-6.2	-1.3	-2.6
2011	-6.7	-8.2	-1.9	-2.6
2012	-8.2	-9.2	-2.3	-2.2
2013	-9.1	-9.5	-2.5	-2.0
2014	-9.8	-9.5	-2.7	-1.6
2015	-9.6	-8.6	-2.7	-0.8
2016	-9.3	-8.4	-2.6	-0.9
2007-2016 Average	-6.3	-6.7	-1.8	-1.7

Notes: Table displays the predicted response of the cyclical component of mortality for four age groups, relative to 2006Q1 (2006Q1 component set to zero), given a time series of economic factors and factor loadings estimated by the DFM. Values indicate the annual average of the predicted level of the cyclical component of mortality relative to 2006Q1, defined as the cumulative sum of quarter-on-quarter changes since 2006Q1 (as estimated by the DFM).

Table A.7: Impact of the Great Recession on Life Expectancy by Age

Age	Mortality rate (per 100,000)	Life Expectancy (without recession)	Life Expectancy (with recession)	Change in life expectancy	
				Percent increase	Years increase
35	128	44.071	44.085	0.030%	0.013
45	286	34.788	34.812	0.068%	0.024
55	623	26.061	26.096	0.134%	0.035
65	1,385	18.004	18.056	0.291%	0.052
75	3,388	11.068	11.137	0.625%	0.069

Notes: This table translates our empirical DFM mortality estimates into the implications of the Great Recession for life expectancy at various ages. Column (1) displays unisex mortality rates by age based on the 2007 SSA mortality tables. Column (2) translates mortality rates by age into remaining life expectancy. Column (3) considers how this remaining life expectancy would change if mortality rates declined as indicated in column (1) of Table A.3 and then returned to normal. Columns (4) and (5) report the percentage difference in life expectancy and the difference in life expectancy in years, respectively, between column (3) and column (2). Remaining life expectancy at age A is defined as the average number of years lived past age A , assuming an equivalent number of males and females starting at this age. For each gender, life expectancy is obtained as the sum over each age x of the share of individuals of that gender that die at age x multiplied by the number of years lived since age A .

Table A.8: Welfare Costs of the Great Recession by Age

	Mortality			
	Exogenous	Endogenous		
		(2)	(3)	(4)
(1)				
Panel A. Starting age 35				
$\gamma = 1.5$	3.88	3.78	3.63	3.47
$\gamma = 2$	3.94	3.86	3.72	3.58
$\gamma = 2.5$	4.01	3.93	3.81	3.69
Panel B. Starting age 45				
$\gamma = 1.5$	4.25	4.03	3.69	3.34
$\gamma = 2$	4.32	4.12	3.82	3.51
$\gamma = 2.5$	4.39	4.21	3.94	3.67
Panel C. Starting age 55				
$\gamma = 1.5$	4.83	4.40	3.72	3.05
$\gamma = 2$	4.90	4.52	3.91	3.31
$\gamma = 2.5$	4.97	4.63	4.09	3.56
Panel D. Starting age 65 (no consumption declines)				
$\gamma = 1.5$	0.00	-0.87	-2.23	-3.56
$\gamma = 2$	0.00	-0.77	-1.98	-3.15
$\gamma = 2.5$	-0.00	-0.68	-1.75	-2.80
Panel E. Starting age 65 (65+ consumption declines)				
$\gamma = 1.5$	5.74	4.82	3.38	1.97
$\gamma = 2$	5.82	4.99	3.72	2.47
$\gamma = 2.5$	5.89	5.16	4.02	2.92
VSLY	-	\$100k	\$250k	\$400k

Notes: Table displays the welfare cost of recessions, based on equation (25), at various ages under exogenous and endogenous mortality, for various assumptions about risk aversion (γ) and the value of a statistical life year (VSLY) for 35-year-old individuals. In Panel D, we specify welfare effects for a 65-year-old assuming no 65+ consumption declines. In Panel E, we assume 65+ consumption declines of the same magnitude as for individuals under 65. This welfare cost is the amount the individual would need to be paid to accept the stochastic aggregate state relative to an otherwise similar economy that stays in the non-recession state for all time periods, measured as a percentage of average annual consumption. A 10-year duration of the Great Recession is considered, followed by a period without recessions until the end of life.