# The Impact of the Great Recession on Mortality: A Time Series Approach

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**Abstract**

To examine the impact of the Great Recession on mortality, we augment the dynamic factor time series model of Stock and Watson (2012) to include mortality. Our estimates indicate that the economic conditions of the Great Recession decreased mortality by 2 percent between 2006 and 2011. [In on-going work we will examine mortality effects separately by demographics.] We use the estimates of the impact of the Great Recession on mortality and on consumption to calibrate a model of the welfare cost of the Great Recession. Compared to a calibration based only on recession-induced consumption declines, accounting for endogenous mortality lowers the welfare cost of the Great Recession, particularly at older ages where it may even be welfare-improving.

****PRELIMINARY AND INCOMPLETE!****

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# 1 Introduction

The 2007-2009 Great Recession represented the largest contraction in the U.S. economy since the Great Depression. Economists have documented substantial, aggregate, time-series declines in asset prices, income, and earnings, and used these estimates to calculate welfare losses from the Great Recession (e.g. Glover et al. (2020), Hur (2018), Menno and Oliviero (2020), and Peterman and Sommer (2019)). Empirical work exploiting spatial variation in the economic severity of the Great Recession across different parts of U.S. has likewise documented substantial declines in a variety of economic measures including employment and consumption (e.g. Mian et al. (2013), Rinz (2022), and Yagan (2019)), but also estimated reductions in mortality in local labor markets that were harder hit (Finkelstein et al. (2025)). Such pro-cyclical mortality effects could mitigate or potentially erase the welfare losses from the economic declines associated with the Great Recession. However, estimates of the Great Recession's impact on mortality that exploits cross-sectional variation in the intensity of the Great Recession will miss any general equilibrium effects that do not differentially affect different local areas but operate through nationwide changes in factors such as interest rates, stock market value, or malaise. This leaves open the question of whether the Great Recession in *aggregate* reduced mortality, and if so, by how much.

In this paper, therefore, we augment the dynamic factor, time series model of Stock and Watson (2012), which is trained on data on 132 economic indicators from 1959 through 2007, to include mortality, and use the resultant estimates to predict the impact of the Great Recession on mortality. We impose the exclusion restriction that the 132 economic indicators may influence mortality but mortality does not influence them. Our estimates predict that the Great Recession reduced the cyclical component of mortality (i.e. mortality after residualizing for the secular trend and quarterly component) by 2 percent by Q2 2011. This estimate is quite similar in magnitude to the estimated impact of the Great Recession on mortality by 2011 based on spatial variation in the impact of the Great Recession across local labor markets (Finkelstein et al. (2025)), although the time pattern of the decline is considerably more gradual in the aggregate estimates from the dynamic factor model.

[TO COME: extensions of predictions out through 2016; also variation by demographics.]

In the final part of the paper we use the predictions of the dynamic factor model for consumption and mortality during the Great Recession to calibrate the welfare consequences of the Great Recession from its impact on consumption alone as well and compare this to the welfare consequences arising from its impacts on both consumption and mortality. We also compare how the consumption and mortality impacts differ across demographic groups. [RESULTS TO COME]

Our analysis is in the spirit of work in macroeconomics that incorporates health into welfare comparisons across countries and secular improvements in health into welfare analyses of economic

growth within and across countries (e.g. Becker et al. (2005), Brouillette et al. (2021), Hall and Jones (2007), Jones and Klenow (2016), Murphy and Topel (2006), and Nordhaus (2002)). There has been comparatively less attention, however, to incorporating cyclical fluctuations in health into welfare analysis of business cycles. There are of course exceptions, including Edwards (2009), Egan et al. (2014), and Finkelstein et al. (2025), all of which suggest that incorporating pro-cyclical mortality in welfare analyses of business cycles based solely on their economic impacts has a quantitatively substantial impact on the estimated welfare cost of business cycles.[1] Such findings help motivate our analysis of the welfare consequences of the Great Recession-induced mortality changes.

Our paper also contributes to the large empirical literature on the economic impacts of the Great Recession (some of which we reference above), as well as the - largely disjoint - large, empirical literature on the relationship between the economy and health. Here, the well-documented positive relationship between GDP and life expectancy within countries, across countries, and overtime (e.g. Chetty et al. (2016), Costa (2015), and D. Cutler et al. (2006) stands in marked contrast to the growing body of evidence that mortality is pro-cyclical within many countries including the U.S. (e.g. Miller et al. (2009), Ruhm (2000), and Stevens et al. (2015), Canada (Ariizumi and Schirle (2012)), Germany (Neumayer (2004)), Spain (Granados (2005)), and France (Buchmueller et al. (2007)), among others. However, these findings are typically based on local labor market fluctuations, and thus may not capture general equilibrium effects of aggregate, national recessions.[2]

The rest of the paper proceeds as follows. Section 2 describes our methods and data, Section 3 presents our aggregate empirical results, Section 4 explores their welfare implications, and Section 5 extends both the empirical estimates and their welfare analysis to consider heterogeneous impacts across different demographic groups. The last section concludes.

[1] Specifically, 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, while Finkelstein et al. (2025) find that extending the Krebs (2007) model to include pro-cyclical mortality in addition to counter-cyclical earnings considerably reduces the welfare costs of business cycles.

[2] Important exceptions include Edwards (2009) and Egan et al. (2014) who document that aggregate mortality is pro-cyclical in the United States over the 20th century. Other exceptions include work documenting 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).

# 2 Empirical Methods and Data

## 2.1 Augmented Stock and Watson Model

We employ the dynamic factor model (DFM) used in Stock and Watson (2012), extending it to include mortality.

**Recap of Stock and Watson Model.** The DFM is 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. Using this approach, Stock and Watson (2012) are able to predict most of the variation in 200 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 serve as reliable indicators of the state of the economy; they are estimated based on quarterly, time-series data on 132 economic indicators from Q1 1959 through Q3 2007. Stock and Watson (2012) then use 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, and to thus 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.

The DFM's structure is represented by

$$X_t = \Lambda F_t + e_t \tag{1}$$

where $X_t = (X_{1t}, X_{2t}, ..., X_{nt})'$ represents a vector of 132 economic indicator time series measured quarterly in period from 1959 through 2011 Q2, $F_t$ represents a vector containing six factors, $\Lambda$ 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 $\Lambda F_t$ term is called the common component of $X_t$.

In equation (1) above, both $\Lambda$ and $F_t$ 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 $\Lambda$ 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 $\Lambda$ 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:[3]

$$\hat{F}_t^{59-07} = \hat{\Lambda}^{59-07} X_t^{59-07}. \tag{2}$$

Finally, to produce factors in the 2008-2012 period, we hold the 1959-2007 factor-loadings fixed and plug in the observed $X_t$ in 2008-2012:

$$\hat{F}_t^{08-12} = \hat{\Lambda}^{59-07} X_t^{08-12} \tag{3}$$

This procedure applied to the original data reproduces the results from Stock and Watson (2012).

**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.[4] To this end, we obtain factor-loadings $\Lambda_m$ for mortality (denoted by $m_t$) by running an OLS regression of the mortality time series on the economic factors over the period from 1959 to 2007 Q3:

$$m_t^{59-07} = \hat{\Lambda}_m^{59-07} \hat{F}_t^{59-07} \tag{4}$$

where $\hat{F}_t^{59-07}$ are the factors estimated by Stock and Watson (2012) in equation (2). This approach imposes the exclusion restriction that the economic factors may influence mortality but mortality does not influence them.

Then, using the estimated factor-loadings for mortality ($\hat{\Lambda}_m^{59-07}$) from equation (4), together with the 2008-2012 factors ($\hat{F}_t^{08-12}$), we predict the mortality rate over the 2008-2012 period:

$$\hat{m_t}^{08-12} = \hat{\Lambda}_m^{59-07} \hat{F}_t^{08-12}. \tag{5}$$

The outcome from equation (5) serves as a prediction of the path of mortality rates given economic conditions during the Great Recession.

[3]For further details on the estimation procedure, see Stock and Watson (2016). Note also that since $F_t$ and $\Lambda$ are determined jointly, the solution to the problem is not unique, as a solution to $\Lambda F_t$ could also be $\Lambda H H^{-1} F_t$ for some invertible matrix $H$. Thus, this procedure requires an arbitrary normalization of $\Lambda$ (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.

[4]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.

## 2.2 Data and Variables

**Recap of Stock and Watson Variables and their Transformation.** We use the Stock and Watson (2012) dataset of 200 quarterly, national-level economic indicators from 1959 to 2012. These 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. As in Stock and Watson (2012), we use only 132 of these economic indicators to estimate the DFM model, and do not include top-line aggregates such as GDP and total consumption as well as mortality data; we also transform the economic indicators (e.g. to quarterly growth rates) and detrend them to eliminate low frequency variation via a biweight kernel, such that the time series become plausibly stationary.

A particular indicator that we will focus on below is consumption, which is defined as real personal consumption expenditures (PCE) at the national level. Following Stock and Watson (2012), we take the log first-difference of the time series, that is, $log(C_{t+1}) - log(C_t) = log(C_{t+1}/C_t)$. Thus, this data represents growth rates relative to the previous quarter. We then remove the long-term trend via a biweight filter procedure with a centered moving window of $\pm 30$ quarters, such that the time series is centered around zero – see Stock and Watson (2012) for more information.

**Mortality data and its Transformation.** Information on age-specific deaths comes from the National Center for Health Statistics (NCHS) individual-level mortality data starting in 1968; these data include the exact date of death (day/month/year), allowing us to measure age-specific quarterly death counts. We combine these with yearly, national population data by age bin from the Survey of Epidemiology and End Results (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.[5] We focus on age-adjusted, mortality rates so that our analysis is not affected by varying age composition over time.

A challenge is that the SEER population data is 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 reflects population as of July 1st (NIH National Cancer Institute and Vilhuber (2021)), we calculate quarterly population as a weighted average of the current year, previous year, and subsequent year's population, with the weights varying by quarter.[6] Appendix Figure A.1 shows that our quar-

[5] The 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+.

[6] Specifically, let $t-1$, $t$, and $t+1$ denote the previous, current and subsequent year population, respectively. We then define year $t$ Q1 population by $0.5 \times Pop_{t-1} + 0.5 \times Pop_t$, Q2 population by $0.25 \times Pop_{t-1} + 0.75 \times Pop_t$, Q3

terly estimates are consistent with yearly estimates published by the National Center for Health Statistics (NCHS).

Since we are interested in the relationship between economic activity and mortality, we filter the national quarterly mortality time series data for its cyclical component, i.e., the component of the time series that varies at business cycle frequency.[7] To this end, we decompose the quarterly log mortality rate time series into the sum of four separate components: (i) a long-term trend, (ii) a seasonal/quarterly component, (iii) a cyclical component, and (iv) an idiosyncratic error term. Specifically, we remove both the long-term trend as well as the seasonal component by obtaining residuals of an OLS regression of the log age-adjusted mortality rate on indicators for quarter of year and a linear yearly trend using data through 2006:[8]

$$log(y_{tq}) = \sum_{k=1}^{4} \beta_k \mathbb{I}_{q=k} + \delta * year_t + \epsilon_{tq} \tag{6}$$

Figure 1 shows the results. The dashed line shows our estimate of the long-term linear trend $\hat{\delta}$. Consistent with prior work (e.g. D. M. Cutler and Meara (2001) and Ma et al. (2015)), we estimate that mortality declines are approximately log-linear, with an average annual decline of about 1.1 percent. The solid line shows the long-term trend plus the $\hat{\epsilon}_{tq}$ residuals, which contain both the cyclical and idiosyncratic error components; in other words, the solid line shows mortality rates purged of seasonal variation via the $\beta_k$ coefficients.

In Figure 2 we present the time series of the estimated $\hat{\epsilon}_{tq}$ residuals directly (solid black line). Since mortality is specified in logs, the y-axis values in Figure 2 can be interpreted as the percent deviation of the age-adjusted mortality rate from its long-term trend. To separate the idiosyncratic error component from the cyclical error component in these residuals, we smooth the time series via a biweight filter, generating the dashed-red time series in Figure 2; this series represents the quarterly estimates of the cyclical component of age-adjusted mortality.[9]

Finally, we take the first-difference of this estimated cyclical component, since economic activity is more strongly associated with changes in the cyclical component of mortality than with the component's level.[10] This first differencing yields our final mortality time series shown in Figure 3. The values in Figure 3 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

population by $Pop_t$ and Q4 population by $0.25 \times Pop_{t+1} + 0.75 \times Pop_t$.

[7] This frequency can be thought of as approximately every 6-32 quarters, as per Baxter and King (1999).

[8] Parameters are estimated using data only until 2006 to avoid look-ahead bias.

[9] The bandwidth is selected using a method that minimizes mean squared error. In an alternative specification, we employ a larger bandwidth, yielding a smoother time series. Results are quantitatively similar.

[10] Similarly, the analyses of impacts of local labor market unemployment on mortality likewise considers how *changes* in the unemployment rate impact mortality (e.g. Finkelstein et al. (2025) and Ruhm (2000)).

component of mortality increased by 0.25 percentage points since the last quarter (for example, from 1% above trend to 1.25% above trend), or equivalently that the mortality rate increased by 0.25 percent.

# 3 Results

## 3.1 Drivers of Mortality

For ease of presentation, we aggregate the 200 economic indicators into the 13 broad categories discussed in Section 2.2.[11] Table 1 displays the $R^2$ of the common component for these 13 categories (replicating Stock and Watson (2012)) as well as the (new) $R^2$ for the cyclical component of the mortality rate (bottom row). The results suggest that movements in the cyclical component of mortality can be partially explained by macroeconomic factors, with an $R^2$ of 0.13 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, since mortality was not used in estimating the factors. That said, the mortality common component $R^2$ is similar in magnitude to that of prices ($R^2$=0.15).

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 2 displays the $R^2$ obtained from each model; again, the bottom row shows the results for mortality. Results indicate that the first factor, which is strongly associated with employment-related variables, can explain about one-quarter of the total variation in mortality explained by the model ($R^2 = 0.03$ for the first factor, compared to $R^2$ of 0.13 for all six factors). With a second factor included in the model, it can now explain about 70 percent of the total variation in mortality explained by the model; this second factor is strongly associated with housing starts and earnings, among others. In addition, when we examine specific, individual economic indicators, it appears that the pattern observed for mortality does not match that of GDP, instead matching other aggregates more closely such as consumption, automobile industrial production and the long-term unemployment rate (see Appendix Table A.1). By contrast, Table 2 indicates that the fourth and fifth factors, which are primarily associated with wealth-related variables such as the stock prices and wealth, and housing prices, do not provide any additional explanatory power. The lack of co-movement between between mortality rates on the one hand and stock prices and wealth on the other hand may help explain why Finkelstein et al. (2025) - which examined cross-regional variation in the impact of the Great Recession that

[11] 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.

would not capture national impacts operating via stock market changes - found similar impacts of the Great Recession on mortality as the national time-series analysis.

### 3.2 Impact of Great Recession

Figure 4 shows the predicted path for the cyclical component of the mortality rate based on the estimates from the DFM. 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 as early as 2006, 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, relative to 2006Q1, the model predicts the cyclical component of mortality rates to decrease by 2 percentage points by 2011Q2, such that overall mortality is predicted to decrease by 2 percent.

We can compare the estimated mortality decline due to the Great Recession from the DFM to prior estimates of the impact of the Great Recession based on spatial variation in the impact of the Great Recession across local labor markets. Exploiting this variation in the economic impact of the Great Recession, Finkelstein et al. (2025) estimate that a one percentage point increase in the local area unemployment rate reduced local area mortality by 0.5 percent.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 (Ruhm (2000)). As noted in the Introduction, however, estimates based on local variation in the unemployment rate will miss any mortality impacts of the Great Recession that operate through nationwide-changes - such as any mortality impacts of the decline in the stock market. Interestingly, however, the magnitude of the implied mortality declines from these two approaches are quite similar by the end of our study period in 2011. Specifically, since, on average, the unemployment rate increased by 4.6 percentage points between 2007 and 2009, estimates based on local labor market variation imply that the Great Recession reduced mortality by about 2.3 percent in 2011, which is quite similar to the 2 percent estimate from the DFM. However, the timing of the impact appears different, with Figure 4 indicating a gradual reduction in mortality from the Great Recession that reached 2 percent by 2011, while Finkelstein et al. (2025) estimate an immediate and persistent impact on mortality.

**Robustness** We examined the robustness of the estimated impact of the Great Recession on mortality (see Figure 4) to a number of alternative specifications. First, since we estimate the relationship between economic conditions and mortality using 1959-2007 data, we are implicitly

assuming that that this relationship is stable over this period, which may not be realistic. In Appendix A, therefore we explore a variation of the model with a break in factor loadings; the results indicate similar impacts of the Great Recession on mortality through the middle of 2008 (a little over a 1 percent decline) but considerably less persistent after that.

** More TO COME **

**Consumption** The welfare analysis in the next Section will also use the predicted impact of the DFM on consumption. Figure 5 shows the results; once again, we normalize results relative to 2006Q1. Like the results for mortality in Figure 4, the model predicts declines starting in 2006, however, unlike mortality which continues to decline due to the Great Recession, consumption declines level off after about 2009. The model predicts consumption to decrease by around 9 percent in the 2007-2009 period, relative to its long term trend.[12] For comparison, we also estimate the impact of the Great Recession on consumption using the spatial variation in the impact of the Great Recession on local labor markets as in Yagan (2019) and Finkelstein et al. (2025). Appendix B presents the results, which suggest similar impacts on consumption as the time series analysis, although - as with mortality - a different time profile to the effects when using cross-sectional variation in the impact of the Great Recession to estimate its imapct.

# 4 Welfare Implications

We assess how incorporating mortality declines affects analysis of the welfare implications of the Great Recession. To do so, we use the time-series estimates of the impact of the Great Recession on consumption and mortality, and compare calibrations of a model of the welfare cost of the Great Recession based solely on consumption effects to one that also incorporates mortality effects.[13]

## 4.1 Setup

We consider a large $N$ of identical agents. The representative agent's expected lifetime utility is given by:

$$U(c^{\omega}(t), m^{\omega}(t)) = \sum_{t=0}^{\infty} \beta^t S(m^{\omega}(t)) u(c^{\omega}(t)), \tag{7}$$

[12] Table A.1 shows common component $R^2$ for consumption over the 1959-2007 period; the fit is very good ($R^2$=0.63) since consumption closely co-moves with economic indicators.

[13] A caveat to this approach is that it incorporates only direct impacts of the Great Recession on mortality. There is 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. This negative investment effect may especially hold given the slow recovery from the recession and its associated hysteresis effects (Yagan (2019)).

where $c^{\omega}(t)$ is the agent's consumption in period $t$ and aggregate state $\omega$, $m^{\omega}(t)$ is the mortality rate (allowed to vary over the life-cycle), and $\beta$ is the agent's subjective discount rate. The cumulative survival rate $S(m^{\omega}(t)) = \prod_{\tau=0}^{\tau=t}(1 - m^{\omega}(\tau))$ 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 $c^{\omega}(t)$ units of consumption every period and entirely consume their endowment; however, by calibrating the model based on the estimated impacts of the Great Recession on consumption below, we capture partial insurance to income shocks (Blundell et al. (2008)).

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

$$u(c) = b + \frac{c^{1-\gamma}}{1-\gamma}, \tag{8}$$

where $b$ governs the willingness to pay for additional years of life. Assuming that consumption is constant over time , the value of a statistical life-year (VSLY) is given by:

$$\text{VSLY} = \frac{U(c,m)/u'(c)}{T} \tag{9}$$

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 will follow Hall and Jones (2007) by parameterizing $b$ to match a given VSLY for 35 year-olds.

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. For now, given that we only estimate the impact of the Great Recession over five years (2006-2011), we model the Great Recession as a shock at $t = 0$ that moves the economy to state $L$ for five 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:

$$c^{\omega}(t) = c^{H}(t) \cdot (1 + dc(t) \cdot \mathbf{1}(\omega = L)) \tag{10}$$

$$m^{\omega}(t) = m^{H}(t) \cdot (1 + dm(t) \cdot \mathbf{1}(\omega = L)) \tag{11}$$

where $dc(t)$ and $dm(t)$ denote the percentage decline in consumption and the mortality rate from the Great Recession ($dc(t) < 0$ and $dm(t) < 0$); they may vary over time ($t$) to account for dynamic effects of the recession. In subsequent work we will also allow them to vary across individuals by

demographics such as age.

We define the welfare cost of the Great Recession ($\Delta_{GR}^{dm}$) 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:

$$\sum_{t=0}^{\infty} \beta^t S(m^{\omega}(t)) u((1+\Delta_{GR}^{dm}) c^{\omega}(t)) = \sum_{t=0}^{\infty} \beta^t S(m^{H}(t)) u(c^{H}(t)) \tag{12}$$

The right-hand side of equation (12) 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 $0 \leq t \leq 4$ 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.

### 4.2 Calibration

We calculate age-specific, unisex mortality rates for mortality in "normal" times (the $m^H(t)$ matrix) based on the 2007 SSA mortality tables, and set $m^H(t) = 1$ starting at age 100. We normalize $c^H(t) = 1$. We use the estimates from the DFM in Figures 4 and 5 and to calibrate the proportional impacts of the Great Recession on consumption ($dc(t)$) and mortality ($dm(t)$), respectively. 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 decline in consumption relative to 2006 (and relative to a long-term trend). Since we are currently only using data until 2011, we assume that effects last for only the 2007-2011 period.

Our results will depend on the age profile of mortality and age effects in addition to their time profile. For our baseline analysis, we assume that, consistent with the evidence from Finkelstein et al. (2025), 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.[14] We also 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

[14]Using data from the 2007 SSA mortality tables, at age 35, remaining life expectancy is 44 years, and the Great Recession increases life expectancy by 0.016 years (0.037 percent), while at age 65, remaining life expectancy is 18 years and the Great Recession increases life expectancy by 0.065 years (0.36 percent), i.e., by ten times as much in percentage terms.

65, with no consumption effects at older ages. Figure 6 below displays consumption paths by starting age at $t = 0$.

We set $\beta = 0.96$, following the business cycle literature (Krebs (2007)) as well as estimates of the discount rate (e.g., Giglio et al. (2014), Gourinchas and Parker (2002), and Koster and Pinchbeck (2022)). We report results for a range of risk-aversion parameters ($\gamma$), allowing values of $\gamma = 1.5$, 2 and 2.5. We calibrate values of $b$ to match VSLY values of \$100k, \$250k or \$400k for 35 year-olds, as mentioned previously.[15] The high end of the range is based on several different sources described in Kniesner and Viscusi (2019). The low end of the range follows the assumed \$100k VSLY made by e.g., Cutler (2005) and Cutler et al. (2022), and is also similar to the baseline VSLY in Hall and Jones (2007).

### 4.3 Results

Figure 7 shows our estimates of the welfare costs of the Great Recession by age, under the baseline assumptions of $\gamma = 2$ and VSLY of \$250k, while Table 3 shows results for other assumptions about $\gamma$ and VSLY. For a 35-year-old with exogenous mortality, we find that that the Great Recession imposed an average welfare cost of about 1.62 percent of average annual consumption. This welfare cost rises with age; since older individuals have fewer years remaining, the (constant) willingness to pay in terms of consumption translates into a higher share of remaining lifetime consumption.

Columns (2) through (4) in Table 3 show that accounting for endogenous mortality reduces the welfare cost of the Great Recession at all ages but, as explained in Section 4.2, 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 4 percent (from 1.62 percent of average annual consumption to 1.56 percent). However, for a 55-year-old, endogenous mortality reduces the welfare cost of the Great Recession by about 16 percent (from 2.05 percent of average annual consumption to 1.73 percent). Recall that (for now) we make the assumption that Great-Recession induced consumption declines are limited to those under 65. Thus, with endogenous mortality, a shock of the size of the Great Recession becomes welfare-improving starting at age 63, as shown in Figure 7.

## 5 Allowing for heterogeneity

Thus far we have considered a representative agent who experiences the average change in mortality, as well as the average change in consumption (if under 65) estimated in the prior section. In practice,

[15] We impute yearly consumption to be $c = \$50k$, such that VSLY can be two, five, or eight times yearly consumption.

of course, impacts of recessions are likely heterogeneous both by observable characteristics - such as age - as well as idiosyncratic across observationally equivalent agents. Given concavity of the utility function over consumption, this heterogeneity can have potentially non-trivial impacts on welfare analysis. In this section, we will empirically examine heterogeneity in the impacts of the Great Recession on consumption and on mortality by age, and examine how these affect the welfare analysis. *** TO COME **

## 6 Conclusion

In this paper, we employed a time series approach to understand the impacts of economic conditions related to the Great Recession on mortality. ** MORE TO COME **

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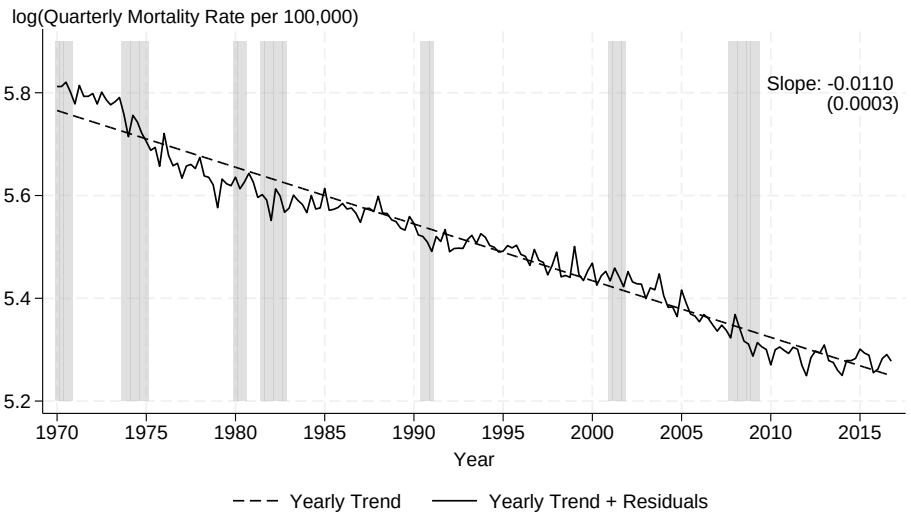
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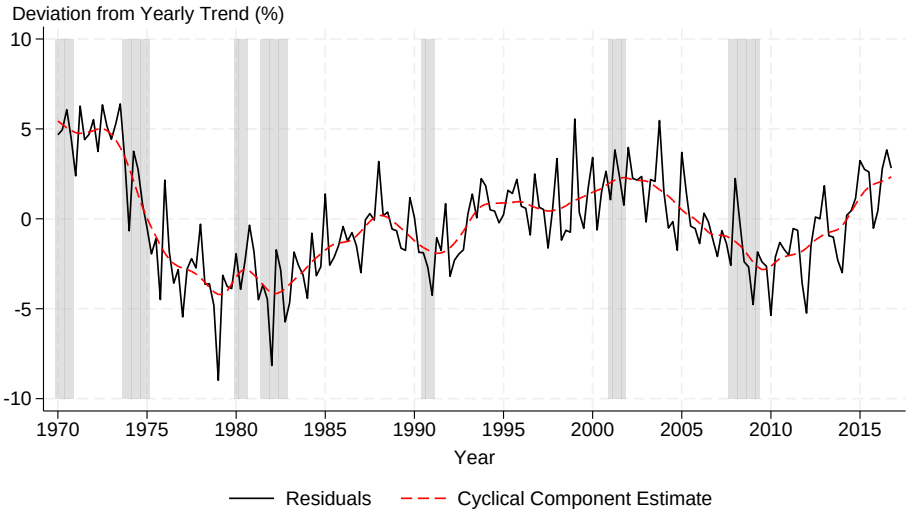
# Figures

Figure 1: Linear Filter Yearly Trend versus Trend + Residuals (Demeaned of Quarter intercepts)



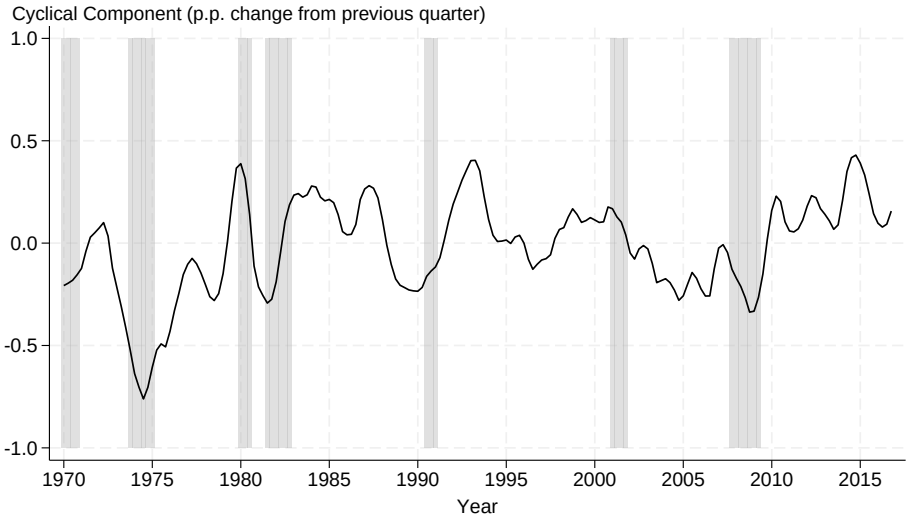

Notes: Yearly trend is calculated via OLS regression as indicated in equation (6), estimated with data until 2006 to avoid look-ahead bias issues. Seasonal component is excluded from figure. Recessions shaded in gray.

Figure 2: Linear Filter Residual (Cyclical + Error Components)



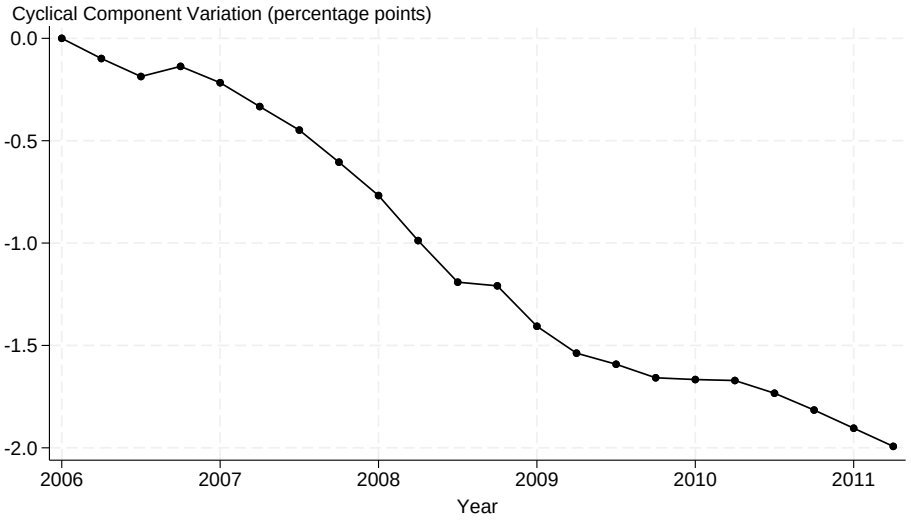

Notes: Y-axis values reflect percent deviations from the long-term trend. Recessions shaded in gray. The cyclical component is obtained via a biweight kernel that smooths the residual time series.

Figure 3: First Difference of Linear Filter Cyclical Component



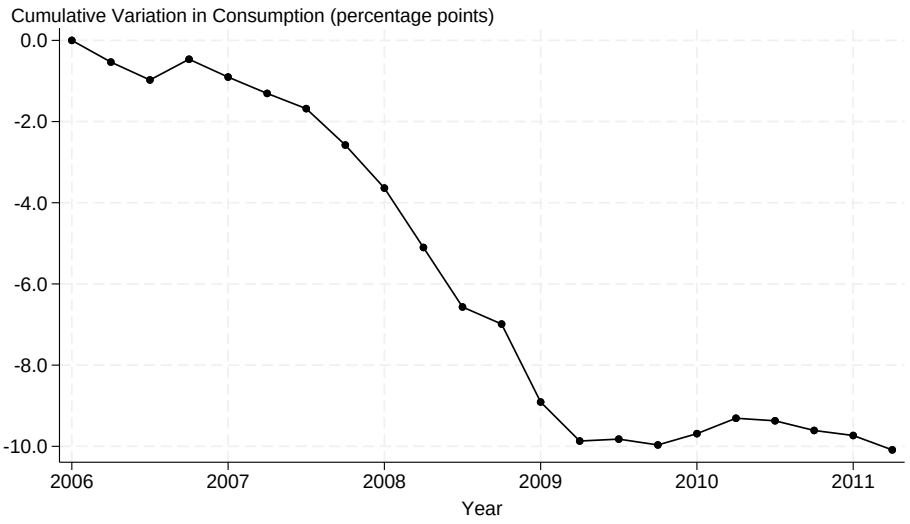

Notes: Y-axis values reflect the percentage point quarter-on-quarter change in the cyclical component of the mortality rate. For example, a value of 0.25 means that the cyclical component increased by 0.25 percentage points since the last period. Recessions shaded in gray.

Figure 4: Predicted Response of Mortality Cyclical Component around the Great Recession (relative to 2006Q1)



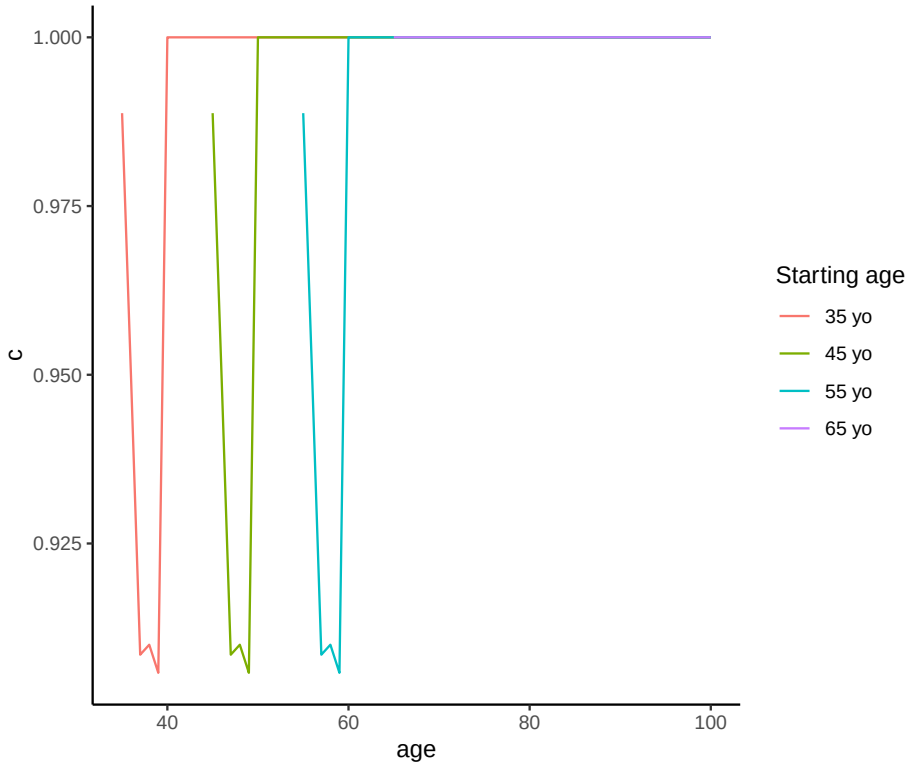

Notes: Figure displays the predicted response of the cyclical component of mortality, relative to 2006Q1 (2006Q1 component set to zero), given a time series of economic factors and factor loadings estimated by the DFM. Y-axis values represent the predicted level of the cyclical component relative to 2006Q1, which is defined as the cumulative sum of quarter-on-quarter changes in the cyclical component since 2006Q1 (as estimated by the DFM).

Figure 5: Predicted Response of Consumption around the Great Recession (relative to 2006Q1)



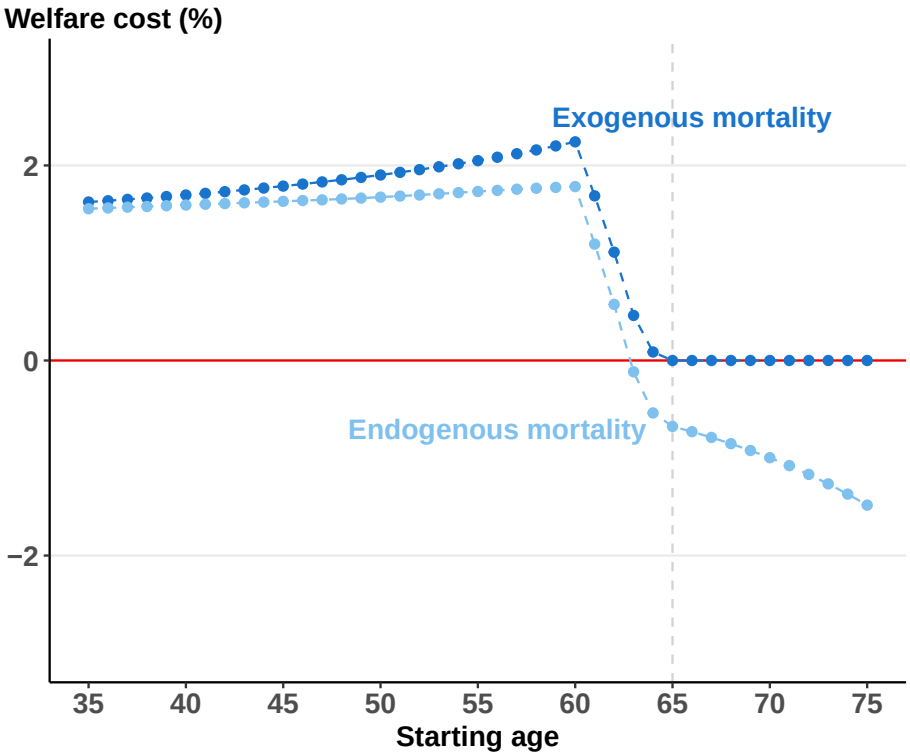

Notes: Figure displays the predicted response of consumption, relative to 2006Q1 (2006Q1 component set to zero), given a time series of economic factors and factor loadings estimated by the DFM. Y-axis values represent the predicted level of consumption relative to 2006Q1, which is defined as the cumulative sum of quarter-on-quarter changes in consumption since 2006Q1 (as estimated by the DFM).

Figure 6: Consumption paths by age




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 Section 4. Baseline $c^H(t) = 1$, and the Great Recession consumption shock is determined by DFM estimates, as per Figure 5.

Figure 7: Welfare Costs of the Great Recession by Age




Notes: Figure displays the welfare cost of recessions, based on equation (12), 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. These estimates assume $\gamma = 2$, $\beta = 0.96$, and $b$ corresponding to a VSLY of \$250k for 35 year-old individuals.

# Tables

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

| | | | | Computed over 15 quarters starting at indicated cyclical peak | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Series Category | N | 1959-2007Q3 | 1984-2007Q3 | 1960Q2 | 1969Q4 | 1973Q4 | 1980Q1 | 1981Q3 | 1990Q3 | 2001Q1 | 2007Q4 |
| National income and product accounts | 21 | 0.56 | 0.43 | 0.56 | 0.46 | 0.62 | 0.66 | 0.59 | 0.64 | 0.49 | 0.65 |
| Industrial production | 13 | 0.72 | 0.6 | 0.78 | 0.77 | 0.86 | 0.86 | 0.8 | 0.66 | 0.61 | 0.8 |
| Employment and unemployment | 46 | 0.62 | 0.5 | 0.64 | 0.68 | 0.76 | 0.76 | 0.81 | 0.61 | 0.63 | 0.78 |
| Housing starts | 8 | 0.37 | 0.21 | 0.09 | 0.26 | 0.54 | 0.46 | 0.54 | 0.44 | -0.16 | 0.27 |
| Inventories, orders, and sales | 8 | 0.54 | 0.35 | 0.39 | 0.69 | 0.72 | 0.73 | 0.68 | 0.66 | 0.43 | 0.64 |
| Prices | 39 | 0.15 | 0.05 | 0 | 0.15 | 0.37 | 0.18 | 0.08 | 0.03 | 0.14 | 0.13 |
| Earnings and productivity | 13 | 0.37 | 0.29 | 0.52 | 0.38 | 0.35 | 0.3 | -0.03 | 0.32 | 0.36 | -0.11 |
| Interest Rates | 18 | 0.4 | 0.3 | -0.07 | 0.39 | 0.3 | 0.5 | 0.44 | 0.29 | 0.07 | -0.5 |
| Money and Credit | 12 | 0.44 | 0.26 | 0.22 | 0.47 | 0.55 | 0.65 | 0.63 | 0.4 | 0.06 | -0.37 |
| Stock Prices and Wealth | 11 | 0.47 | 0.52 | 0 | 0.67 | 0.74 | 0.62 | 0.5 | 0.37 | 0.31 | 0.77 |
| Housing Prices | 3 | 0.67 | 0.67 | . | . | . | 0.59 | -0.01 | 0.6 | 0.72 | 0.57 |
| Exchange Rates | 6 | 0.56 | 0.66 | -2.64 | 0.47 | 0.64 | 0.48 | 0.66 | 0.75 | 0.72 | 0.6 |
| Other | 2 | 0.42 | 0.42 | -0.4 | 0.15 | 0.87 | 0.89 | 0.89 | 0.48 | -0.6 | 0.31 |
| **Mortality Rate** | 1 | 0.13 | 0.1 | . | 0.32 | 0.26 | -0.14 | 0.62 | -0.02 | -0.43 | 0.37 |

Notes: each column represents $R^2$'s of the common components for each series category, computed over two 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 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 | 0.29 | 0.43 | 0.49 | 0.52 | 0.55 | 0.56 |
| Industrial production | 13 | 0.37 | 0.56 | 0.63 | 0.67 | 0.7 | 0.72 |
| Employment and unemployment | 46 | 0.5 | 0.55 | 0.59 | 0.6 | 0.61 | 0.62 |
| Housing starts | 8 | 0.01 | 0.24 | 0.26 | 0.28 | 0.29 | 0.37 |
| Inventories, orders, and sales | 8 | 0.33 | 0.52 | 0.52 | 0.53 | 0.54 | 0.54 |
| Prices | 39 | 0.02 | 0.05 | 0.11 | 0.12 | 0.13 | 0.15 |
| Earnings and productivity | 13 | 0.03 | 0.17 | 0.26 | 0.31 | 0.36 | 0.37 |
| Interest Rates | 18 | 0.14 | 0.29 | 0.32 | 0.36 | 0.39 | 0.4 |
| Money and Credit | 12 | 0.14 | 0.29 | 0.39 | 0.42 | 0.44 | 0.44 |
| Stock Prices and Wealth | 11 | 0.04 | 0.12 | 0.29 | 0.33 | 0.43 | 0.47 |
| Housing Prices | 3 | 0.09 | 0.15 | 0.22 | 0.59 | 0.58 | 0.67 |
| Exchange Rates | 6 | 0 | 0.01 | 0.04 | 0.16 | 0.24 | 0.56 |
| Other | 2 | 0.02 | 0.15 | 0.15 | 0.21 | 0.41 | 0.42 |
| Mortality Rate | 1 | 0.03 | 0.09 | 0.11 | 0.11 | 0.11 | 0.13 |

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 1.

Table 3: Welfare Costs of the Great Recession by Age

| | Mortality | | | |
|---|---|---|---|---|
| | Exogenous | Endogenous | | |
| | (1) | (2) | (3) | (4) |
| Panel A. Starting age 35 | | | | |
| $\gamma = 1.5$ | 1.60 | 1.57 | 1.52 | 1.47 |
| $\gamma = 2$ | 1.62 | 1.60 | 1.56 | 1.51 |
| $\gamma = 2.5$ | 1.65 | 1.63 | 1.59 | 1.56 |
| Panel B. Starting age 45 | | | | |
| $\gamma = 1.5$ | 1.76 | 1.69 | 1.58 | 1.47 |
| $\gamma = 2$ | 1.79 | 1.73 | 1.63 | 1.54 |
| $\gamma = 2.5$ | 1.82 | 1.77 | 1.68 | 1.60 |
| Panel C. Starting age 55 | | | | |
| $\gamma = 1.5$ | 2.02 | 1.88 | 1.66 | 1.44 |
| $\gamma = 2$ | 2.05 | 1.93 | 1.73 | 1.54 |
| $\gamma = 2.5$ | 2.08 | 1.98 | 1.80 | 1.63 |
| Panel D. Starting age 65 | | | | |
| $\gamma = 1.5$ | 0.00 | -0.29 | -0.76 | -1.22 |
| $\gamma = 2$ | 0.00 | -0.26 | -0.68 | -1.09 |
| $\gamma = 2.5$ | -0.00 | -0.23 | -0.60 | -0.97 |
| VSLY | - | \$100k | \$250k | \$400k |

Notes: Table displays the welfare cost of recessions, based on equation (12), at various ages under exogenous and endogenous mortality, for various assumptions about risk aversion ($\gamma$) and the value of a statistical life year (VSLY) for 35 year-old individuals. 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 5-year duration of the Great Recession is considered, followed by a period without recessions until the end of life.

# A Break in Factor Loadings

Our baseline model assumes that factor loadings are constant over the 1959 - 2007 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 $\Lambda_m$ in 1984.[16]

We obtain factor-loadings similarly to equation (4) but allow for a break in factor-loadings in 1984, as indicated by equation (13) below:

$$m_t^{59-07} = \hat{\Lambda}_{1m}^{59-07} \hat{F}_t^{59-07} + \hat{\Lambda}_{2m}^{59-07} (\hat{F}_t^{59-07} * \mathbf{1}(Year_t \geq 1984)) \tag{13}$$

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 2008-2012 period similarly to equation (5):

$$\hat{m_t}^{08-12} = (\hat{\Lambda}_{1m}^{59-07} + \hat{\Lambda}_{2m}^{59-07}) \hat{F_t}^{08-12} \tag{14}$$

Figure A.2 displays results the predicted path of mortality relative to 2006Q1, calculated similarly to the main measure in Figure 4. We see that the model with breaks predicts a decrease in mortality of around 1 to 1.5 percent by 2008, a similar magnitude to the model without breaks, but predicts a milder shock in longer horizons.

# B Consumption Impacts based on Local Labor Market variation

Following Yagan, 2019 and Finkelstein et al., 2025, we leverage spatial variation in the economic severity of the Great Recession across the U.S. to estimate its impact on consumption. Specifically we estimate:

$$y_{st} = \beta_t [SHOCK_s * \mathbf{1}(Year_t)] + \alpha_c + \gamma_t + \epsilon_{st}, \tag{15}$$

where $y_{st}$ is log per-capita Personal Consumption Expenditure (PCE),[17] $SHOCK_s$ is a measure of the impact of the Great Recession on state $s$, $\mathbf{1}(Year_t)$ is an indicator for calendar year $t$, $\alpha_s$ and

[16] We choose 1984 as the break point following Stock and Watson (2012). Furthermore, data-driven approaches in the literature generally find factor-loadings breaks 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.

[17] This is the same data source as used in the main paper for the DFM.

$\gamma_t$ are state and year fixed effects, respectively, and $\epsilon_{st}$ is the error term. Following Yagan, 2019, we parameterize the impact of the Great Recession on state $s$ (i.e., $SHOCK_s$) as the percentage point change in state unemployment rate between 2007 and 2009. The coefficients of interest are the $\beta_t$'s; they measure impacts on the outcome $y_{st}$ in year $t$ across areas differentially impacted by the Great Recession. We omit the interaction with the shock variable in 2006 so that all $\beta_t$ coefficients are relative to 2006. Thus $\beta_t$ in equation (15) captures the percent change in per-capita PCE in state $s$ and year $t$ (relative to that state's 2006 PCE) associated with a one-percentage-point increase in the unemployment rate from 2007 to 2009 in that state.

Figure A.3 shows results from estimating equation (15), with coefficient $\beta_{2006}$ normalized to zero. Places harder hit by the recession experienced a decline in consumption that persisted until at least 2011, with coefficients indicating about a 1.61 percent (standard error = 0.27) decrease in yearly consumption in the 2010-2011 period per percentage point increase in unemployment between 2007 and 2009.[18] Given that the Great Recession increased average local area unemployment by 4.6 percentage points between 2007 and 2009, results suggest an average 7.4 percent decrease in consumption across states. This is quite similar to the DFM estimate of a 9 percent decline in consumption from the Great Recession by 2009 (see Figure 5), however while the DFM estimates indicate that consumption flattens out after that, the estimates in Figure A.3 suggest continued consumption declines.[19]

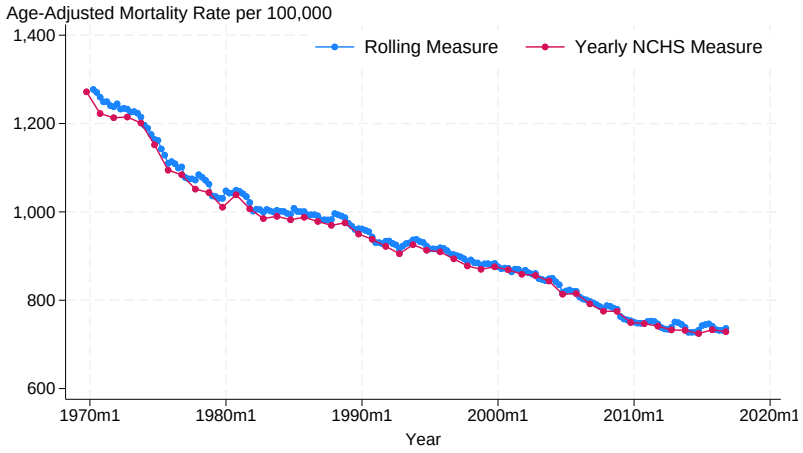
Overall, cross-regional evidence and time series evidence imply similar magnitudes of the effect of the Great Recession on consumption, suggesting little role for general equilibrium effects that shift the level of consumption in every state; in other words, there's no evidence of a large "missing intercept", which is consistent with the evidence by Wolf (2023) on stimulus checks.

[18] We restrict the sample to 2011 for consistency with the time-series analysis. We have also run a specification of the cross-regional regression until 2016 and found that consumption declines persisted until 2016.

[19] By contrast, we saw that the DFM estimates of mortality impacts suggested continued declines through 2011 whereas the estimates based on cross-sectional variation in the impact of the Great Recession suggested immediate and persistent declines in mortality.

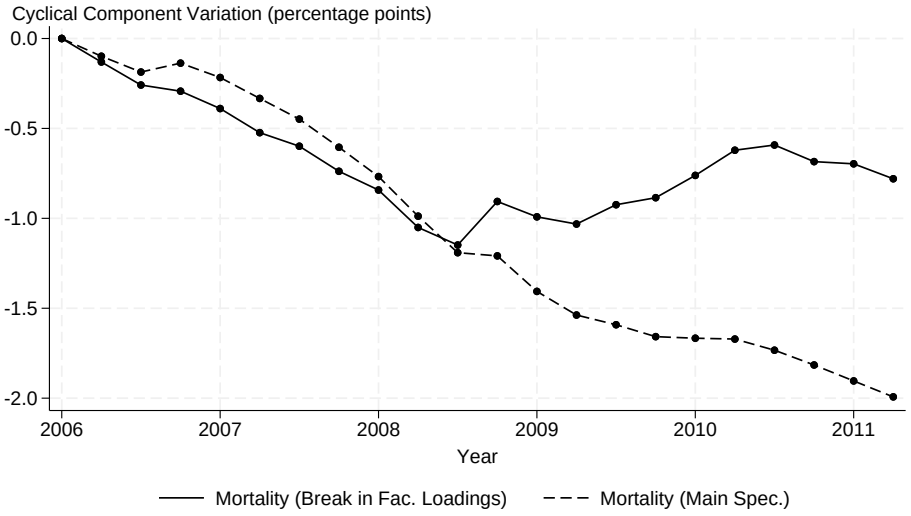
# C Appendix Figures and Tables

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




Notes: Quarterly measure represents the sum of the previous four-observations to create measure over past 12 months. Yearly data obtained from NCHS.

Figure A.2: Predicted Response of Mortality Cyclical Component around the Great Recession (relative to 2006Q1) – Version with Break in Mortality Factor Loadings



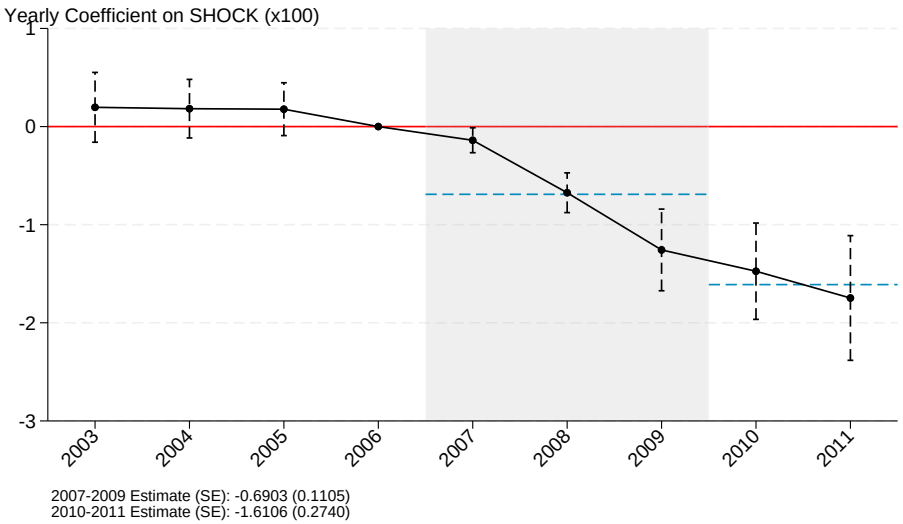

Notes: Figure displays the predicted response of the cyclical component of mortality, relative to 2006Q1 (2006Q1 component set to zero), given a time series of economic factors and factor loadings estimated by the DFM. Y-axis values represent the predicted level of the cyclical component relative to 2006Q1, which is defined as the cumulative sum of quarter-on-quarter changes in the cyclical component since 2006Q1 (as estimated by the DFM). Results for two mortality specifications are shown: mortality predicted with a break in factor loadings in 1984, as per equation (14) (solid line). Dashed line refers to the main mortality specification, as per Figure 4.

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

| | | | Computed over 15 quarters starting at indicated cyclical peak | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Series | 1959-2007Q3 | 1984-2007Q3 | 1960Q2 | 1969Q4 | 1973Q4 | 1980Q1 | 1981Q3 | 1990Q3 | 2001Q1 | 2007Q4 |
| GDP | 0.73 | 0.62 | 0.81 | 0.79 | 0.83 | 0.79 | 0.85 | 0.73 | 0.64 | 0.64 |
| Consumption (total) | 0.63 | 0.45 | 0.59 | 0.77 | 0.66 | 0.82 | 0.72 | 0.74 | 0.02 | 0.57 |
| Consumption (services) | 0.35 | 0.22 | 0.28 | 0.46 | -0.06 | 0.62 | 0.47 | 0.47 | -0.25 | 0.84 |
| Nonresidential fixed investment | 0.63 | 0.57 | 0.64 | 0.77 | 0.9 | 0.58 | 0.57 | 0.5 | 0.69 | 0.86 |
| Industrial production (total) | 0.87 | 0.79 | 0.9 | 0.86 | 0.94 | 0.93 | 0.94 | 0.89 | 0.76 | 0.95 |
| Industrial production (automobiles) | 0.58 | 0.29 | 0.59 | 0.61 | 0.7 | 0.64 | 0.39 | 0.66 | 0.13 | 0.57 |
| Nonfarm employment | 0.92 | 0.91 | 0.93 | 0.94 | 0.93 | 0.95 | 0.98 | 0.93 | 0.91 | 0.96 |
| Unemployment rate | 0.84 | 0.75 | 0.77 | 0.88 | 0.95 | 0.91 | 0.88 | 0.76 | 0.79 | 0.89 |
| Short-term unemployment rate | 0.82 | 0.7 | 0.81 | 0.87 | 0.9 | 0.88 | 0.84 | 0.81 | 0.75 | 0.78 |
| Long-term unemployment rate | 0.61 | 0.58 | 0.55 | 0.62 | 0.68 | 0.74 | 0.71 | 0.44 | 0.51 | 0.64 |
| Housing starts | 0.59 | 0.39 | 0.27 | 0.59 | 0.83 | 0.79 | 0.76 | 0.62 | 0.29 | 0.53 |
| OFHEO house price index | 0.49 | 0.44 | . | . | . | 0.59 | -0.01 | 0.6 | 0.42 | 0.57 |
| PCE inflation | 0.51 | 0.54 | 0.25 | 0.7 | 0.66 | 0.44 | 0.4 | 0.57 | 0.56 | 0.82 |
| PCE gas and energy inflation | 0.37 | 0.48 | -0.42 | -1.69 | -0.63 | 0.25 | 0.23 | 0.55 | 0.48 | 0.71 |
| Federal funds rate | 0.44 | 0.34 | -0.01 | 0.47 | 0.57 | 0.48 | 0.41 | 0.72 | 0.14 | -1.51 |
| Real monetary base | 0.16 | 0.09 | 0.18 | 0.39 | 0.22 | 0.65 | 0.59 | -0.18 | -0.35 | -0.03 |
| Real commercial and industrial loans | 0.44 | 0.54 | 0.48 | 0.47 | 0.55 | -1.42 | -1.07 | 0.7 | 0.62 | 0.46 |
| TED Spread | 0.54 | 0.02 | . | . | 0.78 | 0.74 | 0.7 | -0.05 | -0.04 | 0.76 |
| Gilchrist-Zakrajsek spread | 0.48 | 0.48 | . | . | 0.89 | 0.11 | 0.49 | 0.12 | 0.65 | . |
| S&P 500 | 0.72 | 0.69 | 0.75 | 0.68 | 0.89 | 0.62 | 0.65 | 0.37 | 0.81 | 0.89 |
| VIX | 0.47 | 0.5 | . | 0.38 | 0.74 | -0.78 | -0.69 | 0.4 | 0.75 | 0.89 |
| SLOOS lending standards | 0.6 | 0.18 | . | . | 0.65 | 0.79 | 0.67 | 0.55 | -1.49 | 0.47 |
| Household net worth–disposable income ratio | 0.16 | 0.14 | -0.18 | 0.67 | 0.48 | 0.78 | 0.06 | 0.28 | -0.46 | 0.51 |
| Household liabilities | 0.57 | 0.48 | -0.19 | 0.73 | 0.9 | 0.76 | 0.7 | 0.79 | 0.18 | 0.77 |
| Mortality Rate | 0.13 | 0.1 | . | 0.32 | 0.26 | -0.14 | 0.62 | -0.02 | -0.43 | 0.37 |

Notes: each column represents $R^2$'s of the common components for selected individual economic and mortality indicators, computed over two period sub-samples (1959-2007 and 1984-2007) and 15-quarter periods after each U.S. postwar cyclical peak. $R^2$ defined as per Table 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 the data section.

Figure A.3: Impact of Great Recession Unemployment Shock on Consumption




Notes: This figure displays the yearly coefficients $\beta_t$ from equation (15, where the outcome $y_{st}$ is log per-capita personal consumption expenditures (PCE), and $SHOCK_s$ 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% confidence intervals on each coefficient. N=51 states (plus DC).