**Finance and Economics Discussion Series**
**Divisions of Research & Statistics and Monetary Affairs**
**Federal Reserve Board, Washington, D.C.**

# How Well Did Social Security Mitigate the Effects of the Great Recession?

**William B. Peterman and Kamila Sommer**

**2014-13**

NOTE: Staff working papers in the Finance and Economics Discussion Series (FEDS) are preliminary materials circulated to stimulate discussion and critical comment. The analysis and conclusions set forth are those of the authors and do not indicate concurrence by other members of the research staff or the Board of Governors. References in publications to the Finance and Economics Discussion Series (other than acknowledgement) should be cleared with the author(s) to protect the tentative character of these papers.

# How Well Did Social Security Mitigate the Effects of the Great Recession?*

William B. Peterman
Federal Reserve Board of Governors†

Kamila Sommer
Federal Reserve Board of Governors‡

January 2014

**Abstract**

This paper quantifies the welfare implications of the U.S. Social Security program during the Great Recession. We find that the average welfare losses due to the Great Recession for agents alive at the time of the shock are notably smaller in an economy with Social Security relative to an economy without a Social Security program. Moreover, Social Security is particularly effective at mitigating the welfare losses for agents who are poorer, less productive, or older at the time of the shock. Importantly, in addition to mitigating the welfare losses for these potentially more vulnerable agents, we do not find any specific age, income, wealth or ability group for which Social Security substantially exacerbates the welfare consequences of the Great Recession. Taken as a whole, our results indicate that the U.S. Social Security program is particularly effective at providing insurance against business cycle episodes like the Great Recession.

JEL: E21, D91, H55
Key Words: Social Security, Recessions, Overlapping Generations.

*Views expressed in this paper are our own and do not reflect the view of the Federal Reserve System or its staff. For preliminary discussions and helpful comments, we thank Christopher Carroll, Jonathan Heathcote, Victor Rìos-Rull, and Vasia Panousi, as well as seminar participants at the Federal Reserve Board of Governors, the Federal Reserve Bank of San Francisco, The Federal Reserve Bank of Atlanta, University of California at Santa Cruz, and Georgetown University, and conference participants at Midwestern Macroeconomics, Computation in Economics and Finance, SED Annual Meetings, and Society of Government Economists Annual Meetings.

†20th and C Street NW, Washington DC 20551. Tel: 202-452-3703. E-mail: william.b.peterman@frb.gov.
‡20th and C Street NW, Washington DC 20551. Tel: 202-452-2909. E-mail: kamila.sommer@frb.gov.

# 1 Introduction

Designed in part to alleviate old age poverty in the wake of the Great Depression, Social Security aims to provide inter- and intra-generational consumption insurance for older-age individuals.[1] However, the insurance is not without costs: retirement benefits and payroll taxes distort agent's labor and savings decisions. Generally, previous studies found that the economic costs of the distortions dominate in the long run, leading Social Security to be on average welfare reducing.[2] Despite this well documented result, little is known about the welfare implications of Social Security for agents of different ages, incomes, wealth and abilities, especially at times of large adverse swings in economic activity. These periods are of particular interest because the need for the insurance as well as the effects of the distortions may be amplified. Moreover, the change in these effects may not be uniform across all agents. To help fill this gap, and motivated by the Great Recession, this paper examines the role that Social Security plays in mitigating or exacerbating the welfare consequences of large and broad-based shocks to wealth and unemployment for agents of different ages and economic backgrounds.

The paper starts by documenting two salient features of the Great Recession: a sudden, large and broad-based decline in household wealth, and persistent increases in the rate and duration of unemployment spells. First, using the 2007-2009 panel of the Survey of Consumer Finances, we show that between 2007 and 2009 the median level of household wealth declined by approximately 20 percent irrespective of household age, wealth, or income. Second, using the Current Population Survey micro data, we document that the Recession was associated with large increases in the unemployment rate and average duration of unemployment spells, with the increases being particularly large for younger and less educated households. These empirical facts motivate our choice to model the Great Recession as a one-time shock causing a twenty percent loss in household wealth, combined with increased likelihood and duration of unemployment spells that, similar to the data, persist over numerous years.

[1] In addition to insuring old age consumption, Social Security provides disability insurance. In this paper, we abstract from the disability insurance aspect of the program and focus only on the part of the program that insures post-retirement consumption.

[2] One exception is Imrohoroglu et al. (2003) who show that if preferences are time-inconsistent, then the benefits of Social Security may outweigh the costs.

Next, we quantify Social Security's role in mitigating or exacerbating the adverse effects of the Great Recession using a computational experiment conducted in four main steps. First, we build a benchmark Aiyagari-Bewley-Huggett-Imrohoroglu overlapping generations (OLG) life cycle model that is augmented to include both idiosyncratic productivity and unemployment risks, endogenous labor supply, endogenous retirement decision, and a realistically modeled U.S. Social Security program.[3] Second, we build a counterfactual economy that excludes the Social Security program. Third, in each model, we calculate the welfare lost (relative to their respective steady states) due to the exogenous wealth and unemployment shocks for agents alive at time of the shocks. Finally, in the spirit of differences-in-differences (DiD) estimation, we calculate the difference in welfare losses due to the shocks between the two economies for agents of varying ages, wealth, income and abilities. Comparing the welfare losses due to the wealth and unemployment shocks between the two economies identifies the role that Social Security plays in either mitigating or exacerbating the adverse effects of these shocks for agents of different ages and economic backgrounds.

Before examining the effect of Social Security on the welfare implications of the Great Recession, it is useful to revisit the long-run welfare effects of the program. Social Security increases welfare primarily by providing both inter- and intra-generational insurance. Conversely, the program reduces welfare by distorting agents' labor and savings decisions. In particular, the payroll tax makes it harder for younger and low-wage agents to earn enough after-tax income to both smooth consumption over their lifetime and to accumulate precautionary savings. Additionally, the program "crowds-out" private savings, thereby reducing the stock of aggregate capital available for production.[4] Similar to previous studies, we find that the economic costs of these distortions outweigh the insurance benefits in the steady state. We estimate that the program reduces ex-ante welfare by the equivalent of 7.5% of expected lifetime consumption (CEV). Moreover, through a combination of partial and general equilibrium analysis, we show that approximately two thirds of the estimated long-run

[3]In the benchmark economy, we follow a large literature in modeling the Social Security program as Pay As You Go (PAYGO). However, for added realism as well to increase understanding of our results, we relax the PAYGO assumption later in the paper and repeat our analysis in an environment where the payroll tax does not change dynamically along the transitional path in response to the aggregate shocks.

[4]In a PAYGO setting, the program re-directs what would otherwise be private savings in capital into retirement transfers. This result has been well documented in other studies discussed below.

welfare reduction arises from the direct distortionary effects of Social Security on agents' labor and savings decisions while the remaining one third is accounted for by the general equilibrium effects of these distortions.

Turning to the average effects of the program on welfare losses due to the Great Recession, we find that, on balance, Social Security mitigates the welfare losses induced by the wealth and unemployment shocks. In particular, we find that Social Security reduces the average welfare losses for agents alive at the time of the shock by the equivalent of 1.6% of expected future lifetime consumption. Social Security mitigates some of the average welfare losses due to the Great Recession primarily because it reduces the exposure of agents to the wealth shock. In the counterfactual model without Social Security, agents are completely exposed to this shock because all of their post-retirement consumption is financed with private savings. In contrast, in the benchmark economy agents are less vulnerable to this shock because their post-retirement consumption is partially financed with Social Security benefits which, unlike private savings, are unaffected by the shock.

Zooming in on the implications of Social Security on the welfare losses due to the Great Recession for agents of different ages, we find that Social Security is particularly effective at mitigating the welfare losses for agents who are older at the time of the shock. Older agents who are still working at the time of the shock have less time prior to their retirement to rebuild their wealth by increasing their labor supply relative to the younger individuals. This effect is enhanced even further for agents who are retired at the time of the shock and cannot offset any of the losses by working more. Moreover, due to the presence of increasing mortality risk, Social Security benefits comprise a growing portion of consumption for these retired agents as they age.[5] Therefore, the Social Security benefits play an increasingly important role providing insurance for these older agents during the Great Recession.

In contrast, we find that Social Security slightly exacerbates the welfare losses caused by the shocks for agents who are younger at time of the shock. The negligibly larger welfare losses for these younger agents arise from the presence of the payroll tax that is particularly distortionary during the economic downturn when incomes are depressed, budget constraints

[5]Optimizing, rational agents rely more heavily on the benefit as their age and their expected probability of survival decreases.

are tighter and unemployment risk rises.[6] Turning to the future generations, we find that Social Security has virtually no effect on welfare losses due to the shock for these agents who enter the economy after the shock occurs. Lastly, slicing the welfare effects by wealth, income and ability, we find that Social Security mitigates welfare losses due the Recession somewhat more for agents with lower lifetime incomes, wealth and abilities because Social Security makes up a relatively larger portion of their post-retirement consumption.[7]

Overall, we find that Social Security plays an economically significant role in reducing the welfare losses due to the Great Recession, especially for poorer agents, less productive agents, lower ability agents, and agents who are older at the time of the shock. Moreover, we do not find any specific age, income, wealth or ability group for which Social Security substantially exacerbates the welfare consequences of the Great Recession. The ability of Social Security to mitigate welfare losses for some of the most vulnerable demographic groups during this type of a business cycle episode, without significantly exacerbating the welfare consequences of the shock for other agents, indicates that this program is particularly effective at providing insurance against these episodes.

Nevertheless, welfare losses attributed to the program in the steady state are large. Therefore, we explore the ability of a scaled down program, with a potentially lower long-run welfare cost, to mitigate the welfare losses due to the Great Recession. In particular, we examine a counterfactual program (in the spirit of the Supplemental Security Income (SSI) program) that provides a smaller benefit than Social Security and is means-tested. Although we find that this smaller-scale program only mitigates the equivalent of 0.7% of expected future lifetime consumption for agents alive at the time of the shock (relative to 1.6% for the Social Security), the ex-ante welfare costs in the steady state are significantly reduced (1.2% versus 7.5% CEV).

Our work is related to three strands of the literature. The first strand focuses on the welfare consequences of the Great Recession. Most closely related to our work, Glover et al. (2012) and Hur (2013) who use a calibrated OLG model to quantify how welfare costs of

[6]Higher unemployment risk increases the need for precautionary savings and further tightens budgets of agents who experience an unemployment spell.

[7]This finding is particularly interesting since the program has been associated with a large reduction in elderly poverty rates over the last century (see Engelhardt and Gruber (2004)).

severe recessions, such as the Great Recession, are distributed across different age groups. This paper advances this research agenda by not just focusing on the welfare effects of the shock but also by exploring how effective the Social Security program is at mitigating these effects across different cohorts.

The second strand tries to measure the long-run implications on welfare of a Social Security program. These works try to weigh the relative benefit from providing partial insurance against risks for which no market option exists against the welfare costs of distorting an individual's incentives to work and save. These studies, that largely focus on quantifying the benefit of providing intra-generational insurance for idiosyncratic earnings and mortality risks, include Auerbach and Kotlikoff (1987), Hubbard and Judd (1987), Hubbard (1988), Imrohoroglu et al. (1995), Fuster et al. (2007), Storesletten et al. (1998), and Hong and Rìos-Rull (2007).[8] Moreover, Krueger and Kubler (2006) examine the welfare implications of Social Security in a steady-state model with a moderate level of aggregate risk, designed to weigh the inter-generational insurance benefits from Social Security against the program's economic costs. By and large, the studies find that Social Security is not welfare improving: the insurance benefits from Social Security are outweighed by the distortions that the program imposes.[9] Similar to these papers, we aim to examine the welfare consequences of the current Social Security program. However, our study is different in that it focuses on the welfare implications of the Social Security program over the transitional period after a large shock, as opposed to focusing on the long-run welfare effects of the program.

The final strand of the literature examines the effect on the economy of reforming the current Social Security program. Examples of these studies include: Olovsson (2010), Imrohoroglu and Kitao (2012), Kitao (2012), Huggett and Parra (2010), and Huggett and Ventura (1999). Amongst these papers, Olovsson (2010) examines the welfare gains of a Social Security program that efficiently shares aggregate risks between generations. The author finds that although agents would prefer to be born into these more efficient programs, the welfare costs during the transition outweigh the benefits for living agents. In the spirit of Olovs-

[8]For a theoretical discussion of the different types of risks that Social Security can provide insurance against see Shiller (1998).

[9]One exception is Imrohoroglu et al. (2003), which find that if preferences are time-inconsistent then the benefits of Social Security outweigh the costs.

son (2010), we solve and document the welfare effects on all the living individuals during a transitional period. However, instead of exploring the dynamics along the transitional path after a reform of the Social Security program, this paper studies how the economy evolves during a particular business cycle episode.

This paper is organized as follows: Section 2 discusses the empirical data surrounding wealth and unemployment during the Great Recession while Section 3 introduces the computational model. Section 4 presents the competitive equilibrium. Section 5 describes the functional forms and calibration parameters. Section 6 reports the results of the computational experiment. Section 7 concludes.

# 2 Changes in Wealth and Unemployment during the Great Recession

This section examines two different channels by which the Great Recession affected households. In particular, we explore how household wealth and unemployment evolved over this recent business cycle episode.

## 2.1 Changes in Household Wealth

We first examine the composition of the household balance sheet in 2007 and the change in households' wealth from 2007 to 2009 using both the 2007 wave and 2007-2009 panel of the Survey of Consumer Finance (SCF). Over the Great Recession, there was a large fall in both stock prices and home values. For example, the Dow Jones Industrial declined approximately thirty percent over 2007 and 2008. Over the same period, the Case-Shiller Nation Home Price Index declined a similar amount. Given the large declines in the stock and home values, it is of interest to determine the exposure of households to the decreases in these assets' prices as of 2007.

The second and third column of Table 1 illustrate that household wealth in the 2007 SCF, regardless of age, was notably exposed to changes in house prices and stock values. Over the life cycle, more than 45 percent of household net worth was, on average, invested

either in stock or residential housing equity after the age of 25. Even though the percentage invested in these asset classes was slightly lower for younger households, stocks and housing still represented a large fraction of these households' net worth. Focusing on financial assets only (column I), the fraction of household financial assets directly held in stocks was even larger, fluctuating in a steady range between one half and two thirds over the life cycle. Furthermore, a similar portfolio allocation pattern was present with regard to the liquid retirement wealth (column IV): between one half and two thirds of retirement funds were directly invested in the stock market.[10] Taken together, these findings suggest that household funds explicitly allocated to post-retirement consumption were considerably exposed to the stock and home price declines associated with the Great Recession.

Table 1: **Allocation of Wealth in 2007 SCF**

| Age | Fraction of Financial Assets Invested in Stocks | Fraction of Net Worth Invested in Stocks or in Residential Housing Equity | Fraction of Net Worth Invested in Stocks or in Housing Equity | Fraction of IRA/Thrift/Keogh Invested in Stocks | Fraction of Liquid Retirement Wealth Invested in IRA/Thrift/Keogh |
|---|---|---|---|---|---|
| 20-24 | 0.15 | 0.33 | 0.44 | 0.54 | 0.98 |
| 25-29 | 0.54 | 0.62 | 0.67 | 0.56 | 0.94 |
| 30-34 | 0.51 | 0.45 | 0.48 | 0.59 | 0.95 |
| 35-39 | 0.67 | 0.58 | 0.59 | 0.6 | 0.94 |
| 40-44 | 0.55 | 0.54 | 0.57 | 0.56 | 0.97 |
| 45-49 | 0.56 | 0.44 | 0.49 | 0.53 | 0.94 |
| 50-54 | 0.58 | 0.56 | 0.58 | 0.51 | 0.94 |
| 55-59 | 0.54 | 0.50 | 0.57 | 0.53 | 0.94 |
| 60-64 | 0.55 | 0.52 | 0.57 | 0.50 | 0.91 |
| 65-69 | 0.52 | 0.53 | 0.56 | 0.51 | 0.91 |
| $> 70$ | 0.55 | 0.56 | 0.63 | 0.46 | 0.84 |

**Note:** Total housing equity includes residential and non-residential housing equity. Retirement wealth is defined as the amount of household wealth invested in IRA, Thrift and Keogh.

Next, we determine whether the large concentration of household net worth in these asset classes translated into widespread losses in wealth across different age, wealth and income groups. Between 2007 and 2009, the median household wealth declined by 21.5%.[11] Table 2 describes the median change in household wealth for different age, wealth, and income groups. Consistent with the findings in Bricker et al. (2011), we find that the losses were widespread and of similar magnitude across the groups.[12]

[10] On average, over 90 percent of household retirement wealth (i.e., IRA, Thrift and Keogh) is concentrated in private savings accounts (401K, IRA and Keogh) in the SCF 2007.

[11] The estimates are based on the data from the 2007-2009 SCF panel.

[12] Although the wealth shock associated with the Great Recession did not affect everyone in the same way, Bricker et al. (2011) finds that almost two thirds of families experienced a loss of wealth between 2007

Table 2: **Median Change of Wealth in SCF 2007-2009 Panel**

| Age of Head | | Percentile of Wealth | | Percentile of Total Income | |
|---|---|---|---|---|---|
| $< 35$ | -34% | $< 10$ | -65% | $< 10$ | -24% |
| $35 - 45$ | -28% | $10 - 25$ | -42% | $10 - 25$ | -26% |
| $45 - 55$ | -21% | $25 - 50$ | -18% | $25 - 50$ | -25% |
| $55 - 65$ | -16% | $50 - 75$ | -17% | $50 - 75$ | -20% |
| $65 - 75$ | -15% | $75 - 90$ | -21% | $75 - 90$ | -19% |
| $> 75$ | -22% | $90 - 100$ | -23% | $90 - 100$ | -18% |

**Note:** Table captures 2007-2009 change in household net worth by the household head's age and the percentiles in the household wealth and income distribution as of 2007.

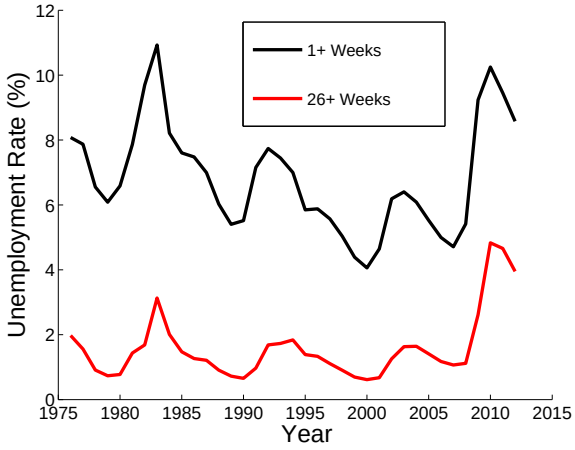
Given these findings, we choose to model the wealth shock associated with the Great Recession as a one-time unexpected, uniform 20% decline in household wealth. This approach requires three implicit assumptions. The first two assumptions (that the shock was uniform and caused a roughly 20% decline in wealth) are supported by the findings in Tables 1 and 2. We choose to make the last assumption (that the shock was unexpected) for two reasons. First, both popular press reports and survey evidence at the time of the shock point to a general belief that house prices would not fall. For example, in surveys of home buyers in four metropolitan areas in 2003, Case and Shiller (2004) find that less than fifteen percent of respondents thought buying a home involved a great deal of risk. Furthermore, at the time of the survey, between 83 and 95 percent of respondents believed that house prices would increase over the next several years.[13] As Table 1 depicts, on average, a large fraction of households' balance sheet was invested in housing equity. Second, we choose to model the shock as unexpected because, due to the Great Moderation, there was a belief that the risk of severe economic downturns was significantly reduced. For example, in his 2003 presidential address to the American Economic Association, Robert Lucas stated that the "central problem of depression-prevention has been solved."[14] These beliefs could have led many to believe that although investing in stocks still carried downside risk, there was

and 2009. Controlling for losses by income and age, the authors find that the median decline in wealth was between 15% and 25%.

[13]For examples of popular press reports, see "Housing Prices Always Rise" in the Washington Post's series on the worst ideas of the decade published on December 17th, 2009, by Greg Ip. The author notes that, prior to the Great Recession, generally both homeowners and investors were operating under the belief that home prices would never fall.

[14]For more discussion of the state of economics prior to the Great Recession see Paul Krugman's Op-Ed piece in the New York Times entitled "How Did Economists Get It So Wrong?," in September 2nd, 2009.

Figure 1: **Unemployment Rates by Year**




**Note:** Based on the March Supplement CPS data.

minimal risk of a widespread, severe decline in prices.

Although we model the shock as unexpected, we do not take the stance that after the Great Moderation economists or the general public thought the business cycle was over. Instead, we believe that these assumptions are consistent with a general belief that severe shocks, such as the one associated with the Great Recession, were generally outside the feasible set.[15]

## 2.2 Changes in Long-term Unemployment Risk

Next, using the Current Population Survey (CPS), we examine how unemployment changed over the Great Recession.[16] The Great Recession is associated with a large increase in unemployment and an extension of the average unemployment duration. As Figure 1 shows, the U.S. unemployment rate roughly doubled from 5 to 10 percent between March 2006 and March 2010.[17] At the same time, the fraction of the labor force that was unemployed 26 plus weeks in a given year increased by 4 percentage points, respectively, while the median length of unemployment in a given year rose from 13 to 21 weeks over the same period.[18]

[15] Another interpretation of our assumption is that households were not generally holding savings in order to buffer against large catastrophic shocks. Instead, their precautionary savings were primarily held to buffer against mild business cycle fluctuations and idiosyncratic earnings fluctuations.

[16] We use the CPS March Supplement files publically available through the IPUMS CPS website.

[17] For the official Bureau of Labor Statistics (BLS) estimates, see http://data.bls.gov/pdq/SurveyOutputServlet.

[18] Moreover, the fraction of workers in the U.S. unemployed for longer than 26 consecutive weeks rose from about 15 percent in 2006 to well over 40 percent by 2010 (see *The 2013 Long-Term Budget Outlook* (2013)).

Table 3: **Unemployment Rate (by Age and Education)**

| | 2005-2006 | | 2009-2010 | |
|---|---|---|---|---|
| **Age** | **Low Education** | **High Education** | **Low Education** | **High Education** |
| 20-45 | 8.06 | 3.70 | 15.95 | 7.05 |
| $> 45$ | 4.46 | 2.78 | 10.04 | 5.82 |

**Note:** Based on the March Supplement CPS data. High education individuals have at least some college.

Tables 3 and 4 depict the average unemployment rates and duration by age and education in both 2005-2006 and 2009-2010 CPS data. We define highly educated individuals as those who have at least some additional education following the high school graduation. Table 3 documents that both the level and the magnitude of the increase in the unemployment rate have varied with respondents' age and educational attainment. In particular, young, low-education individuals experienced the highest odds of unemployment in the pre-Recession data and also observed the largest percentage point increase in unemployment rates during the Great Recession. In contrast, the increases in the average unemployment duration were relatively constant by age and education. The average unemployment duration in a given year increased by roughly 7 weeks across ages and education groups. Taken together, we choose to model the unemployment shock associated with the Great Recession as an increase in both the frequency and duration of the exogenous unemployment spells over their long-run levels (see Section 5.4 for details).

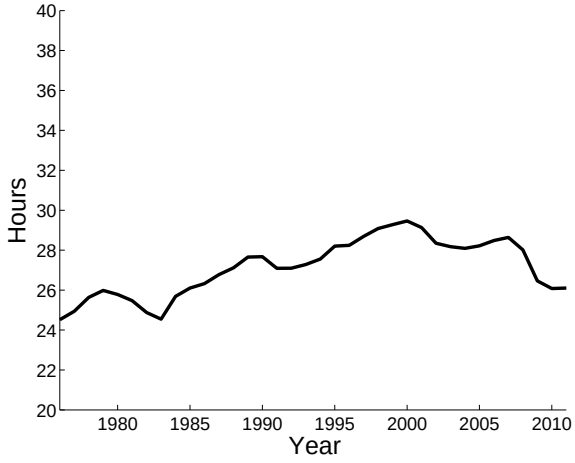
Table 4: **Average Duration of Unemployment Spell (Weeks)**

| | 2005-2006 | | 2009-2010 | |
|---|---|---|---|---|
| **Age** | **Low Education** | **High Education** | **Low Education** | **High Education** |
| 20-45 | 18.7 | 17.9 | 25.2 | 24.2 |
| $> 45$ | 23.2 | 24.2 | 31.1 | 31.6 |

**Note:** Based on the March Supplement CPS data. High education individuals have at least some college.

Modeling the labor shock through unemployment spells may not capture all changes in aggregate hours worked per working-age population during the Great Recession. Figure 2 plots the evolution of the aggregate hours worked in the economy (defined here as the total hours worked normalized by the total population between ages 20 and 69) since 1976. As can be seen in the figure, despite a general downward trend after 2000, the average hours

Figure 2: **Aggregate Hours Worked per Working-Age Population**




dropped considerably starting in 2008.[19] Theoretically, the observed decline in average hours could be attributed to (i) an increase in unemployment (either due to the changes in the frequency or duration), (ii) a decrease in labor force participation, or (iii) workers working fewer hours (intensive margin). Since we only incorporate the first channel into our model, it is of interest to determine the relative size of each of these potential channels.

The first column of table 5 describes the percentage point deviation, accounting for the general trend, in aggregate hours after 2007.[20] Furthermore, the second through fourth columns decompose the deviations into the three possible sources of the overall change. The table depicts that aggregate hours decreased a bit in 2008 and then declined much more from 2009 to 2011. Overall, the smaller change in aggregate hours in 2008 can be primarily explained by fluctuations on the intensive margin. Moreover, a majority of the larger declines in aggregate hours from 2009-2011 can be explained by changes in unemployment. Since our model only incorporates changes in unemployment, our model will have a difficult time matching the total fluctuations in hours during the early periods of the Great Recession when the other channels (i.e., changes in participation and changes in hours on the intensive margin) played a large role in affecting aggregate hours worked.

[19] As opposed to a general downward trend explaining the post-2000 decline in aggregate hours, an alternative explanation is the combination of the effects of the two recessions since 2000.

[20] The trend growth of aggregate hours was calculated as the average growth rate from 1997 through 2005.

Table 5: **Decomposition of the Changes in Aggregate Hours**

| Year | % Deviation in Agg. Hours | % Due to Intensive | % Due to Unemployment | % Due to Participation |
|---|---|---|---|---|
| 2008 | -2.2% | 53% | 31% | 16% |
| 2009 | -7.6% | 29% | 59% | 12% |
| 2010 | -8.9% | 24% | 62% | 14% |
| 2011 | -8.8% | 21% | 53% | 26% |

# 3 Model

Our framework is an Aiyagari-Bewley-Huggett-Imrohoroglu economy with overlapping generations of heterogenous agents. Agents derive utility from consumption and leisure. Agents supply labor elastically and receive an idiosyncratic uninsurable stream of earnings that is governed by their labor decisions, productivity shocks, and the dynamics of the market efficiency wage. Agents make joint decisions about their consumption, labor supply and savings. Idiosyncratic productivity shocks can be partially insured through precautionary holdings of a single asset in the economy and through labor supply decisions. Retired agents receive retirement benefits payments from a PAYGO Social Security system that is funded through income taxation of working-age individuals. Social Security payments provides another margin of consumption insurance at old age. An important feature of this model is that agents choose the age at which they retire, taking into consideration realistic features of the U.S. Social Security program such as progressive benefit payments that are is related to an agent's past earnings history, early retirement penalties, and delayed retirement credits.

## 3.1 Demographics

Time is assumed to be discrete, and the model period is equal to one year. In each period, the economy is populated by $J$ overlapping generations of individuals of ages $j = 20, 21, ..., J$, with $J$ being the maximum possible age an agent can live. The size of each new cohort grows at a constant rate $n$. Lifetime length is uncertain with mortality risk rising over the lifetime. The conditional survival probability from age $j$ to age $j+1$ is denoted $\Psi_j$ where $\Psi_J = 0$. Annuity markets do not exists to insure life-span uncertainty and agents are assumed to

have no bequest motive. In the spirit of Conesa et al. (2009), accidental bequests, which arise from the presence of mortality risk, are distributed equally amongst the living in the form of transfers $Tr_t$.

Agents work until they choose to retire at an endogenously determined age $j = R$. Endogenous retirement is an important extension of many existing models used to study the Social Security program. In the model, upon reaching the minimum retirement age $j = \underline{R}$, an agent chooses every period whether to retire or not. We assume that the binary decision to retire (i.e., $I = \{0, 1\}$ where $I = 1$ denotes the event of retirement) is irreversible, making retirement a self-absorbing state.[21]

## 3.2 Endowments, Preferences and Unemployment Risk

Each period $t$, an agent is endowed with one unit of time that can be used for leisure or market work. An agent's labor earnings are given by $y_t = w_t \omega_t h_t (1 - D_t)$, where $w_t$ represents a wage rate per efficiency unit of labor, $h_t$ is the fraction of the time endowment spent on labor market activities, $D_t$ is the fraction of the time endowment in each period that the agent is exogenously unemployed, and $\omega_t$ is the idiosyncratic labor productivity which follows:

$$\log \omega_t = \theta_j + \alpha + \nu_t + \epsilon_t. \tag{1}$$

In this specification, based on the estimates in Kaplan (2012) from the Panel Study of Income Dynamics (PSID), $\theta_j$ governs the average age-profile of wages (or age-specific human capital), $\alpha \sim NID(0, \sigma_\alpha^2)$ is an individual-specific fixed effect (or ability) that is observed at birth and stays fixed for an agent over the life cycle, $\epsilon_t \sim NID(0, \sigma_\epsilon^2)$ is a transitory shock to productivity received every period, and $\nu_t$ is a persistent shock, also received each period, which follows a first-order autoregressive process:

$$\nu_t = \rho \nu_{t-1} + \psi_t \text{ with } \psi_t \sim NID(0, \sigma_\nu^2) \text{ and } \nu_1 = 0. \tag{2}$$

[21] Cahill et al. (2011) demonstrate that few people who retire re-enter the labor force. Furthermore, Coile and Levine (2006) find that the boom and bust cycle of the stock market in 2001 did not have a statistically significant effect on the rate of re-entry of retirees back into the labor force.

Additionally, the exogenous unemployment shock, $D_j$, is discretized to two values, zero and $d_{a,j} \in [0,1]$. The positive value $d_{a,j}$ arrives with a probability $p^U(\alpha, j)$ which is a function of an agent's ability $\alpha$ and age $j$.[22] When the unemployment spell hits, the worker loses the option to work during a fraction $(d_{a,j})$ of their time endowment and receives an unemployment insurance benefit with a replacement rate $\iota$.[23]

Agent's preferences over the stream of consumption, $c$, and labor supply, $h$, over the life cycle are governed by a time-separable utility function:

$$E_0 \sum_{j=0}^{J} \beta^j U(c_j, h_j), \tag{3}$$

where $\beta$ is the discount factor and where the expectation is taken with respect to the life-span uncertainty, the idiosyncratic labor productivity process, and the unemployment process. The period utility function, $U(c_j, h_j)$, is modeled as the weighted average of the utility from the sub-period in which an agent is employed and the sub-period in which the agent is unemployed:

$$U(c_j, h_j) = (1 - D_j)u(c_j, h_j) + D_j u(c_j, 0).^{24} \tag{4}$$

Modeling the per-period utility function as the weighted average of the utility flows from the two sub-periods allows us to pick a relatively longer, computationally more tractable model period (one year), but still incorporate unemployment spells that are shorter than one year. We make the additional assumption that consumption is constant across the full year period. Since we use a utility function that is separable in consumption and hours worked, the constant consumption assumption is not binding as long as the agent realizes $D_j$ at the beginning of the period and agents are able to ease intra-period liquidity constraints by borrowing between two subperiods that are within the same year.

[22] As documented in Section 2.2, both age and ability (for which we use education attainment as a proxy) are important determinants of unemployment risk in the data.

[23] Unemployment benefits are not tied to an agent's earnings but instead replace a $\iota$ percent of the average annual labor earnings in the economy.

[24] It is assumed that $c_j$, the flow of consumption, is equal in each of the sub-periods.

## 3.3 Market Structure

The markets are incomplete and agents cannot fully insure against the idiosyncratic labor productivity, unemployment, and mortality risks by trading state-contingent assets. They can, however, partially self-insure these risks by accumulating precautionary asset holdings, $a_t$. The stock of assets earns a market return $r_t$. We assume that agents enter the economy with no assets and are not allowed to borrow against future income, so that $a_0 = 0$ and $a_t \geq 0$ for all $t$.

## 3.4 Technology

Firms are perfectly competitive with constant returns to scale production technology. Aggregate technology is represented by a Cobb-Douglas production function of the form $Y = F(K, N) = K^{\zeta} N^{(1-\zeta)}$, where $K$ and $N$ are aggregate capital and labor (measured in efficiency units) and $\zeta$ is the capital share of output. Capital depreciates at a constant rate $\delta \in (0, 1)$. The firms rent capital and hire labor from agents in competitive markets, where factor prices $r_t$ and $w_t$ are equated to their marginal productivity. The aggregate resource constraint is:

$$C_t + K_{t+1} - (1 - \delta)K_t + G_t \leq K_t^{\zeta} N_t^{1-\zeta}, \tag{5}$$

where, in addition to the above described variables, $C_t$ and $G_t$ represent aggregate individual and government consumption, respectively.

## 3.5 Government Policy

The government partakes in four activities. First, the government distributes accidental bequests of the deceased agents in a form of lump-sum transfers, $Tr_t$, to the living.[25] Second, the government collects a proportional Social Security tax, $\tau_t^{ss}$, on pre-tax labor income of working-age individuals (up to an allowable taxable maximum $\overline{y}$) to finance Social Security payments, $b_t^{ss}$, for retired workers (for details, see Section 3.6). Third, the government

[25] By the timing convention, agents realize at the beginning of the period whether they die. Subsequently, the transfers are received at the beginning of the period before agent's idiosyncratic labor productivity status is revealed.

distributes the unemployment benefits, $b^{\text{ui}}$, to agents who are exogenously separated. These benefits are a function of the average income across all agents in the economy and are not related to agents' idiosyncratic earnings histories. Fourth, the government consumes in an unproductive sector. Following Conesa et al. (2009), Kitao (2012) and Imrohoroglu et al. (1995), the government consumption, $G_t$, is exogenously determined, and is modeled as proportional to the total output in the steady state economy, so that $G_t = \phi Y_t$. The government uses income tax revenue to finance its spending in the unproductive sector and on unemployment benefits. In the spirit of many studies including Conesa and Krueger (2006), the government taxes each individual's taxable income according to a progressive income tax schedule. The taxable income, $T(\tilde{y}_t)$, is defined as:

$$\tilde{y}_t = y_t + r_t(Tr_t + a_t) - 0.5\tau_t^{ss} \min\{y_t, \overline{y_t}\}, \tag{6}$$

where, as is the case under the current U.S. tax law, the part of the pre-tax labor income ($y_t$) that is accounted for by the employer's contributions to Social Security ($0.5\tau_t^{ss} \min\{y_t, \overline{y_t}\}$) is not taxable.

## 3.6 Social Security

We model the Social Security system to mimic the U.S. system. In the U.S., Social Security benefits for retired workers are based on each worker's average level of earnings calculated over the highest 35 years of earnings.[26] A baseline benefit formula is then applied to each worker's average level of labor earnings to calculate the pre-adjustment Social Security benefit.[27] The benefit formula is designed to ensure that the Social Security system is progressive, with the replacement rate being inversely related to past earnings. In particular, the marginal replacement rate changes when earnings reach two different bend points which jointly determine the degree of progressivity of the Social Security benefits. The third (implicit) bend point is the cutoff on Social Security benefits and contributions. The cutoff limits not only

[26]These earnings are expressed as workers' average indexed monthly earnings (AIME).

[27]The monthly Social Security benefit is called primary insurance amount (PIA). Once annualized, the PIA corresponds to the model baseline retirement benefit $b_{base}^{ss}$. In general, the PIA is the benefit a person would receive if she elects to begin receiving retirement benefits at her normal retirement age (NRA).

the annual amount of earnings subject to payroll taxation but also the maximum earnings used to calculate the Social Security benefits. Finally, the Social Security system makes various adjustments to the baseline benefit amount depending on the retirement age, such as permanent percentage reductions for early retirement and permanent percentage credits for retirement past the normal retirement age (NRA).[28]

To model these features of the U.S. Social Security system, we proceed in three steps. First, following Huggett and Parra (2010) and Kitao (2012), we calculate the model analog of each worker's average level of labor earnings over the working life cycle. At every age, the total accumulated earnings follow the law of motion:

$$x_{j+1} = \begin{cases} \frac{\min\{y_j, \overline{y}\} + (j-1)x_j}{j} & \text{if} \quad j \leq 35, \\ \max\{x_j, \frac{\min\{y_j, \overline{y}\} + (j-1)x_j}{j}\} & \text{if} \quad 35 < j < R, \\ x_j & \text{if} \quad j \geq R, \end{cases} \tag{7}$$

where $x_j$ is the accounting variable capturing the equally-weighted average of earnings before the retirement age $R$; and $\overline{y}$ is the maximum allowable level of labor earnings subject to the Social Security tax that corresponds to the benefit-contribution cap. Moreover, to infuse an additional degree of realism while maintaining the model's tractability, we extend on the specification in Huggett and Parra (2010) by introducing a rule to ensure that the total accumulated labor earnings, $x_j$, accrued over the working life cycle and used in the benefit calculation cannot fall below their previously realized level, $x_{j-1}$, after 35 working periods.[29] Moreover, since agents are not allowed to work during their retirement, which is assumed to be a self-absorbing state, $x_j$ becomes constant at $j = R$.

Second, the pre-adjustment Social Security benefit, $b^{ss}_{base}$, for each retiree is calculated using a convex, piecewise-linear function of average past earnings observed at retirement

[28]Under the current law, the age at which a worker becomes eligible for full Social Security retirement benefits – the NRA – depends on the worker's year of birth. For people born before 1938, the NRA is 65. For slightly younger workers, it increases by two months per birth year, reaching 66 for people born in 1943. The NRA remains at 66 for workers born between 1944 and 1954 and then begins to increase in two-month increments again, reaching 67 for workers born in 1960 or later.

[29]Computing the Social Security benefit over the highest 35 years of earnings would render the model intractable, as it would require tracking each period's earnings as part of the model's state space.

age, $x_R$, so that the marginal benefit rate varies over three levels of taxable income:

$$\begin{aligned} &\tau_{r1} \quad \text{for} \quad 0 \leq x_R < b_1 \\ &\tau_{r2} \quad \text{for} \quad b_1 \leq x_R < b_2 \\ &\tau_{r3} \quad \text{for} \quad b_2 \leq x_R < b_3, \end{aligned} \tag{8}$$

where $\{b_1, b_2, b_3 = \overline{y}\}$ are the two bend points plus the benefit-contribution cut-off point, and where $\tau_{r1}, \tau_{r2}, \tau_{r3}$ represent the marginal replacement rates in the progressive Social Security payment schedule associated with the respective bend points.

Third, adjustments for early and late retirement are calculated. In the U.S., workers can begin receiving permanently reduced monthly retirement benefits after reaching the minimum retirement age, $\underline{R}$.[30] The size of the reduction varies with the months out of labor force between the time at which worker retired and her NRA.[31] Conversely, when an individual retires after reaching the NRA, the Social Security benefit payments are increased by a fixed permanent proportion for every year spent working between the NRA and the maximum retirement age, $\overline{R}$, for which the credit is available.[32] As a result, the total Social Security benefit $b^{ss}$ obtained by the retiree is defined as:

$$b^{ss} = \begin{cases} (1 - n\kappa_1(n))b^{ss}_{base} & \text{if} \quad \underline{R} \leq R < NRA \\ (1 - n\kappa_2(n))b^{ss}_{base} & \text{if} \quad NRA \leq R < \overline{R}, \end{cases} \tag{9}$$

where $n = (NRA - R)$ represents the years of early (delayed) retirement over which the penalty (credit) is accrued; and where $\kappa_1(n)$ and $\kappa_2(n)$ represent functions of yearly rates for early (delayed) retirement penalty (credit), respectively.

[30] In the U.S., the minimum retirement age at which Social Security benefits become available is set at 62. In the data, more than two-thirds of the workers began receiving Social Security retirement benefits before their normal retirement age. The majority of those early recipients began collecting benefits at age 62. Source: Social Security Administration, Annual Statistical Supplement, 2000, p. 240.

[31] A benefit is reduced 5/9 of one percent for each month before normal retirement age, up to 36 months. If the number of months exceeds 36, then the benefit is further reduced 5/12 of one percent per month.

[32] The delayed benefit retirement credit varies with year of birth, but reaches currently is 2/3 of 1 percent of the benefit for every month delayed (or 8 percent annualized) for individuals born after 1942. No credit is given after age 69. See Pingle (2006) for more details.

## 3.7 Timing Convention

At the beginning of the period, uncertainty about early death is revealed to all agents. The living agents receive transfers from accidental bequests and observe their retirement status from the previous period. Agents that previously retired receive the Social Security benefit and interest on their accumulated asset holdings, pay off their tax liabilities and make their consumption-saving decision. For agents that have not retired in previous periods, the labor productivity status and the unemployment shock are revealed. Agents eligible for retirement then determine whether to retire or work. Working agents supply labor and capital to the firm and production takes place. Next, the working agents receive factor income, pay off their tax liabilities, and make their consumption-saving decision. If an agent chooses to retire then the agent receives Social Security benefit and makes consumption-savings decision.

## 3.8 Dynamic Program of a Previously Working Agent

An agent who was working in the previous period and is indexed by type $(a_t, x_t, \alpha, \epsilon_t, \nu_t, j, D)$ solves the dynamic program:

$$V_t(a,x,\alpha,\epsilon,\nu,j,d) = \begin{cases} \max_{c,a',x',h} U(c,h) + \beta s_j EV_{t+1}(a',x',\alpha,\epsilon',\nu',j+1,D') & \text{if} \quad j \leq \underline{R}, \\ \max_{c,a',x',h,I=\{0,1\}} U(c,h) + \beta s_j EV_{t+1}(a',x',\alpha,\epsilon',\nu',j+1,D') & \text{if} \quad \underline{R} < j \leq \overline{R}, \end{cases} \tag{10}$$

subject to

$$\begin{aligned} c + a' &= (1+r)(Tr+a) + y - T(\tilde{y}) - \tau^{ss}\min\{y,\overline{y}\} + Db^{\text{ui}} \quad \text{if} \quad I=0, \\ c + a' &= (1+r)(Tr+a) - T(\tilde{y}) + b^{ss} \qquad\qquad\qquad\qquad\quad \text{if} \quad I=1. \end{aligned} \tag{11}$$

by choosing consumption, $c$, savings, $a'$, time spent working, $h$, and whether to retire, $I \in \{0,1\}$. The accounting variable $x$ is the average lifetime labor earnings as of period $t$ and follows the law of motion specified in equation 7. Agents earn interest income $r(Tr+a)$ on the lump-sum transfer, $Tr$, from accidental bequests and on asset holdings from the previous period, $a$. $y$ represents the pre-tax labor income of the working agents and is described in Section 3.2. $\tilde{y}$ defines the taxable income on which the income tax, $T$, is paid, and follows the process in equation 6. $D$ is the state variable for the fraction amount of

time an agent is exogenously unemployed while $b^{\text{ui}}$ represents the exogenously determined unemployment benefits. Finally, $\tau^{ss}$ is the Social Security tax rate that is applied to the pre-tax labor income, $y$, up to an allowable taxable maximum, $\overline{y}$. As in the U.S. system, agents of age $j < \underline{R}$ are not eligible for Social Security benefits and, as such, are not allowed the decision to permanently retire.[33] Upon reaching the minimum retirement age, agents make a permanent decision to retire, with $I = 1$ describing the event of retirement ($I = 0$ otherwise). Finally, agents are forced into a mandatory retirement after reaching age $\overline{R}$.

### 3.9 Dynamic Program of a Previously Retired Agent

Upon reaching the minimum retirement age $\underline{R}$, agents are allowed to retire permanently. Retired agents receive a constant stream of Social Security payments whose size is determined by the level of the average life cycle labor earnings observed at the retirement period, $x_R$, and the age they choose to retire. Retired agents are no longer affected by labor productivity shocks because they cannot longer work. As such, a retired agents indexed by type $(a_t, x_R, j)$ solves the dynamic program:

$$V_t(a, x_R, j) = \max_{c,a'} U(c, 0) + \beta s_j E V_{t+1}(a', x_R, j + 1), \tag{12}$$

subject to

$$c + a' = (1 + r)(Tr + a) + b^{ss} - T(\tilde{y}), \tag{13}$$

by choosing consumption, $c$, and savings, $a'$. Similarly to non-retired agents, retirees earn interest income $r(Tr + a)$ on the transfer, $Tr$, and their existing asset holdings, $a$, but also receive the Social Security payment, $b^{ss}$.

## 4 Equilibrium

In this section we define a stationary steady state competitive equilibrium. An agent's state variables, $\Xi$ are assets ($a$), average past earnings ($x$), age ($j$), ability ($\alpha$), persistent shock

[33] Instead, agents can decide not to participate in the labor market prior to reaching the minimum retirement age $j = \underline{R}$ by choosing zero labor hours (i.e., $h = 0$).

($\nu$), idiosyncratic shock ($\epsilon$), unemployment shock ($D$), retirement status ($I$). For a given set of exogenous demographic parameters ($n, \Psi_j$), a sequence of exogenous age-specific human capital ($\{\theta_j\}_{j=1}^{\overline{R}}$), government tax function ($T : \mathbb{R}_+ \to \mathbb{R}_+$), Social Security tax rate $\tau^{ss}$, Social Security benefits formula ($B^{ss} : \mathbb{R}_+ \times j \to \mathbb{R}_+$), a production plan for the firm (N,K), and a utility function ($U : \mathbb{R}_+ \times \mathbb{R}_+ \to \mathbb{R}_+$), a steady state competitive equilibrium consists of agent's decision rules for $c, h, a$, and $I$ for each state variable, factor prices $(w, r)$, transfers ($Tr$), and the distribution of individuals $\mu(\Xi)$ such that the following holds:

1. Given prices, policies, transfers, and initial conditions the agent solves the dynamic programming problem in equations 10 - 13, with $c$, $h$,$a'$, and $I$ as associated policy functions.

2. The prices $w_t$ and $r_t$ satisfy
$$r_t = \zeta(\frac{N_t}{K_t})^{1-\zeta} - \delta$$
$$w_t = (1-\zeta)(\frac{N_t}{K_t})^{\zeta}.$$

3. The Social Security policies satisfy:
$$\sum \min\{wD\omega h, \overline{y}\}\tau^{ss}\ \mu(\Xi) = \sum b^{ss}\ I\ \mu(\Xi).$$

4. Transfers are given by:
$$Tr = \sum (1-\Psi_j)a\ \mu(\Xi).$$

5. Government budget balance:
$$G = \sum T^y[r(a+Tr) + wD\omega h - .5\tau^{ss}\min\{wD\omega h, \overline{y}\}]\ \mu(\Xi) - \sum (D)b^{\text{ui}}\ \mu(\Xi).$$

6. Market clearing:
$$K = \sum a\ \mu(\Xi),\ N = \sum \omega h\ \mu(\Xi) \text{ and}$$
$$\sum c\ \mu(\Xi) + \sum a\ \mu(\Xi) + G = K^{\zeta}N^{1-\zeta} + (1-\delta)K.$$

7. The distribution of $\mu(x)$ is stationary, that is, the law of motion for the distribution of individuals over the state space satisfies $\mu(x) = Q_\mu \mu(x)$, where $Q_\mu$ is a one-period recursive operator on the distribution.

# 5 Calibration

The model is calibrated in two stages. In the first stage, values are assigned to parameters that can be determined from the data without the need to solve the model. In the second stage, the remaining parameters are estimated by the simulated method of moments (SMM) to match key moments of the U.S. cross-sectional and aggregate data. These parameters values are shown in Table 7.

## 5.1 Demographics, Endowments, Unemployment risk and Preferences

There are 80 overlapping generations of individuals of ages $j = 20, ..., 100$. We follow Conesa et al. (2009) and Kitao (2012) in setting population growth rate, $n$, to 1.1 percent to match the yearly population growth in the U.S. economy. The conditional survival probabilities, $\Psi_j$, are derived from the U.S. life tables (Bell and Miller (2002)).[34]

Following Huggett and Parra (2010), the process for the idiosyncratic labor productivity, $\omega$, is calibrated based on the estimates from the PSID data in Kaplan (2012).[35] The deterministic labor productivity profile, $\exp^{\theta_j}$, is shown in Figure 5.1. The profile is (i) smoothed by fitting a quadratic function in age, (ii) normalized such that the value equals unity when an agent enters the economy, and (iii) extended to cover ages 20 through 69 which we define as the last period in which agents are assumed to be able to participate in the labor activities ($\overline{R}$).[36] The permanent, persistent, and transitory idiosyncratic shocks to individual's productivity are distributed normal with a mean of zero. The remaining parameters are also set in accordance with the estimates in Kaplan (2012): $\rho = 0.958$, $\sigma_\alpha^2 = 0.065$, $\sigma_\nu^2 = 0.017$ and

[34]For $J$, we assume the probability of survival is zero.
[35]For details on estimation of this process, see Appendix E in Kaplan (2012).
[36]The estimates in Kaplan (2012) are available for ages 25-65.

Figure 3: **Deterministic Age Profile of Wages**

$\sigma_\epsilon^2 = 0.081$. We discretize all three of the shocks in order to solve the model, representing the transitory shock with two states, the permanent shock with two states, and the persistent shock with five states. For expositional convenience, we refer to the two different states of the permanent shock as high and low ability types.

The unemployment shock, $D$, which represents the fraction of the time during which an agent is unemployed in a given period, is discretized to take on two values so that $D \in \{0, d(\alpha, j)\}$. $d(\alpha, j)$ and its arrival probability, $p_d(\alpha, j)$, vary with agents' age and ability, and are calibrated to match their corresponding 2007 CPS values listed in Table 6.

Table 6: **Unemployment Parameters**

| | $\mathbf{p_d}(\alpha, \mathbf{j})$ | | $\mathbf{d}(\alpha, \mathbf{j})$ | |
|---|---|---|---|---|
| **Age** | **Low Education** | **High Education** | **Low Education** | **High Education** |
| 20-45 | 7.5% | 3.1% | 18.2% | 15.5% |
| $> 45$ | 4.4% | 2.7% | 20.6% | 22.6% |

**Note:** Based on the March Supplement CPS data. Duration is expressed as the percent of the period an agent is unemployed.

The unemployment insurance, $b^{\text{ui}}$, is determined as a fraction of the average annual earnings in the economy. The average replacement rate fluctuated between 32 and 37 percent in the 2000-2006 CPS data.[37] We therefore set this rate, $\iota$, at 35 percent in the benchmark

[37]The Replacement Rate is the ratio of the claimants' weekly benefit amount to the claimants' average weekly wage. The replacement ratio is computed as the weighted average of the weekly benefit amount to the weighted average of normal hourly wage $\times$ 40 Hrs. Weekly wage is based on hourly wage of usual job of claimant, normalized to a 40-hour work week and may not equal the claimant's actual average weekly

model.

As discussed in Section 3.2, the per-period utility, $U(c,h)$, is modeled as the weighted average between the utility flows from the sub-period in which the agent is unemployed and the sub-period in which the agent is employed.[38] We model the preferences within each sub-period as additively separable between consumption ($c$) and labor ($h$):[39]

$$u(c_{it}, h_{it}) = \frac{c_{it}^{1-\gamma}}{1-\gamma} - \chi_1 \frac{h_{it}^{1+\frac{1}{\sigma}}}{1+\frac{1}{\sigma}} - \chi_2 I, \tag{14}$$

with $\gamma > 0$, $\sigma > 0$, $\chi_1 > 0$ and $\chi_2 > 0$. The binary indicator $I$ denotes a non-retired agent. The constant relative risk aversion preferences over consumption are standard and are characterized by the risk aversion coefficient, $\gamma$, which determines an agent's desire to smooth consumption across time and states. The existing estimates of $\gamma$ typically range between 1 and 3; thus in this paper, we set $\gamma = 2$. The parameter $\sigma$ represents the Frisch labor supply elasticity on the intensive margin. Past microeconometric studies estimate the Frisch elasticity to be between 0 and 0.5 (see, for example, Kaplan (2012), Altonji (1986), MaCurdy (1981), Domeij and Floden (2006) or Browning et al. (1999)). However, more recent research shows that these estimates may be biased downward (see Imai and Keane (2004), Domeij and Floden (2006), Pistaferri (2003), Chetty (2009), Peterman (2012b), and Contreras and Sinclair (2008)). As such, we calibrate $\sigma$ at 0.5 – the upper range of the available estimates.[40] The scaling constant $\chi_1$ is calibrated such that, on average, agents work one third of their time endowment prior to the normal retirement age. Additionally, consistent with the data, the fixed cost of working, $\chi_2$, is calibrated so that seventy percent of individuals retire by the normal retirement age.[41] The fixed cost $\chi_2 > 0$ implies that the disutility from working

wage. Similarly,the Department of Labor reports the average replacement rate relative to individual's pre-unemployment earnings at about 40 percent.

[38] If $D = 0$ then there is only one sub-period.

[39] Our choice of a utility function that is both additively separable in labor and consumption and uses labor instead of leisure is based on results in Peterman (2013) and Conesa et al. (2009). The authors demonstrate that when leisure (instead of labor) enters the utility function then the Frisch labor supply elasticity on the intensive margin is not constant over the lifetime.

[40] We note that estimates of the Frisch elasticity from simulated data in this model would be larger than 0.5 due to changes in the wages affecting an agent's PIA. However, Peterman (2012a) demonstrates that the increase in elasticity from endogenously determined Social Security benefits is small.

[41] See http://www.ssa.gov/policy/docs/statcomps/supplement/2007/index.html (5a.pdf)

discontinuously increases when an agent goes from zero to positive hours worked.[42] Finally, in order to characterize the agent's preferences described in equation 3, we calibrate the discount factor, $\beta$, to 0.990 to match the U.S. capital-to-output ratio of 2.7.

## 5.2 Social Security

For simplicity, we set the NRA at 66, irrespective of the calendar year in which an agent was born. Following the current U.S. Social Security system, the minimum retirement age, $\underline{R}$, is set at 62, while the maximum age over which delayed retirement credits can be accrued, $\overline{R}$, is set at 69. As discussed above, it is assumed that at age 70 no agent in the economy works. The early retirement penalty parameters, $\kappa_1$ and $\kappa_2$, are based on the actual value in the U.S. Social Security system, and are set at 6.7 percent ($\kappa_{1a}$) for the first three years of early retirement and at 5 percent ($\kappa_{1b}$) for years four and five. The delayed retirement credit, $\kappa_2$, is set at 8 percent per annum. The marginal replacement rates in the progressive Social Security payment schedule ($\tau_{r1}, \tau_{r2}, \tau_{r3}$) are also set at their actual respective values of 0.9, 0.32 and 0.15. Finally, we follow Huggett and Parra (2010) in setting the bend points ($b_1$, $b_2$, $b_3$) and the maximum earnings ($\overline{y}$) equal to the actual multiples of mean earnings used in the U.S. Social Security system so that $b_1$, $b_2$ and $b_3 = \overline{y}$ occur at 0.21, 1.29 and 2.42 times average earnings in the economy.

## 5.3 Government

We set the government spending in the unproductive sector to 17 percent of GDP in the steady state ($\phi = 0.17$). We follow a host of literature (two examples include Conesa et al. (2009) and Imrohoroglu and Kitao (2012)) and use the three parameter tax function from Gouveia and Strauss (1994) to capture the progressivity of the U.S. income tax function:

$$T(\tilde{y}_t; \Upsilon_0, \Upsilon_1, \Upsilon_2) = \Upsilon_0(\tilde{y}_t - (\tilde{y}_t{}^{-\Upsilon_1} + \Upsilon_2)^{-\frac{1}{\Upsilon_1}}). \tag{15}$$

[42] An alternative formulation in which there would be an active extensive margin with reasonable parameter values is to include a non-linear mapping between hours and productivity (for example, see Rogerson and Wallenius (2009)). Although both modeling options create an active extensive margin, we found that solving for a steady state when using a fixed cost was more stable with respect to initial guesses.

Table 7: **Calibration Parameters**

| Parameter | Value | Source/Target |
|---|---|---|
| Demographics: | | |
| Normal Retirement Age: NRA | 66 | By Assumption |
| Minimum Retirement Age: $\underline{R}$ | 62 | U.S. SS Program |
| Maximum Retirement Age: $\overline{R}$ | 69 | By Assumption |
| Max Age: $J$ | 100 | By Assumption |
| Surv. Prob: $\Psi_j$ | | Bell and Miller (2002) |
| Pop. Growth: $n$ | 1.1% | Conesa et al. (2009) |
| Firm Parameters: | | |
| $\zeta$ | .36 | Data |
| $\delta$ | 8.33% | $\frac{I}{Y} = 25.5\%$ |
| A | 1 | Normalization |
| Preference Parameters: | | |
| Conditional Discount: $\beta^{***}$ | 0.990 | $\frac{K}{Y} = 2.7$ |
| Risk aversion: $\gamma$ | 2 | Conesa et al. (2009) |
| Frisch Elasticity: $\sigma$ | 0.5 | Data; Intensive Frisch= $\frac{1}{2}$ |
| Disutility to Labor: $\chi_1^{***}$ | 44.4 | Avg. $h_j = \frac{1}{3}$ |
| Fixed Cost to Working: $\chi_2^{***}$ | 1.07 | 70% retire by $J_{nr}$ |
| Productivity Parameters: | | |
| Persistence Shock: $\sigma_\nu^2$ | 0.017 | Kaplan (2012) |
| Persistence: $\rho$ | 0.958 | Kaplan (2012) |
| Permanent Shock: $\sigma_\alpha^2$ | 0.065 | Kaplan (2012) |
| Transitory Shock: $\sigma_\epsilon^2$ | 0.081 | Kaplan (2012) |
| Government Parameters: | | |
| $\Upsilon_0$ | .258 | Gouveia and Strauss (1994) |
| $\Upsilon_1$ | .768 | Gouveia and Strauss (1994) |
| $\Upsilon_2^{***}$ | 5.08 | Mrkt Clearing |
| $\phi$ | 17% | Conesa et al. (2009) |
| $\iota$ | 35% | Data |
| Social Security: | | |
| $\kappa_{1a}$ | 6.7% | U.S. SS Program |
| $\kappa_{1b}$ | 5% | U.S. SS Program |
| $\kappa_2$ | 8% | U.S. SS Program |
| $\tau_{r1}$ | 90% | U.S. SS Program |
| $\tau_{r2}$ | 32% | U.S. SS Program |
| $\tau_{r3}$ | 15% | U.S. SS Program |
| $b_1^{***}$ | .21 x Avg Earnings | Huggett and Parra (2010) |
| $b_2^{***}$ | 1.29 x Avg Earnings | Huggett and Parra (2010) |
| $b_3^{***}$ | 2.42 x Avg Earnings | Huggett and Parra (2010) |
| $\tau^{ss***}$ | 10.0% | Mrkt Clearing |

**Note:** $^{***}$ denotes parameters either calibrated through the Method of Simulated Moments or were determined in equilibrium through market clearing.

In this tax function, $\Upsilon_0$ primarily controls the average tax rate, $\Upsilon_1$ primarily controls the progressivity of the tax policy, and $\Upsilon_2$ is a scaling factor. We use the estimates from Gouveia and Strauss (1994) for $\Upsilon_0$ and $\Upsilon_1$, and calibrate $\Upsilon_2$ such that, in the steady state, the income tax revenue equals government spending. Finally, the Social Security tax, $\tau^{ss}$, is determined so that the steady state Social Security program is balanced budget.

## 5.4 The Great Recession

Consistent with the changes in the economy described in Section 2, we model the Great Recession as shocks to household wealth and unemployment. The wealth shock is modeled as a one-time unexpected twenty percent depreciation of assets at the beginning of the first period. The unemployment shock is modeled as an increase in both the frequency and length of unemployment spells. Table 8 describes how we model the changes in the probability of being unemployed over time. The 2008-2012 increases are calculated as the percentage point deviations in the respective unemployment rates from the 2007 pre-crisis benchmark rate by both age and type.[43] After 2012, we project the deviations using the contour of the CBO long-term unemployment rate projections (see *The 2013 Long-Term Budget Outlook* (2013)). In the same vein, Table 9 describes how we model the changes in the average unemployment duration.[44] We model both shocks as unexpected in the first period but assume that, after the initial surprise, there is no additional aggregate uncertainty during the perfect-foresight transition back to the steady state.[45]

[43] All estimates are based on the March Supplement CPS data. High types are agents who receive the more productive ability ($\alpha$) shock at birth. Young agents are agents between ages 20-46.

[44] These deviations (relative to 2007) account for the trend in duration over the last few decades. We assume that the evolution of the duration of unemployment spells follows the same pattern as the CBO long-term projection of the unemployment rate.

[45] After the initial shocks, agents have perfect foresight along the transitional path with regard to the evolution of economic aggregates. However, idiosyncratic uncertainty still exists.

Table 8: **Shock to the Unemployment Rate (pp)**

| Year | Young Low | Young High | Old Low | Old High |
|---|---|---|---|---|
| 2008 | 1.9 | 0.4 | 0.5 | 0.3 |
| 2009 | 7.6 | 3.5 | 4.9 | 2.9 |
| 2010 | 9.4 | 4.4 | 6.4 | 3.4 |
| 2011 | 8.3 | 3.9 | 5.3 | 3 |
| 2012 | 6.2 | 3.4 | 4.1 | 3 |
| 2013 | 6.2 | 3.4 | 4.1 | 3 |
| 2014 | 6.2 | 3.4 | 4.1 | 3 |
| 2015 | 4.1 | 2.3 | 2.7 | 2 |
| 2016 | 2.1 | 1.1 | 1.4 | 1 |
| 2017 | 0 | 0 | 0 | 0 |

**Note:** The 2008-2012 increases are calculated as the percentage point (pp) deviations in the respective unemployment rates from the 2007 pre-crisis benchmark rate by both age and type. Estimates are based on the March Supplement CPS data. Young agents are agents between ages 20-46. After 2012, we project the deviations using the contour of the CBO long-term unemployment rate projections.

Table 9: **Shock to the Duration of Unemployment (Weeks)**

| Year | Young Low | Young High | Old Low | Old High |
|---|---|---|---|---|
| 2008 | -2.2 | -1.1 | -1.2 | 0.4 |
| 2009 | 1.6 | 1.9 | 2.9 | 1.6 |
| 2010 | 11.1 | 12.6 | 15.5 | 13.4 |
| 2011 | 14.5 | 15.9 | 17.2 | 18.6 |
| 2012 | 13.7 | 14.3 | 17.5 | 16.5 |
| 2013 | 13.7 | 14.3 | 17.5 | 16.5 |
| 2014 | 13.7 | 14.3 | 17.5 | 16.5 |
| 2015 | 9.1 | 9.5 | 11.7 | 11 |
| 2016 | 4.6 | 4.8 | 5.8 | 5.5 |
| 2017 | 0 | 0 | 0 | 0 |

**Note:** The 2008-2012 increases are calculated as the deviations (in weeks) in the respective unemployment durations from the 2007 pre-crisis benchmark duration by both age and type. Estimates are based on the March Supplement CPS data. Young agents are agents between ages 20-46. After 2012, we assume that the evolution of the duration of unemployment spells follows the same pattern as the CBO long-term projection of the unemployment rate.

# 6 Results

## 6.1 Steady State Predictions

This section compares the benchmark and counterfactual economies in the steady state. Table 10 shows the aggregate variables in each economy while Figure 4 depicts the life cycle profiles. As shown Panel B of Figure 4 and in Table 10, the average savings profile as well as the level of aggregate capital $K$ is higher in the counterfactual versus the benchmark economy. This is because, in the counterfactual economy, agents finance all of their post-retirement consumption from private funds, as opposed to a part of their old-age consumption being funded with Social Security benefits in the benchmark model. The lower $K$, paired with the aggregate labor supply $N$ that is roughly identical between the two economies, translates into a lower return to capital $r$ and higher market wage $w$.[46] In turn, the lower return $r$ in the counterfactual economy affects the inter-temporal allocation of consumption and leisure. As illustrated in Panel A and Panel C of Figure 4, the lower $r$ induces agents to both consume more and enjoy more leisure early in life. On the extensive margin, since the lower $r$ reduces the relative importance of leisure later in life, agents tend to retire at a later age in the counterfactual economy without Social Security.

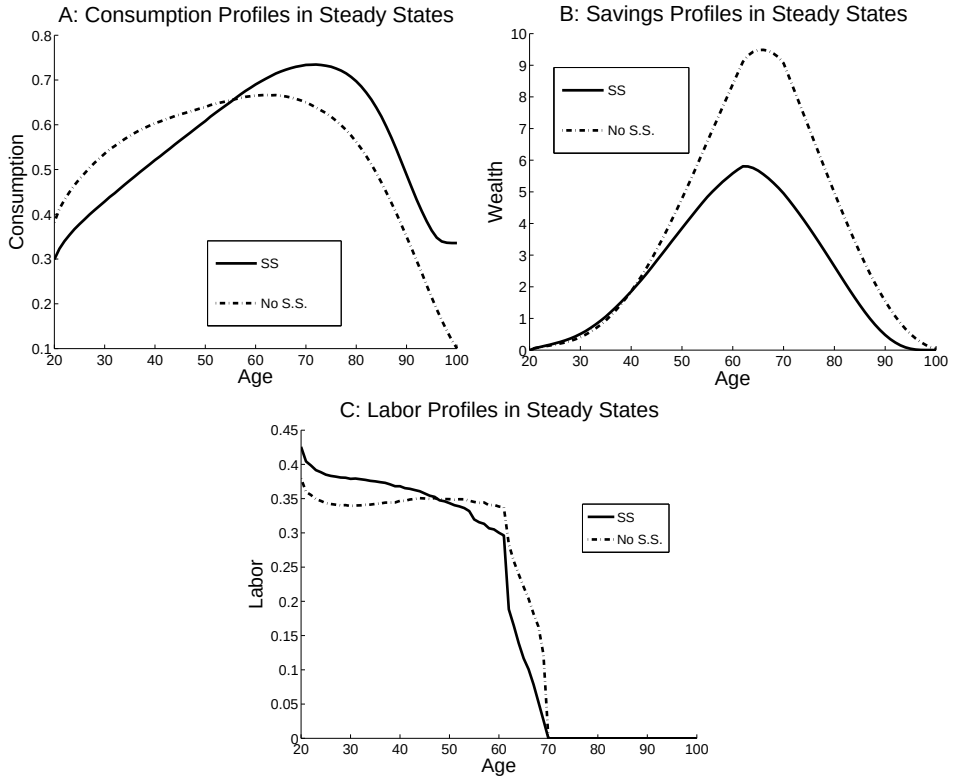
Table 10: **Aggregates in the Steady States**

| **Aggregate** | **Full S.S.** | **No S.S.** |
|---|---|---|
| Y | 0.93 | 1.06 |
| K | 2.51 | 3.6 |
| N | 0.53 | 0.53 |
| w | 1.12 | 1.27 |
| r | 0.05 | 0.02 |
| Tr | 0.04 | 0.06 |
| $\tau^{ss}$ | 0.1 | 0 |
| Avg. Retire. Age: | 64.7 | 67.9 |

**Note:** "Full S.S." denotes the benchmark economy with the U.S. Social Security program. "No S.S." denotes the counterfactual economy with no Social Security.

[46]The removal of Social Security mostly affects how agents fund their post-retirement consumption. That said, Social Security does not have a large effect on an agents incentives to work and therefore the effects on aggregate labor are second order.

Figure 4: **Life Cycle Profiles in Steady State**




**Note:** "SS" denotes the benchmark economy with the U.S. Social Security program. "No S.S." denotes the counterfactual economy with no Social Security.

Table 11 describes the long-run, ex-ante welfare consequences of Social Security. We find that, in the steady state, agents are willing to give up 7.5% of their per-period consumption in order to be born into the counterfactual economy without Social Security versus the baseline with Social Security. The estimated welfare effect aligns well with effects estimated in other studies (see Huggett and Parra (2010), Hong and Rìos-Rull (2007), Storesletten et al. (1998), and Imrohoroglu et al. (2003)) who report ex-ante welfare losses from the program between 3.7% and 12.9%.[47]

Although are estimate falls well within the range of the estimates reported in other studies, to our knowledge, our model is the first to simultaneously incorporate endogenous labor, endogenous retirement, and idiosyncratic labor productivity, unemployment, and mortality

[47]Huggett and Parra (2010) do not estimate the welfare gains from eliminating Social Security but instead estimate the welfare gains from a variety of reforms to the Social Security program and income taxation. From the results they report, it seems reasonable to assume that removing the program would lead to welfare gains within this range.

risks. Although Social Security provides both inter- and intra-generational insurance in the steady state, it reduces average welfare by (i) directly distorting agents' savings and labor decisions and also through (ii) general equilibrium effects. In particular, the payroll tax makes it harder for younger and low-wage agents to earn enough after-tax income to both smooth consumption over their lifetime and to accumulate precautionary savings. In addition, the progressive contribution-benefits formula affects agents' labor supply decisions. Finally, the program "crowds-out" private savings, thereby reducing the stock of aggregate capital, which affects the marginal product of both capital and labor in the general equilibrium.

We next isolate the relative contribution of direct distortions versus general equilibrium effects of Social Security to ex ante average steady-state welfare.[48] We find that the welfare gained from removing the direct distortions from Social Security is 5% CEV, or about two thirds of the total welfare effect of Social Security. The remainder, 2.5% CEV, represents the additional welfare consequences of Social Security from the general equilibrium effects.[49]

Table 11: **Decomposition of the Welfare Lost from Social Security**

| **Average** | **Direct Distortions** | **General Equilibrium** |
|---|---|---|
| 7.5% | 5% | 2.5% |

**Note:** "Average" denotes the average, steady state welfare loss due to Social Security. "Direct Distortions" captures the amount of the average loss due to the direct distortions associated with Social Security, while "General Equilibrium" captures the amount of the welfare loss due to the general equilibrium effects.

Our finding that the general equilibrium effects on welfare are smaller than the effect of the direct distortions is different from previous studies. In particular, Storesletten et al. (1998) estimate that, in partial equilibrium, Social Security is welfare enhancing. There are two main differences between Storesletten et al. (1998) and this paper. First, this paper endogenizes both the labor and retirement decisions while Storesletten et al. (1998) include them exogenously. Second, we disallow agents from borrowing while Storesletten et al. (1998)

[48]To isolate the effect of the direct distortions on agents' consumption-saving decisions, we conduct a partial equilibrium experiment in which we remove Social Security but hold prices at the levels of the baseline model with Social Security.

[49]These general equilibrium effects are mainly comprised of the lower wage rate due to Social Security "crowding out" capital.

Table 12: **Welfare Lost from Social Security**

| | **Quint 1** | **Quint 2** | **Quint 3** | **Quint 4** | **Quint 5** |
|---|---|---|---|---|---|
| Income | 7.6% | 7.8% | 7.4% | 7.1% | 7.7% |
| Productivity | 8.0% | 7.5% | 7.3% | 6.9% | 7.7% |
| Wealth | 8.3% | 7.9% | 7.2% | 6.9% | 7.2% |

**Note:** Average, steady state welfare losses due to Social Security by quintiles of agents' lifetime income, lifetime wealth, and productivity.

allow agents to borrow. Including endogenous labor supply, endogenous retirement decisions, and tighter liquidity constraints enhance the distortions from Social Security.

Table 12 depicts the welfare losses due to Social Security for agents in various quintiles of the lifetime labor income, productivity, and wealth distributions.[50] As can be seen in the table, the ex-ante welfare losses due to Social Security typically range between 6.9% to 8.0% across the distribution. Interestingly, the reduction in ex-ante welfare is the largest for the bottom two and the top quintiles. The bottom two quintiles of the distributions are particularly adversely affected by the effect of payroll taxes on budget constraints. In contrast, agents in the upper end of the labor income, productivity, and wealth distributions are particularly adversely affected by the progressive scheme of the Social Security program which redistributes resources away from the top echelon of the distribution to other less fortunate agents.

## 6.2 Recessional Dynamics of Aggregates

This section studies the evolution of economic aggregates in the benchmark and counterfactual model along the transitional path. As described in Section 5.4, we model the Great Recession as a one-time unexpected depreciation in capital, combined with a persistent increase in the likelihood and duration of unemployment spells. Figure 5 compares the benchmark model's predictions of the evolution of aggregate output, hours, and consumption, after the shock, to the data.[51] In Panel A, output follows a similar pattern in both the model and the

[50]Productivity is measured as the lifetime average idiosyncratic productivity, and is comparable to a agent's average wage. Income is measured as the agent's lifetime labor income.

[51]In the data, output, hours, and consumption grow over time; we therefore base the comparisons on the de-trended data.

data. Initially, output drops approximately eight percent in both the model and the data and then slowly recovers.

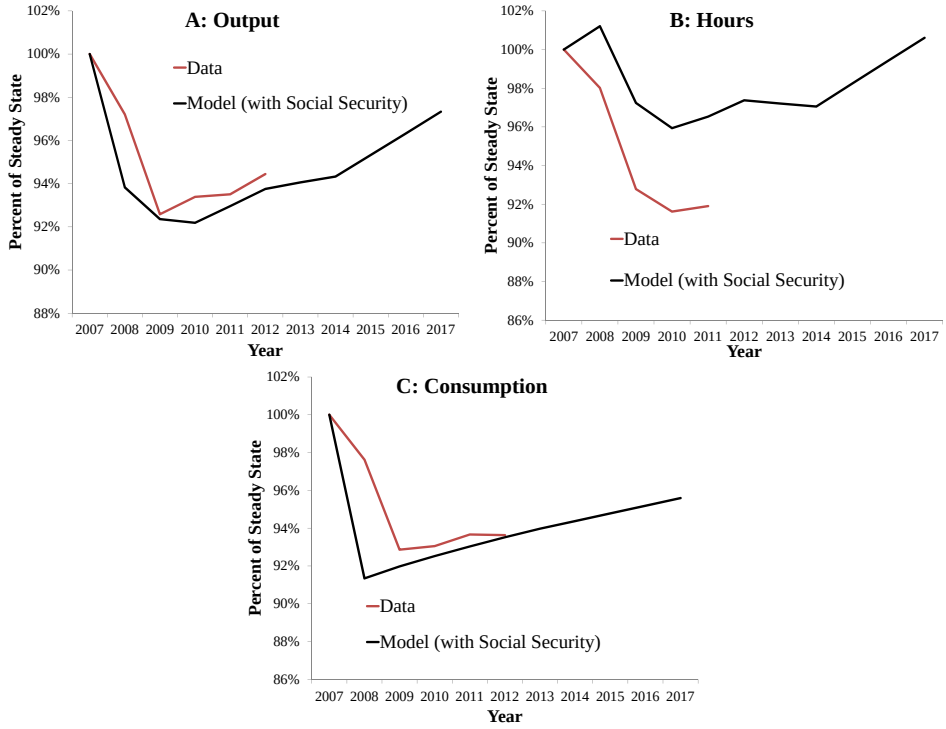
Turning to the aggregate hours, the general shape of their evolution is similar; however, the overall size of the decline is about twice as large in the data compared to the model. Additionally, the model predicts that hours rise initially after the shocks even though hours fell in 2008. As discussed in Section 2.2, these differences are partially accounted for by the fact that the exogenous unemployment shock in the model incorporates fluctuations in hours only on the extensive margin due to unemployment. However, as shown in Section 2.2, both changes in the participation rate and changes in hours on the intensive margin account for the majority of the total decline in aggregate hours in 2008 (see Table 5). Moreover, these two channels also explain between 30% and 40% of the aggregate fluctuations in the first few years after 2008.

Finally, Panel C compares the evolution of aggregate consumption. Again, while the general contour of the model's prediction is similar to the data, the model predicts a more pronounced drop in consumption and a more rapid recovery. The relatively larger response in the model can be in part ascribed to the informational differences between the model and the data. In the model, agents have a perfect foresight with respect to the size and evolution of the shocks, and their effects on the economy. In contrast, in the data, the severity of the Great Recession was not perfectly known in 2008. It is possible that the uncertainty about the size of the shocks and their effects on the future path of the economy led to a shallower but more persistent drop in consumption in the data relative to the model.

Comparing the real value of assets in the model to equity prices over the transition provides an assessment of how well our model captures the fluctuations in prices in the wake of the shock. In the model, twenty percent of household wealth is initially lost to the Great Recession. In the model, it takes three and a half years for the cumulative returns on the remaining assets after the shock to offset the initial twenty percent loss.[52] In the data, after bottoming out in March 2009, it took almost three years for the Dow Jones Industrial

[52]In other words, if an agent held one unit of assets at the time of the shock, after the shock they would hold 0.8 units. The cumulative returns on the 0.8 units of the remaining assets over the first three and a half years would equal the 0.2 units of assets lost to the Great Recession.

Figure 5: **Aggregates during Transition**




**Note:** The data represent the deviations after 2007 from each series' trend. Output is from the Bureau of Economic Analysis (BEA), and is de-trended using the potential output from the Congressional Budget Office. Hours are the total average hours worked for individuals between ages 20 and 70 in the CPS March Supplement data. The average series is de-trended using a linear trend from 1997 – 2005. Consumption is the nominal Personal Consumption Expenditures from the BEA . Consumption is normalized using potential output. In addition, we remove a linear trend (calculated between 1997 and 2005) to reflect the trends in both the savings rate and the income to output ratio. All the series are normalized to 100% in 2007.

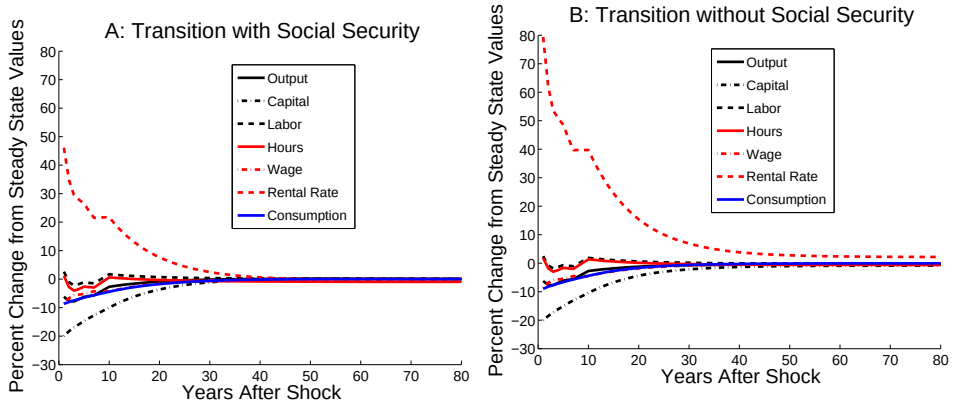
Average to reach its pre-recession high from March 2007.[53]

Overall, although we model the Great Recession in a fairly parsimonious manner, the evolution of economic aggregates and prices appear to match the data reasonably well. Therefore, we believe that this model is a good setting to study the effects of the Great Recession on the agents' welfare.

Figure 6 compares the percent changes in economic aggregates in the benchmark and counterfactual models. Capital decreases by twenty percent in both models by construction at the time of the shocks, and then gradually returns to the steady state values over thirty years. Consumption, wages, and output drop by approximately eight percent in both models

[53]Doing a similar analysis with wages is problematic because of selection.

Figure 6: **Aggregate Fluctuations in Models**




**Note:** Captures changes (%) in economic aggregates relative to the respective steady states along the transitional path in the benchmark and counterfactual economies.

and take approximately twenty five years to converge back to the original steady state levels. Notably, the return to capital increases more in response to the shock in the counterfactual model where, due to the absence of Social Security, the relative size of the capital stock is larger.

## 6.3 Welfare Effects of Social Security Due to the Great Recession

Next we assess the role that Social Security plays in mitigating the welfare consequences of the Great Recession on average and also for agents of different ages, incomes, wealth and abilities. The experiment is conducted in two steps. First, in each model, we calculate the welfare lost (relative to the steady state) due to the exogenous wealth and unemployment shocks. We define the welfare lost due to the shocks as the constant fraction of per-period future expected consumption that an agent would be willing to give up in order to not to live through the Great Recession. Second, in the spirit of a DiD estimation, we calculate the difference in welfare losses due to the shocks between the two economies. The difference in the welfare losses due to the Great Recession in each of the economies identifies the role that Social Security plays in either mitigating or exacerbating the effects of the shocks.

### 6.3.1 Average Welfare Effects of Social Security

Table 13 compares the average welfare losses due to the Great Recession for agents living at the time of the shocks in the benchmark and counterfactual economies. We measure welfare as the consumption equivalent variation (CEV) which is the percentage increase in the expected future per-period consumption that is necessary to make an individual indifferent between two outcomes. As can be seen in the table, the Great Recession reduces average welfare for agents alive at the time of the shocks by an equivalent of 4.3% of their expected future consumption in the benchmark model. In the counterfactual economy, the reduction in average welfare is estimated at an equivalent of 5.9% of expected future consumption. The economically significant difference in average welfare losses between the benchmark and counterfactual economies (1.6%) identifies the non-trivial amount of welfare losses from the Great Recession that Social Security mitigates.

Social Security affects the welfare consequences of the Great Recession through two competing channels. On one hand, Social Security mitigates some of the average welfare losses due to the Great Recession by reducing the exposure of agents to the wealth shock.[54] In the counterfactual model without Social Security, agents must fund all of their post-retirement consumption with savings which are exposed to the shock. In contrast, in the benchmark model, agents are less vulnerable to this shock because their post-retirement consumption is partially financed with Social Security benefits. These benefits, unlike private savings, are unaffected by the shock. On the other hand, Social Security exacerbates welfare losses because the payroll tax because $\tau^{ss}$ tightens budget constraints. This adverse effect of payroll taxation is amplified by the increase in $\tau^{ss}$ during the Great Recession as labor income falls.[55] We find that, on average, the positive welfare effects of the program dominate, meaning that Social Security mitigates the welfare losses due to the Great Recession.

Given that the program mitigates an economically significant amount of the welfare losses from the Great Recession, we next focus of two questions of interest. First, we examine which

[54]The unemployment shock has a limited effect on the average welfare predictions. When the unemployment shock is excluded from the model, the average welfare losses are roughly unchanged.

[55]The PAYGO nature of the Social Security program implies that the equilibrium payroll tax rate $\tau^{SS}$ fluctuates along the transitional path, ensuring a period-by-period balanced budget. Since agents' labor income falls with market wage and higher unemployment during the Recession, the payroll tax increases (see Figure 8). Section 6.3.2 examines the implications of the payroll tax rate fluctuations on welfare.

Table 13: **Avg. Welfare Loss due to the Great Recession for Living Agents**

| | **Avg CEV** |
|---|---|
| Full S.S. | 4.3% |
| No S.S. | 5.9% |
| S.S. Welfare Effect | 1.6% |

**Note:** The S.S. Welfare Effect is the difference between the welfare losses due to the Great Recession in the benchmark (Full S.S.) and counterfactual (No S.S.) economies. A positive value implies a mitigation while a negative value implies an exacerbation of the losses.

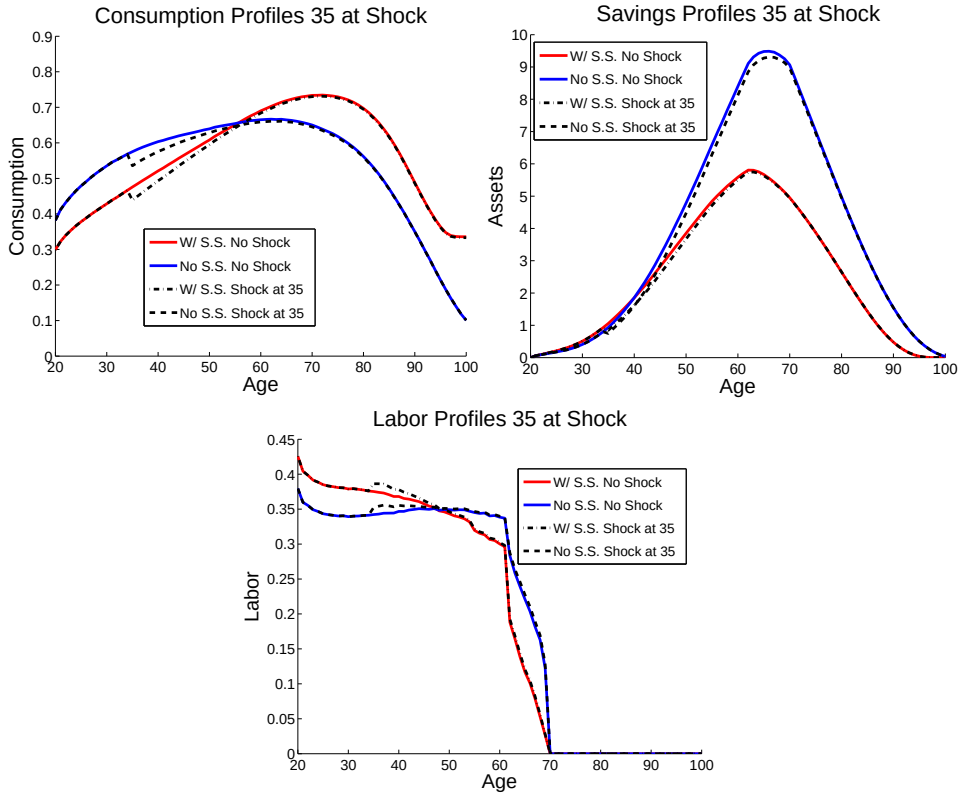
age, income, wealth and ability groups benefit the most from the mitigating effects of Social Security during the Recession. Second, we ask whether the program exacerbates the welfare losses for any particular group.

### 6.3.2 Welfare Effects of Social Security by Age

We next consider the effect of Social Security on welfare losses due to the Great Recession by the age of agents at the time of the shock, shown in Table 14. The estimated effects can be discussed in the context of three broad age categories: (i) agents who are in their prime working ages at the time of the shock (ages 20 to 50), (ii) agents who are nearing retirement at the time of the shock (ages 50 to 70), and (iii) agents who are retired at the time of the shock (ages 70+). As can be seen in the table, Social Security exacerbates the adverse welfare effect of the Great Recession for younger agents between ages 20 and 50. However, the overall effect is small. At the same time, Social Security mitigates a large amount of the welfare losses for older agents who are either near retirement or who have already retired.

Turning first to agents who are younger at time of the shock, Figure 7 compares the average consumption, savings, and labor profiles in the benchmark and counterfactual economies for agents who never experience the Great Recession against the average profiles of agents who are at the onset of the economic downturn, respectively. As can be seen in the figure, young agents respond by increasing their labor supply and reducing their consumption for numerous periods following the shocks. The average change in consumption, savings and labor profiles relative to their steady state counterparts in each model are similar. The similar size of the changes implies that Social Security plays only a small role in affecting the

Figure 7: **Changes in the Avg. Profiles for an Agent Age 35 at the Time of the Shocks**




**Note:** The graphs plot the change in the average life cycle profiles for agents who are 35 year of age at the time of the shock, and compare them to the profiles of agents who never experience the shock in the benchmark (W/ S.S.) and the counterfactual (No S.S.) economies.

welfare consequences of the Great Recession for younger agents.

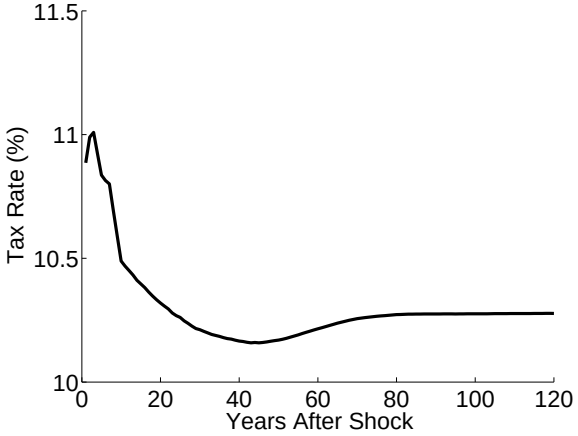
Table 14: **Avg. Welfare Loss due to the Great Recession for Living Agents with Endogenous $\tau^{ss}$ (by Age)**

| Age | **20-29** | **30-39** | **40-49** | **50-59** | **60-69** | **70-79** | **80-89** | **90-98** |
|---|---|---|---|---|---|---|---|---|
| Full S.S. | 2.8% | 3.4% | 4.4% | 5.4% | 5.9% | 5.9% | 5.2% | 3.1% |
| No S.S. | 2.4% | 2.8% | 3.8% | 6% | 10.1% | 14.2% | 16.3% | 18.9% |
| SS Welfare Effect | -0.3% | -0.7% | -0.7% | 0.5% | 4.2% | 8.3% | 11.1% | 15.8% |

**Note:** Repeats analysis in Table 13 by agents' age. Based on an economy with a PAYGO Social Security system where $\tau^{ss}$ clears Social Security budget every period.

The small amount of additional welfare lost by younger agents during the Great Recession due to Social Security arises because the negative effect of payroll tax on agents' welfare during the Great Recession outweighs the positive insurance benefit that Social Security

Figure 8: **Evolution of the Payroll Tax over the Transitional Path**




**Note:** Captures the general equilibrium response of $\tau^{ss}$ along the transitional path in the benchmark model.

provides. In particular, both the existence and the increase in $\tau^{ss}$ during the Great Recession tighten budget constraints. The effect of the tighter budget constraints is particularly painful for younger agents who accumulate savings that are used to smooth lifetime consumption and to partially self-insure against both idiosyncratic productivity and unemployment shocks. At the same time, younger agents are less vulnerable to the wealth shock because they have not yet accumulated a large fraction of their lifetime savings at the time of the shock and have many periods before retirement to re-accumulate assets by working more. Because these agents are less vulnerable to the shock, the insurance from the Social Security benefit, which is unaffected by the shock, is relatively less important. Overall, we find that, for young agents, the exacerbating effect associated with payroll taxation dominates.

As discussed previously, our benchmark results are consistent with the common PAYGO assumption that is generally included in the previous literature. However, allowing the payroll tax to increase during a recession enhances the distortions of the Social Security program during a recession. It also runs counterfactual to recent business cycle episodes.[56] In order to quantify the size of this additional distortion introduced by the PAYGO assumption, we decompose how much of the overall exacerbation of the welfare losses is accounted for by the increase in the payroll tax after the shocks. In particular, we conduct an alternative experiment where the payroll tax is held constant at its steady state value along the transitional

[56]For example, during the Great Recession, the payroll tax was cut in half for several years following the shocks.

Table 15: **Avg. Welfare Loss due to the Great Recession for Living Agents with Flat $\tau^{ss}$ (by Age)**

| Age | **20-29** | **30-39** | **40-49** | **50-59** | **60-69** | **70-79** | **80-89** | **90-98** |
|---|---|---|---|---|---|---|---|---|
| Full S.S. | 2.5% | 3.2% | 4.2% | 5.3% | 5.8% | 5.9% | 5.2% | 3.1% |
| No S.S. | 2.4% | 2.8% | 3.8% | 6% | 10.1% | 14.2% | 16.3% | 18.9% |
| S.S. Welfare Effect | -0.1% | -0.4% | -0.4% | 0.7% | 4.2% | 8.3% | 11.1% | 15.8% |

**Note:** Repeats analysis in Table 14 under the assumption that $\tau^{ss}$ is fixed at the steady-state benchmark level of 0.1 over the transition.

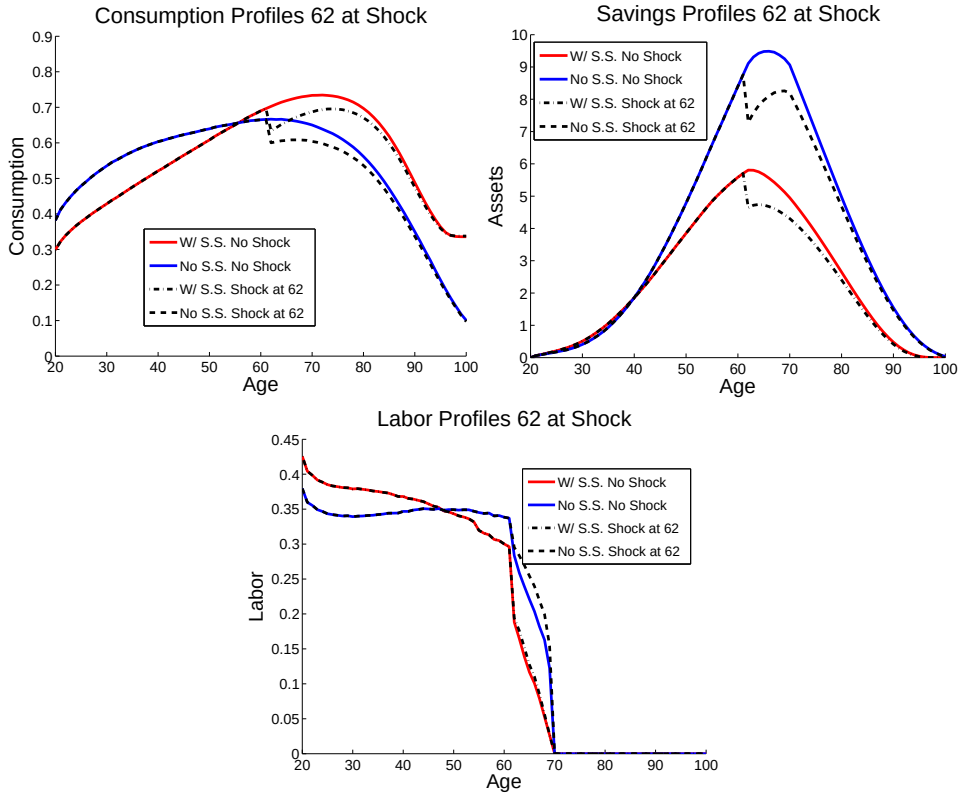
path.[57] Table 15 shows the welfare losses in this alternative experiment. As can be seen in the table, approximately one half of the already small exacerbating effect of Social Security on welfare for younger agents disappears when the payroll tax is held constant. Moreover, the effect of Social Security on the welfare losses due to the Great Recession does not change for older agents.

Turning to older agents who are still working at the time of the shocks, Figure 9 plots the effects of the shock on average labor, consumption, and savings profiles for agents who are 62 at the time of the shocks and compares them against average profiles of the same age agents who do not experienced the Great Recession in both the baseline and counterfactual economies. In both models, agents respond to the shock with a large decrease in consumption and an increase in labor supply which persist for numerous years. However, the effect of shocks on the average profiles is more pronounced in the counterfactual model. Given the bigger response of consumption and labor to shocks in the counterfactual economy, it is not surprising that Social Security mitigates a large amount of the welfare losses from the Great Recession for agents between ages 50 and 70.

Social Security mitigates welfare losses for these agents because the insurance benefit provided by Social Security outweighs the negative effects of payroll taxation. The stream of post-retirement payments from Social Security, which is unaffected by the shocks, is more valuable for older agents relative to their younger counterparts for two reasons. First, older agents close to retirement have less time prior to their retirement to rebuild their wealth by increasing their labor supply relative to younger agents. Second, since these older agents are closer to retirement, they hold a larger fraction of their total lifetime wealth (intended to

[57] This experiment implies that the Social Security system runs a deficit during the recession.

Figure 9: **Changes in the Avg. Profiles for an Agent Age 62 at the Time of the Shocks**

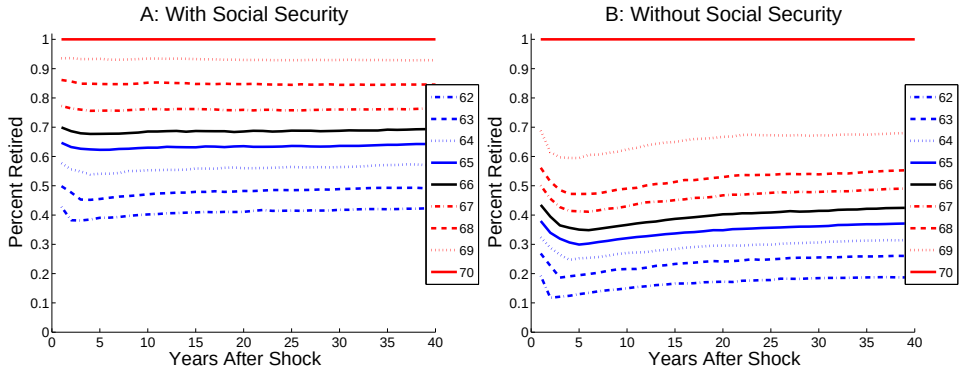



**Note:** The graphs plot the change in the average life cycle profiles for agents who are 62 year of age at the time of the shock, and compare them to the profiles of agents who never experience the shock in the benchmark (W/ S.S.) and the counterfactual (No S.S.) economies.

finance post-retirement consumption) at the time of the shocks. As such, these agents are particularly vulnerable to the effects of the shocks. Moreover, the adverse effect of payroll taxation for these older agents is relatively small. Since these agents already hold a large amount of wealth, the payroll tax causes less of a tightening of their budget constraints.

The effectiveness of Social Security in mitigating the welfare losses due to the Great Recession for older working agents is further reflected by varying magnitudes of the retirement decision responses in each model. Figure 10 captures the fraction of agents retired at a given age in the steady state and also tracks how the fraction changes over time during and after the Great Recession. In the benchmark model with Social Security (Panel A), about 43 percent of all agents age 62 are retired in the steady state (time 0). Two periods into the Great Recession, only about 38 percent of all agents who are age 62 at that point (or age 60 at the time of the shocks) are retired. The 5 percentage point drop in the fraction of retired

Figure 10: **Fraction of Retired Agents Over the Transitional Path**

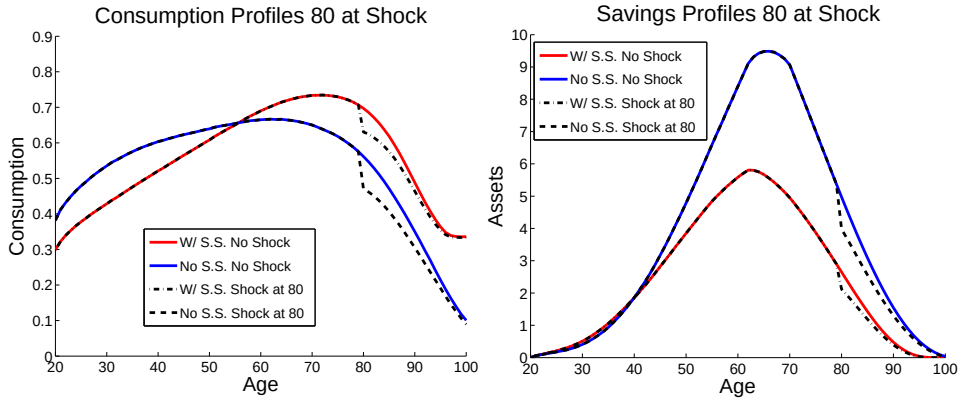



**Note:** The plot captures the fraction of agents retired at a given age along the transitional path in the benchmark and counterfactual economies.

agents due to the shocks demonstrates that pre-retirement agents respond to the shock by delaying their planned retirement past the age of 62. However, the retirement decision of agents who are 66 at the time of the shocks is virtually unaffected by the shocks. Taken together, these results demonstrate that, in the model with Social Security, the shocks cause some agents who have reached the minimum retirement age to delay retirement. However, the retirement is generally not delayed past the normal retirement age of 66. Moreover, the retirement decisions for agents who have reached the normal retirement age at the time of the shock tend to be unaffected. In marked contrast, in the model without Social Security (Panel B), the effect of the shocks on agents' retirement decisions are much larger. Upon impact, the fraction of retired agents at all ages drops by a noticeably larger amount and remains depressed for many periods in the counterfactual model. Overall, the changes in retirement decisions are more pronounced and persistent in the counterfactual model. This is because, without Social Security, older working agents are more vulnerable to the shocks and are therefore are willing to forgo more leisure in order to partially rebuild lost wealth.

Finally, Figure 11 plots the average consumption and savings decisions for agents who are 80 at the time of the shock. In both models these older agents respond to the shock by cutting their consumptions sharply. The much larger drop in consumption in the model without Social Security highlights the large role that Social Security plays in mitigating the adverse effects of these shocks. Social Security is particularly important for retired agents because, as discussed previously, in the counterfactual economy, all of the post-retirement

Figure 11: **Changes in the Avg. Profiles for an Agent Age 80 at the Time of the Shocks**




**Note:** The graphs plot the change in the average life cycle profiles for agents who are 80 year of age at the time of the shock, and compare them to the profiles of agents who never experience the shock in the benchmark (W/ S.S.) and the counterfactual (No S.S.) economies.

consumption is funded with private savings that are subject to the shocks. Moreover, Social Security plays an increasing role mitigating the welfare effects of the Great Recession the older a retired agent is at the time of the shock. Retired agents face an increasing mortality probability as they age. Therefore, in the benchmark model, Social Security benefits comprise a larger portion of consumption as agents age. Hence, Social Security plays an even larger role mitigating the welfare effects of the Great Recession for retired agents the older they are at the time of the shocks.

### 6.3.3 Welfare Effects of Social Security by Income, Wealth and Ability

Tables 16 – 19 show the welfare losses due to the Great Recession in the benchmark and counterfactual economies by ability, average lifetime wealth, average lifetime productivity, and average lifetime labor income, respectively. As before, the differences in the welfare losses across the groups identify the role that Social Security plays in either mitigating or exacerbating the welfare losses caused by the Great Recession. Overall, the results are similar for each of the distributions. First, higher ability, wealthier, higher income, and more productive agents generally suffer relatively larger welfare losses due to the shocks in both models. Because these agents tend to have more savings, the wealth shock results in larger losses. Moreover, due to the progressive nature of the income taxation, re-accumulating these larger amounts of lost wealth would require relatively larger increases in labor. Second, Social

Table 16: **Avg. Welfare Loss due to the Great Recession for Living Agents (by Ability)**

| | **Low** | **High** |
|---|---|---|
| Full S.S. | 4.2% | 4.5% |
| No S.S. | 5.8% | 6.0% |
| S.S. Welfare Effect | 1.7% | 1.4% |

**Note:** Repeats analysis in Table 13 by agents' ability (high/low).

Table 17: **Avg. Welfare Loss due to the Great Recession for Living Agents (by Lifetime Wealth)**

| | **Q1** | **Q2** | **Q3** | **Q4** | **Q5** |
|---|---|---|---|---|---|
| Full S.S. | 4.2% | 4.2% | 4.3% | 4.6% | 4.5% |
| No S.S. | 5.9% | 5.8% | 5.9% | 6% | 6% |
| S.S. Welfare Effect | 1.7% | 1.7% | 1.6% | 1.4% | 1.4% |

**Note:** Repeats analysis in Table 13 by agents' lifetime wealth.

Security generally mitigates a larger share of the welfare losses for lower ability, poorer, lower income, and lower productivity agents relative to their higher income and higher wealth counterparts. The program is more effective at mitigating welfare losses for these agents because Social Security benefits make up a larger portion of these agents' post-retirement consumption. Third, Social Security does not exacerbate the average welfare losses for any of the groups; it only mitigates. Overall, our results highlight the effectiveness of Social Security in mitigating welfare losses due to the shocks for some of the most vulnerable segments of the population without exacerbating the losses for other, potentially less vulnerable groups.

Figure 12 examines the welfare losses by both age at the time of the shock and lifetime income. Panels A and B plot these welfare losses in the benchmark and counterfactual models, respectively. Panels C and D show the effect of Social Security on welfare losses due to the Great Recession for agents who are younger and older than sixty five years of age at the time of the shock, respectively.[58] As before, Panel C demonstrates that Social Security slightly exacerbates the average welfare losses for agents who are younger at the time of the shocks and moderately mitigates the average welfare losses for agents who are near retirement at the time of the shocks. Moreover, the panel shows that the size of the

[58]The effect of Social Security is determined by differencing the welfare losses due to the shocks in the benchmark and counterfactual economies (shown in Panels A and B).

Table 18: **Avg. Welfare Loss due to the Great Recession for Living Agents (by Productivity)**

| | **Q1** | **Q2** | **Q3** | **Q4** | **Q5** |
|---|---|---|---|---|---|
| Full Social Security | 3.6% | 4.2% | 4.5% | 4.9% | 5.3% |
| No Social Security | 5.4% | 5.8% | 6% | 6.3% | 6.6% |
| Social Security Role | 1.9% | 1.6% | 1.5% | 1.4% | 1.3% |

**Note:** Repeats analysis in Table 13 by agents' productivity.

Table 19: **Avg. Welfare Loss due to the Great Recession for Living Agents (by Lifetime Income)**

| | **Q1** | **Q2** | **Q3** | **Q4** | **Q5** |
|---|---|---|---|---|---|
| Full S.S. | 3.6% | 4.3% | 4.5% | 4.7% | 5.3% |
| No S.S. | 5.5% | 5.8% | 6% | 6.2% | 6.5% |
| S.S. Welfare Effect | 1.8% | 1.6% | 1.6% | 1.5% | 1.2% |

**Note:** Repeats analysis in Table 13 by agents' lifetime income.

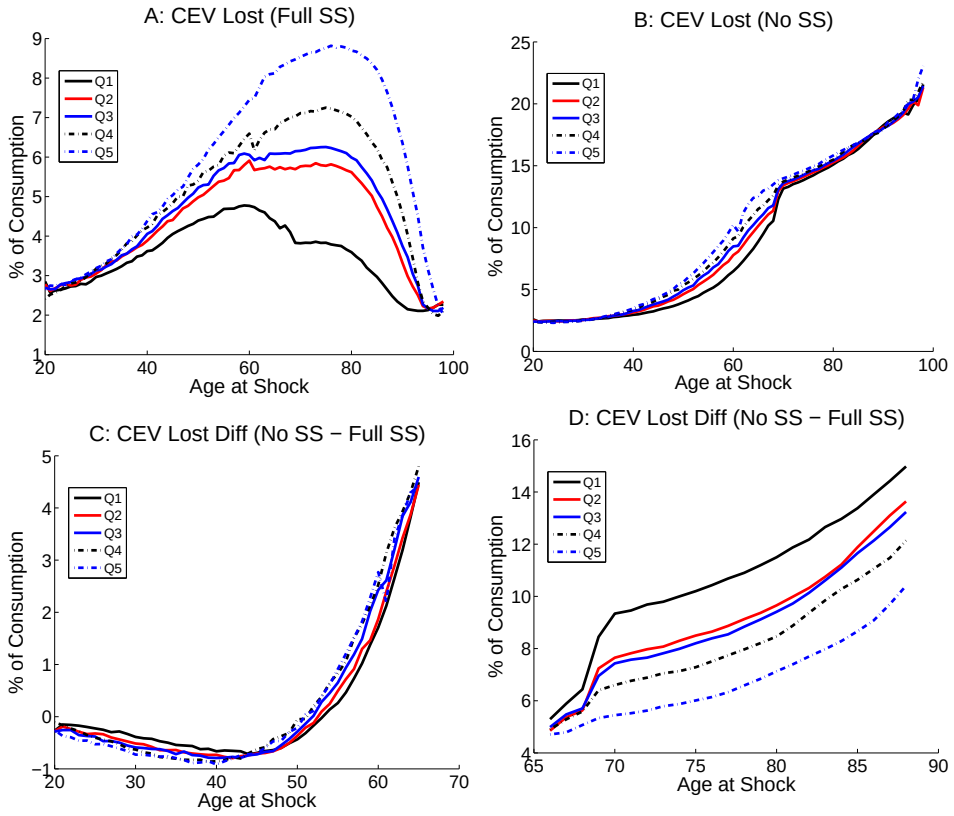
mitigating or exacerbating effects is roughly the same irrespective of agents' income. In contrast, while Social Security mitigates a considerable amount of welfare losses for agents who are 65+ years of age at the time of the shock, there is a notable dispersion in how effective Social Security is at mitigating the welfare losses by an agent's lifetime income (see Panel D). In particular, Social Security mitigates a larger amount of the welfare losses for these older agents at the bottom of the lifetime income distribution because the progressive nature of the program implies that the Social Security benefits comprise a larger portion of these agents' post-retirement consumption.[59]

### 6.3.4 Welfare Effects of Social Security for Future Generations

Figure 13 examines the impact of Social Security on the welfare of agents who enter the economy after the shock. Panel A plots the welfare lost due to the Great Recession for these agents in the model with and without Social Security. Generally, the welfare losses are very similar, signifying that Social Security plays a minor role in either mitigating or exacerbating the effects of the Great Recession for future generations. As shown in Panel B, Social Security causes the future generations' welfare losses due to the Great Recession

[59] A similar qualitative pattern exists if one examines the welfare losses between ability, productivity, or wealth and age.

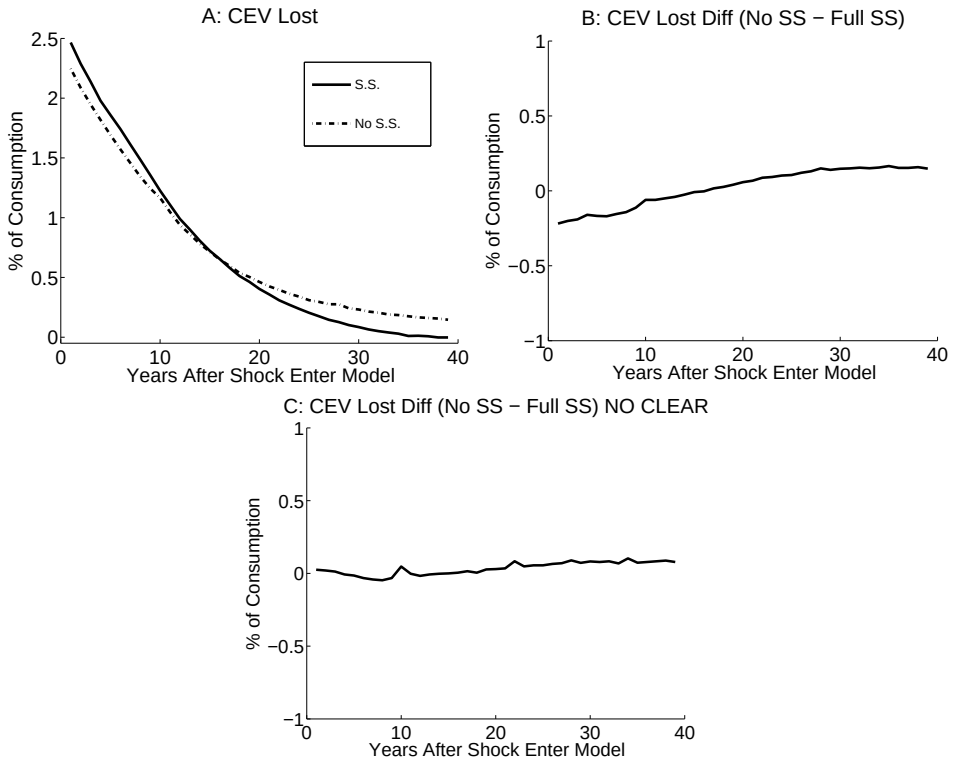
Figure 12: **Avg. Welfare Loss due to the Great Recession for Living Agents (by Age and Income)**




**Note:** Repeats analysis in Table 13 by both agents' age and lifetime income. Panel A captures welfare losses due to the Great Recession in the benchmark economy while Panel B captures the losses in the counterfactual economy. Panel C captures the welfare effect of Social Security for agents between ages 20 and 65. Panel D captures the effect for agents age 65+.

to change by less than 0.2% of expected lifetime consumption. In particular, Social Security exacerbates the average welfare losses for agents who enter the economy right after the shocks. Since agents who enter the economy after the shock are not affected by the initial wealth shock, the payroll tax is the primary channel through which Social Security affects the future generations' welfare. Similar to agents who are young at the time of the shock, the payroll tax is particularly painful for agents who enter the economy shortly after the shock because it further strains their already tight budget constraints. However, the exacerbation is small and largely accounted for by the increase in payroll tax rate, which is counter to recent historical episodes. Indeed, when the payroll tax rate is held constant (shown in Panel C), Social Security has virtually no effect on the welfare losses of agents who enter the

Figure 13: **Avg. Welfare Loss due to the Great Recession for Future Generations**




**Note:** Repeats analysis in Table 13 for future generations. Panel A captures the welfare loss to the Great Recession in the benchmark (S.S.) and counterfactual (No S.S.) economies. Panel B captures the differences between the welfare losses due to the Great Recession between the two economies when $\tau^{ss}$ is endogenously determined such that the Social Security budget clears every period. Panel C shows the difference when $\tau^{ss}$ is exogenously held flat.

economy after the shock. Overall, the already small exacerbating effects gradually recede for generations who enter the economy farther in the future.

## 6.4 Alternative Insurance Programs

Overall, we find that the stylized U.S. Social Security program mitigates an economically significant amount of the welfare losses due to the Great Recession. Moreover, it is effective at mitigating these losses for groups that may be particularly vulnerable, such as older and poorer agents. However, the program does have some undesirable consequences. In particular, it causes a substantial reduction in welfare in the steady state, and also slightly exacerbates the welfare losses due to the Great Recession for agents who are younger at

the time of the shocks. Therefore, we study the effectiveness of a smaller scale program in mitigating welfare losses due to the shocks, and weigh it against the long-term welfare implications of such program. In the spirit of the Supplemental Security Income (SSI) program, we replace the benchmark Social Security with an alternative old-age income insurance program that is means-tested. In this alternative program, instead of benefits being linked to an agent's labor earnings history, benefits are set at 15% of the average economy-wide labor income.[60] Additionally, the SSI program is means-tested; retired agents only receive these benefits if they hold no assets.[61] Similar to the model with Social Security, the payroll tax used to fund SSI is determined such that the budget for SSI is balanced in each period.

We begin by determining the ex-ante welfare effects of SSI in the steady state. We find that the average welfare lost from SSI in the steady state is the equivalent of 1.6% of expected lifetime consumption. Similar to Social Security, we find that SSI distorts labor and savings decisions. However, because SSI is a smaller program that is more targeted towards lower income agents, the distortions on the labor and savings decisions for most agents will be smaller.[62] Because of the smaller distortions, the ex-ante welfare losses in steady state from SSI are only 20% as large as those from Social Security.

Turning to the effect of the program on welfare losses due to the Great Recession, the first three rows of Table 20 presents the average welfare losses for agents living at the time of the shocks in the models with Social Security, SSI, an no retirement insurance program, respectively. The fourth and fifth rows describe the role that each Social Security and SSI play in mitigating the welfare losses due to the Great Recession. We find that, on average for living agents, SSI mitigates welfare losses due to the Great Recession by the equivalent of 0.7% of expected future consumption. Compared to Social Security, we find that even though SSI only causes 20% of the welfare losses in the steady state, it is still approximately 45% as effective at mitigating the welfare losses from the Great Recession as Social Security. Therefore, the more targeted SSI program is relatively more effective at mitigating the effects

[60]The replacement rates generally line up with the estimated rates in Bruan et al. (2013) and Kopecky and Koreshkova (2013).

[61]In the U.S., the means-testing is somewhat less restrictive; however, setting the wealth cutoff at zero captures the nature of a means-tested program.

[62]For comparison, Social Security replaces approximately 40% of average earnings in the U.S. economy (see Rettenmaier and Saving (2006)).

Table 20: **Avg. Welfare Loss due to the Great Recession for Living Agents (by Type of Retirement Insurance Program)**

| | **Avg CEV** |
|---|---|
| Full S.S. | 4.3% |
| SSI | 5.2% |
| No S.S. | 5.9% |
| S.S. Welfare Effect | 1.6% |
| SSI Welfare Effect | 0.7% |

**Note:** "S.S. Welfare Effect" captures the differences between the welfare losses due to the Great Recession in the benchmark (Full S.S.) and counterfactual (No S.S.) economies. "SSI Welfare Effect" captures the differences between the welfare losses in the economy with SSI and the counterfactual economy (No S.S.). A positive value implies a mitigation while a negative value implies an exacerbation of the losses.

of the Great Recession while minimizing long-run, steady state welfare losses.

Next, we compare the welfare effects of both programs for agents of different lifetime income levels and ages at the time of the shock, shown in Table 21. The structure of the table is that same as the one of Table 20, with an added age dimension. Similar to Social Security, SSI on average mitigates a large amount of the welfare losses due to the Great Recession for agents who are retired at the time of the shock. However, SSI has relatively smaller welfare effects on agents who are under age 70 at the time of the shock. The smaller effects on these agents are caused by SSI being a scaled down, more targeted program.[63] Interestingly, instead of slightly exacerbating the welfare losses due to the Great Recession for agents who are prime age at the time of the shock, SSI has virtually no effect on these agents.

Table 22 presents the welfare effects of each of the programs by lifetime income. Similar to Social Security, SSI tends to mitigate a larger amount of the welfare losses for lower income agents. However, the mitigating effects of SSI are even more skewed toward lower income agents because agents only receive SSI benefits if they have no savings.[64] Taken as a whole, these results indicate since SSI is a smaller, more focused program, the costs are smaller but the benefits are more concentrated on older and lower income agents.

[63]Compared to Social Security, SSI is smaller because the benefits replace a lower average percent of lifetime earnings. The program is more targeted because it is means-tested.

[64]This qualitative pattern exists if the welfare effects are examined by ability, productivity, or wealth.

Table 21: **Avg. Welfare Loss due to the Great Recession for Living Agents (by Type of Retirement Insurance Program and Age)**

| | **20-29** | **30-39** | **40-49** | **50-59** | **60-69** | **70-79** | **80-89** | **90-98** |
|---|---|---|---|---|---|---|---|---|
| Full S.S. | 2.8% | 3.4% | 4.4% | 5.4% | 5.9% | 5.9% | 5.2% | 3.1% |
| SSI | 2.5% | 2.8% | 3.8% | 5.7% | 9.2% | 11.6% | 10.2% | 6.9% |
| No S.S. | 2.4% | 2.8% | 3.8% | 6% | 10.1% | 14.2% | 16.3% | 18.9% |
| S.S. Welfare Effect | -0.3% | -0.7% | -0.7% | 0.5% | 4.2% | 8.3% | 11.1% | 15.8% |
| SSI Welfare Effect | -0.1% | -0.1% | 0% | 0.2% | 0.9% | 2.6% | 6.2% | 12% |

**Note:** Repeats analysis in Table 20 by agents' age.

Table 22: **Avg. Welfare Loss due to the Great Recession for Living Agents (by Type of Retirement Insurance Program and Lifetime Income)**

| | **Q1** | **Q2** | **Q3** | **Q4** | **Q5** |
|---|---|---|---|---|---|
| Full S.S. | 3.6% | 4.3% | 4.5% | 4.7% | 5.3% |
| SSI | 4.3% | 5.2% | 5.5% | 5.8% | 6.2% |
| No S.S. | 5.5% | 5.8% | 6% | 6.2% | 6.5% |
| S.S. Welfare Effect | 1.8% | 1.6% | 1.6% | 1.5% | 1.2% |
| SSI Welfare Effect | 1.2% | 0.7% | 0.5% | 0.4% | 0.2% |

**Note:** Repeats analysis in Table 20 by agents' lifetime income.

# 7 Conclusion

This paper quantifies the ability of Social Security to mitigate the welfare losses due to the Great Recession. There are two competing channels by which Social Security primarily affects the welfare implications of the Great Recession. On one hand, Social Security lessens the welfare losses by reducing agents' exposure to the wealth shock. On another hand, the distortions from the payroll tax (used to fund Social Security) are enhanced during the Great Recession when agents tend to face tighter budgets constraints. We find that, on balance, the former channel dominates. In particular, Social Security mitigates the average welfare losses for agents alive at the time of the Great Recession by the equivalent of 1.6% of expected future lifetime consumption.

Given that the relative strengths of these two channels may vary across agents, we also examine the welfare losses by age, income, wealth, and ability groups. We find that Social Security is particularly effective at mitigating the welfare effects of the Great Recession for agents who are poorer, less productive, lower ability, or older at the time of the shock. More-

over, we find that younger agents are the only group for which Social Security exacerbates the welfare losses due to the Great Recession. However, the exacerbating effect on these agents is small and a majority of it is eliminated if payroll taxes do not endogenously increase in response to macroeconomic conditions. The ability of Social Security to mitigate welfare losses for some of the most vulnerable demographic groups, without significantly exacerbating the welfare consequences of the shock for other agents, indicates that this program is a particularly effective at providing insurance for these types of shocks.

Despite the fact that Social Security effectively mitigates the welfare effects of the Great Recession for many potentially vulnerable agents, the welfare consequences of Social Security in the steady state are quite large compared to the mitigating benefits provided by the program during this type of a business cycle episode. Therefore, we also explore the welfare implications of a more targeted, scaled down program. In particular, we examine the welfare implications of a means-tested program, such as SSI, in which the benefits that agents receive are both smaller and unrelated to their individual lifetime income. Although we find that this smaller-scale program only mitigates the equivalent of 0.7% of expected future lifetime consumption for agents alive at the time of the shock (relative to 1.6% for the full-fledged Social Security program), the ex-ante welfare costs in the steady state are significantly reduced (1.2% versus 7.5% CEV). These results indicate that there is some scope for an adjustment of the Social Security program so that it effectively mitigates the welfare effects of large, adverse swing in economic activity for vulnerable agents, with much lower average long-run welfare costs. However, generally, when developing such programs, policy makers will still face a tradeoff between the coverage of the population for which the program mitigates the welfare effects of an adverse business cycle episode and the long-run welfare costs of such program.

# References

**Altonji, Joseph G.**, "Intertemporal Substitution in Labor Supply: Evidence from Micro Data," *The Journal of Political Economy*, 1986, *94* (3), S176–S215.

**Auerbach, Alan J. and Laurence J. Kotlikoff**, *Dynamic Fiscal Policy*, New York, NY: Cambridge University Press, 1987.

**Bell, Felicitie and Michael Miller**, "Life Tables for the United States Social Security Area 1900 - 2100," Actuarial Study 120, Office of the Chief Actuary, Social Security Administration 2002.

**Bricker, Jesse, Brian K. Bucks, Arthur Kennickell, Traci L. Mach, and Kevin Moore**, "Drowning or Weathering the Storm? Changes in Family Finances from 2007 to 2009," NBER Working Papers 16985, National Bureau of Economic Research, Inc 2011.

**Browning, Martin, Lars Peter Hansen, and James J. Heckman**, "Micro data and general equilibrium models," in John B. Taylor and Michael Woodford, eds., *Handbook of Macroeconomics*, Vol. 1, Part 1, Elsevier, 1999, chapter 8, pp. 543 – 633.

**Bruan, R. Anton, Karen Kopecky, and Tatyana Koreshkova**, "Old, Sick, Alone and Poor: A Welfare Analysis of Old-Age Social Insurance Programs," Working Paper, Federal Reserve Bank of Atlanta May 2013.

**Cahill, Kevin, Michael Giandrea, and Joseph Quinn**, "Reentering the Labor Force After Retirement," *Monthly Labor Review*, 2011.

**Case, Karl E. and Robert J. Shiller**, "Is There a Bubble in the Housing Market," Technical Report 1089, Cowles Foundation 2004.

**Chetty, Raj**, "Bounds on Elasticities with Optimization Frictions: A Synthesis of Micro and Macro Evidence on Labor Supply," Working Paper 15616, NBER December 2009.

**Coile, Courtney C. and Phillip B. Levine**, "Bulls, Bears, and Retirement Behavior," *Industrial and Labor Relations Review*, April 2006, pp. 408–429.

**Conesa, Juan Carlos and Dirk Krueger**, "On the Optimal Progressivity of the Income Tax Code," *The Journal of Monetary Economics*, October 2006, *53* (7), 1425–1450.

**_ , Sagiri Kitao, and Dirk Krueger**, "Taxing Capital? Not a Bad Idea After All!," *American Economic Review*, 2009, *99* (1), 25–38.

**Contreras, Juan and Sven Sinclair**, "Labor Supply Response in Macroeconomic Models: Assessing the Empirical Validity of the Intertemporal Labor Supply Response from a Stochastic Overlapping Generations Model with Incomplete Markets," MPRA Paper 10533, University Library of Munich, Germany September 2008.

**Domeij, David and Martin Floden**, "The Labor-Supply Elasticity and Borrowing Constraints: Why Estimates are Biased," *Review of Economic Dynamics*, 2006, *9* (2), 242 – 262.

**Engelhardt, Gary V. and Jonathan Gruber**, "Social Security and the Evolution of Elderly Poverty," Working Paper 10466, National Bureau of Economic Research May 2004.

**Fuster, Luisa, Ayse Imrohoroglu, and Selahattin Imrohoroglu**, "Elimination of social security in a dynastic framework," *Review of Economic Studies*, 2007, *74*, 113–145.

**Glover, Andrew, Jonathan Heathcote, Dirk Krueger, and Josè-Vìctor Rìos-Rull**, "Intergenerational Redistribution in the Great Recession," Technical Report September 2012.

**Gouveia, Miguel and Robert Strauss**, "Effective Federal Individual Income Tax Functions: An Exploratory Empirical Analysis," *National Tax Journal*, June 1994, *47* (2), 317–339.

**Hong, Jay and Josè-Vìctor Rìos-Rull**, "Social security, life insurance and annuities for familes," *Journal of Monetary Economics*, 2007, *54*, 118–140.

**Hubbard, R. Glenn**, "Uncertain Lifetimes, Pensions, and Individual Saving," NBER Working Papers 1363, National Bureau of Economic Research, Inc February 1988.

_ **and Kenneth L. Judd**, "Social Security and Individual Welfare: Precautionary Saving, Borrowing Constraints, and the Payroll Tax," *The American Economic Review*, 1987, *77* (4), pp. 630–646.

**Huggett, Mark and Gustavo Ventura**, "On the Distributional Effects of Social Security Reform," *Review of Economic Dynamics*, 1999, *2* (3), 498 – 531.

_ **and Juan Carlos Parra**, "How Well Does the U.S. Social Insurance System Provide Social Insurance?," *Journal of Political Economy*, 2010, *118* (1), pp. 76–112.

**Hur, Sewon**, "The Lost Generation of the Great Recession," Technical Report, University of Pittsburgh 2013.

**Imai, Susumu and Michael Keane**, "Intertemporal Labor Supply and Human Capital Accumulation," *International Economic Review*, May 2004, *45* (2), 601–641.

**Imrohoroglu, Ayse, Selahattin Imrohoroglu, and Douglas H. Joines**, "A life cycle analysis of social security," *Economic Theory*, 1995, *6*, 83–114.

_ **,** _ **, and** _ , "Time-Inconsistent Preferences and Social Security," *The Quarterly Journal of Economics*, 2003, *118* (2), 745–784.

**Imrohoroglu, Selahattin and Sagiri Kitao**, "Social Security Reforms: Benefit Claiming, Labor Force Participation, and Long-Run Sustainability," *American Economic Journal: Macroeconomics*, September 2012, *4* (3), 96–127.

**Kaplan, Greg**, "Inequality and the life cycle," *Quantitative Economics*, 2012, *3* (3), 471–525.

**Kitao, Sagiri**, "Sustainable Social Security: Four Options," Working Paper, Hunter College January 2012.

**Kopecky, Karen and Tatyana Koreshkova**, "The Impact of Medical and Nursing Home Expenses on Savings and Welfare," Working Paper, Federal Reserve Bank of Atlanta October 2013.

**Krueger, Dirk and Felix Kubler**, "Pareto-Improving Social Security Reform when Financial Markets Are Incomplete!?," *The American Economic Review*, 2006, *96* (3), 737–755.

**MaCurdy, Thomas E.**, "An Empirical Model of Labor Supply in a Life-Cycle Setting," *The Journal of Political Economy*, 1981, *89* (6), 1059–1085.

**Olovsson, Conny**, "Quantifying the risk-sharing welfare gains of social security," *Journal of Monetary Economics*, 2010, *57* (3), 364–375. authorCount :1.

**Peterman, William B.**, "An Extensive Look at Taxes: How does endogenous retirement affect optimal taxation?," Finance and Economics Discussion Series 2012-28, Board of Governors of the Federal Reserve System (U.S.) April 2012.

_ , "Reconciling micro and macro estimates of the Frisch labor supply elasticity," Finance and Economics Discussion Series 2012-75, Board of Governors of the Federal Reserve System (U.S.) October 2012.

_ , "Determining the motives for a positive optimal tax on capital," *Journal of Economic Dynamics and Control*, 2013, *37* (1), 265–295.

**Pingle, Jonathan**, "Social Security's delayed retirement credit and the labor supply of older men," Finance and Economics Discussion Series 2006-37, Board of Governors of the Federal Reserve System (U.S.) 2006.

**Pistaferri, Luigi**, "Anticipated and Unanticipated Wage Changes, Wage Risk, and Intertemporal Labor Supply," *Journal of Labor Economics*, 2003, *21* (3), 729–754.

**Rettenmaier, Andrew J. and Thomas R. Saving**, "How Generous Are Social Security and Medicare?," Policy Report 290, National Center for Policy Analysis October 2006.

**Rogerson, Richard and Johanna Wallenius**, "Micro and Macro Elasticities in a Life Cycle Model with Taxes," *Journal of Economic Theory*, 2009, *144* (6), 2277 – 2292. Dynamic General Equilibrium.

**Shiller, Robert J.**, "Social Security and Institutions for Intergenerational, Intragenerational and International Risk Sharing," Technical Report 1185, Cowles Foundation July 1998.

**Storesletten, Kjetil, Chris Telmer, and Amir Yaron**, "The risk sharing implications of alternative social security arrangements," GSIA Working Papers 252, Carnegie Mellon University, Tepper School of Business October 1998.

*The 2013 Long-Term Budget Outlook*

***The 2013 Long-Term Budget Outlook**, Technical Report, Congressional Budget Office September 2013.*