A Historical Welfare Analysis of Social Security: Whom Did the Program Benefit?*

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Abstract

A well-established result in the literature is that Social Security reduces steady state welfare in a standard life cycle model. However, less is known about the historical quantitative effects of the program on agents who were alive when the program was adopted. In a computational life cycle model that simulates the Great Depression and the enactment of Social Security, this paper quantifies the welfare effects of the program's enactment on the cohorts of agents who experienced it. In contrast to the standard steady state results, we find that the adoption of the original Social Security generally improved these cohorts' welfare, in part because these cohorts received far more benefits relative to their Social Security contributions than what they would have received if they lived their entire life in the steady state with Social Security. Moreover, the standard negative general equilibrium welfare effect of Social Security associated with capital crowd-out was also smaller during the transition than in the steady state, largely because it took many periods for agents to adjust their savings levels in response to the program's adoption. The opposite welfare effects experienced by agents in the steady state versus agents who experienced the program's adoption might offer one explanation for why a program that potentially reduces welfare in the steady state was originally adopted.

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"We can never insure one hundred percent of the population against one hundred percent of the hazards and vicissitudes of life, but we have tried to frame a law which will give some measure of protection to the average citizen and to his family against the loss of a job and against poverty-ridden old age."

F.D. Roosevelt during the signing of The Social Security Act of 1935

1 Introduction

Social Security was implemented in the midst of the Great Depression, and represented the largest U.S. social insurance program at the time. While Social Security has been shown to generally mitigate welfare losses during deep economic downturns (Peterman and Sommer (2014)), a large quantitative macro literature largely finds that the current program reduces steady state welfare in general equilibrium models. The findings from these studies raise a question why the program—given its welfare costs in the steady state—was implemented in the first place. To this end, our paper uses a general equilibrium, heterogeneous-agents life cycle model to quantitatively examine the welfare effects of the Social Security program's adoption on the original cohorts of agents who experienced it. In particular, we ask three questions. First, what were the overall welfare effects on individuals who were alive at the program's adoption? Second, who were the winners and losers from the program's enactment? And third, what were the main channels through which the adoption of the original program affected welfare?

We examine these questions in three steps. First, we build a rich, heterogeneous agent, general equilibrium life cycle model with endogenous labor and retirement that matches the U.S. economy just before the Great Depression and the enactment of the original Social Security program. Second, we introduce two sudden and unexpected shocks—the Great Depression and the subsequent adoption of the original Social Security—and calculate the transition path to a new, post-Great Depression steady state with Social Security fully phased in. Third, along the transition path, we study the welfare of the original cohorts of agents who lived through the Great Depression and the subsequent enactment of Social Security, and compare it to the welfare of agents who experienced a counterfactual transition path where the Great Depression occurs but Social Security is not adopted.

We measure the welfare effects of the original Social Security in two distinct ways. First, we determine the likelihood of a welfare gain from the adoption of Social Security for the original cohorts. Second, we calculate the average size of the welfare gains for agents in these cohorts. In contrast to the standard steady state results, our quantitative experiments suggest that the original program benefited a vast majority of agents who were alive at the time of the program's enactment, with the average welfare effect being large and the gains being widespread. In particular, we estimate that the original program benefited households alive at the time of the program's adoption with a likelihood of almost 90 percent, and increased these original agents' welfare by the equivalent of 5.7% of their expected future lifetime consumption. These welfare benefits were particularly large for working-age individuals near retirement and also for agents with relatively less savings.

In the spirit of economic insights derived from simple two-period models dating back to Samuelson (1958) and Diamond (1965) (for a summary see Feldstein and Liebman (2002)), we find that the opposite welfare effect experienced by the transitional agents versus those in the steady state is in part because transitional agents generally received larger Social Security benefits relative to their contributions than what they would have received if they lived their entire life in the steady state with Social Security.[1] For example, a transitional agent who retired five years after the inception of Social Security would face a lifetime payroll tax burden that was approximately 95 percent lower than that of an agent who lived their whole lifetime with Social Security, but would be entitled to a social Security benefit that was only 40 percent lower. The original cohorts contributed relatively less into the Social Security system for two primary reasons. First, the payroll tax rates were introduced at a low level and gradually scaled up over a number of years. Second, the original cohorts did not start paying into the system until the program was adopted, part way through their life. In contrast, the benefits were fully adopted immediately, resulting in total Social Security benefits that were considerably more generous relative to the contributions for these original cohorts.

Moreover, the standard negative general equilibrium welfare effect of Social Security associated with capital crowd-out were also smaller during the transition than in the steady state. This is

[1] As discussed in Feldstein and Liebman (2002), in a simple 2-period dynamically efficient economy with a capital stock, it can be shown that the initial generations receive a consumption windfall from Social Security while the future generations lose. These subsequent generations' consumption losses are caused by an implicit rate of return on payroll taxes that is lower than the return agents would earn by investing those funds in the capital stock. Moreover, in a simple economy that is operating at a first-best equilibrium, it can be shown that the present value of the consumption losses of all current and future working generations is equal to the windfall consumption that the initial retirees receive.

because it took many periods for agents to adjust their savings levels in response to the program's adoption, so the crowd out of capital took a long period of time to be fully realized. Thus, along the transition, the general equilibrium effect merely mutes the overall welfare gain from the program's adoption for the original cohorts.

Interestingly, and perhaps counter to simple intuition, we find that adopting the program during the Great Depression in fact tapered the welfare benefits from the program for the original cohorts. At first blush, one might be tempted to think that the Great Depression could have bolstered the welfare gains because the insurance from the Social Security benefits would be more valuable during the Great Depression when large amounts of wealth and income were lost. On the other hand, imposing a payroll tax on agents during the Great Depression when agents suffered from tighter budget constraints due to the adverse shock could lower the welfare gains from the program's adoption. On balance, we find that this latter channel dominates because most agents who were eligible for Social Security did not receive Social Security benefits for many years to come, but had to start funding the system immediately.

This paper is related to three strands of the existing literature. The first strand measures the long-run welfare effects of Social Security. These works generally weigh the relative benefit from Social Security providing partial insurance for risks for which no market option exists against the welfare costs of the distortions to an individual's incentives to work and save that the program imposes. Specifically, these studies examine the benefit from (i) providing intra-generational insurance for idiosyncratic risk from earnings and mortality (e.g., Hubbard and Judd (1987), Hubbard (1988), Imrohoroglu et al. (1995), Storesletten et al. (1998), Huggett and Ventura (1999), Imrohoroglu et al. (2003), Huggett and Parra (2010), and Imrohoroglu and Kitao (2012)), (ii) intergenerational insurance for aggregate risk (Krueger and Kubler (2006)), or (iii) both (Harenberg and Ludwig (2013)).[2,3] With a few exceptions, these studies generally find that Social Security is not welfare improving once general equilibrium effects of capital crowd-out are considered.[4]

[2]In studies with aggregate risk, there is no longer a deterministic steady state since different realizations of the aggregate shock will affect the economy. Thus, these studies either provide the range of welfare effects across different realizations of the potential paths for the aggregate shock, or the welfare effects under a particular sequence of shocks.

[3]Huggett and Ventura (1999), Huggett and Parra (2010) and Imrohoroglu and Kitao (2012) are examples of studies that considered welfare effects of reforms to the current program.

[4]Two notable exceptions are Imrohoroglu et al. (2003) and Harenberg and Ludwig (2013). Imrohoroglu et al. (2003) shows that when preferences are time-inconsistent then the benefits of Social Security can outweigh the costs. In another work, Harenberg and Ludwig (2013) find that Social Security can be welfare improving when both id-

Similar to these papers, we quantify the welfare consequences of Social Security. However, this study is different in that it focuses on the welfare implications of Social Security over the transitional period after the program is adopted, as opposed to focusing on steady state effects once the program is well established.

The second, related strand of literature extends the steady state analysis with a study of transitional welfare after Social Security is either adopted, eliminated, or reformed (e.g., Auerbach and Kotlikoff (1987), Conesa and Krueger (1999), Krueger and Kubler (2006), Fuster et al. (2007), Olovsson (2010), Hong and Rìos-Rull (2007) and Kitao (2014)).[5] The two papers most closely related to our study are Auerbach and Kotlikoff (1987) and Krueger and Kubler (2006). These papers find that although a general Social Security program reduces steady state welfare, adopting the program can increase welfare for cohorts alive at the time of the program's introduction.[6] Our paper contributes to this literature by focusing in detail on the adoption of the original program in a historically consistent model that allows us to quantify how the law and economic background interacted in affecting welfare. Moreover, unlike these previous studies, our model incorporates idiosyncratic risk, thereby allowing us to assess how the welfare effects from the adoption of the program differed not only between cohorts but also agents within the same cohort.

Finally, our study is related to empirical literature that measures the average internal rate of return (ROR) of Social Security. This rate equalizes the present discounted value of the total average taxes paid and the average benefit payments for a given birth cohort. Consistent with our paper, these studies find the ROR from Social Security were the largest for cohorts already alive at the time when the program was adopted (see, for example, Leimer (1994), Leimer (2007), or Murphy and Welch (1998)). There are several differences between our paper and the ROR calculations. First, the ROR examines the average effect on each cohort, as opposed to distribution

iosyncratic and aggregate risks are present, but they generally consider a program that is quite small by historical standards.

[5] Instead of studying the adoption or elimination of the program, Olovsson (2010), and Kitao (2014) consider a transition to a reformed system, so the welfare consequences and transitional dynamics from these studies are not as comparable to our exercise.

[6] The studies which have examined a repeal or a reform that reduces the size of the existing Social Security system frequently find transitional welfare losses for the existing generations, even when the repeal or reform is welfare-improving in the long run. One notable exception is Fuster et al. (2007) who quantify the welfare effects of the US Social Security system in a two-sided altruism framework and compute the transitional dynamics implied by different reforms that eliminate social security. That paper concludes that a reform that finances the existing social security claims with debt and consumption taxes would benefit most individuals alive at the moment of the reform.

of the effects within a cohort. Second, the ROR is not a utility-based measure. Since the ROR strictly captures the extent to which each cohort has received or can be expected to receive more or less resources from Social Security than it contributed to it, it does not reflect all the welfare effects of Social Security, such as welfare benefits from insurance and welfare cost from the payroll tax exacerbating liquidity constraints.[7]

This paper is organized as follows. Section 2 introduces the computational model. Section 3 presents the dynamic programming problem. Section 4 describes parametrization of the steady state economies, and compares the initial steady state without Social Security to the available pre-Depression U.S. data. In Section 5, consistent with historical experience, we parameterize the economic shocks associated with the Great Depression and the phase-in of the original Social Security program, and—where possible—compare the simulated transitional path to the historical data. In Section 6, we describe our computational experiment, define our welfare measure, present our welfare findings, and provide some sensitivity analyses. Section 7 concludes.

2 Model

Our framework is a general equilibrium, life cycle economy with overlapping generations of heterogeneous agents, uniquely built and calibrated to quantify the welfare effects of the adoption of the original Social Security program on agents who were alive at the time of the program's adoption. The initial steady state is calibrated to the U.S. economy prior to the Great Depression in which no Social Security exists. We then introduce the Great Depression, after which the economy transitions on a perfect foresight path. However, this path is altered by a second unexpected shock, the introduction of Social Security. Thus, the final steady state represents the U.S. economy after a transition through the Great Depression and the adoption of Social Security in accordance with historical law.

[7]The ROR and welfare frameworks also use different bases of comparison. The welfare calculation compares the welfare in an economy where Social Security exists to welfare in a counterfactual economy without Social Security, and consequently also incorporates the differential general equilibrium effects between these environments. In contrast, the ROR simply compares Social Security taxes paid versus benefits received in an environment where the program exists, without accounting for the general equilibrium effects.

2.1 Demographics

Time is assumed to be discrete, and the model period is equal to one year. Agents, indexed by age j, enter the model when they start working at an exogenously given age $j = 0$, and live up to a maximum possible age of $j = J$. Thus, in each period, the economy is populated by J overlapping generations of individuals of ages $j = 0, ..., J$. 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 Ψ_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. Agents endogenously choose the age R at which the retire. The binary decision to retire (i.e., $I = \{0, 1\}$ where $I = 1$ denotes the event of retirement) is considered irreversible and is restricted to be within the age range of $[\underline{R}, \overline{R}]$.

2.2 Endowments, Unemployment, Preferences and Market Structure

In each period, an agent is endowed with time that can be used for leisure or market work. An agent's labor earnings are given by $y = w\omega h(1-D)$, where w represents the wage rate per efficiency unit of labor; h is the fraction of the available time endowment spent on labor market activities; D is the fraction of the time endowment in each period that the agent is exogenously unemployed; and ω_t is the idiosyncratic labor productivity which follows the process: $\log \omega = \theta_j + \alpha_0 + \nu$. In this specification, θ_j governs the deterministic age-profile of productivity; and $\alpha_0 \sim NID(0, \sigma_\alpha^2)$ is an individual-specific fixed ability type that is observed when an agent enters the economy and stays fixed for an agent over the life cycle. Finally, ν is a persistent shock, received each period, which follows a first-order autoregressive process: $\nu = \rho\nu_{-1} + \psi$, with $\psi \sim NID(0, \sigma_\nu^2)$ and $\nu_0 = 0$. The exogenous independent and identically distributed unemployment shock, D, is discretized to two values: zero and $d \in (0, 1]$. The positive value d, which indicates an unemployment spell, arrives with a probability p^U and thus, by construction, the probability of not experiencing an unemployment spell within a period is $(1 - p^U)$. If the unemployment spell hits, the agent loses the option to work during d percent of their time endowment.

Following Kaplan (2012), an agent's preferences over the life cycle are a governed by the time-separable utility function:

$$E_0 \sum_{j=0}^{J} \beta^j (u(c) + v(h, D)), \tag{1}$$

where c is the stream of consumption; h is the percent of the available time endowment an agent chooses to work; D is the percent of the time endowment that is unavailable for work due to an unemployment spell; and β is the discount factor. Expectations are taken with respect to the life-span uncertainty, the idiosyncratic labor productivity risk, and the unemployment risk.

Agents can hold savings in the form of assets, $a \geq 0$. Agents choose to save for two reasons. First, they save to partially insure against idiosyncratic labor productivity, unemployment, and mortality risks. Moreover, they save in order to help fund their post-retirement consumption. Once Social Security is adopted, the program provides another source of funds for post-retirement consumption.

2.3 Technology

Firms are perfectly competitive with constant returns to scale production technology. Thus, we use a representative firm with a Cobb-Douglas production function $Y = F(A, K, N) = AK^{\zeta}N^{(1-\zeta)}$, where A, K, N, and ζ are aggregate Total Factor Productivity (TFP), capital, labor, and the capital share of output, respectively. Capital depreciates at a constant rate $\delta \in (0, 1)$. The firm rents capital and hires labor from agents in competitive markets, where factor prices r and w are equated to their marginal productivity. The aggregate resource constraint is: $C + K' - (1 - \delta)K + G \leq AK^{\zeta}N^{1-\zeta}$ where, in addition to the above described variables, C and G represent aggregate household and government consumption, respectively.

2.4 Government Policy

The government distributes accidental bequests to the living in a form of lump-sum transfers, Tr, and consumes in an unproductive sector.[8] Government consumption, G, is exogenously determined, and is modeled as proportional to the total output in the steady state economy, so that $G = \phi Y$. The level of government consumption is determined in the steady state without Social

[8]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.

Security and is held constant throughout the transition. Once Social Security is enacted, the government additionally collects a proportional Social Security tax, τ^{ss}, on pre-tax labor income of working-age individuals (up to an allowable taxable maximum $\bar{y}$) to finance Social Security payments, b^{ss}, for retired workers.

The government taxes income according to a schedule $T(\tilde{y})$ in order to raise revenue to finance its consumption in the unproductive sector. The taxable income, $\tilde{y}$, is defined as: $\tilde{y} = y + r(Tr + a) - 0.5\tau^{ss}\min\{y, \bar{y}\}$. The part of the pre-tax labor income (y) that is accounted for by the employer's contributions to Social Security, ($0.5\tau^{ss}\min\{y, \bar{y}\}$), is not taxable. In the benchmark steady state with no Social Security, τ^{ss} is set to zero.

Similar to the current system, the original Social Security benefits were calculated as an increasing, concave, piecewise-linear function of worker's average level of lifetime labor earnings. However, the original program was considerably less progressive, with the benefits formula being governed by a single bend point and two marginal replacement rates. Unlike the current program, the original Social Security benefits were also adjusted for the number of years in which an individual contributed payroll taxes, and the benefits were disbursed only after an agent reached the normal retirement age (NRA) of 65.[9]

In the final steady state with Social Security, Social Security benefits are calculated in three steps. First, we compute each worker's average level of labor earnings over the working life cycle, x_R. At every age, the total accumulated earnings follow the law of motion:

$$x_{j+1} = \frac{\min\{y_j, \bar{y}\} + (j-1)x_j}{j}, \tag{2}$$

where x_j is the accounting variable capturing the equally-weighted average of earnings before the endogenously chosen retirement age R; and $\bar{y}$ is the maximum allowable level of labor earnings subject to the Social Security tax that corresponds to the benefit-contribution cap.[10] Second, for each retiree, the pre-adjustment Social Security benefit, b^{ss}_{base}, is calculated using a convex,

[9]The current system has two bend points and three marginal replacement rates. Moreover, it allows individuals to claim Social Security benefits prior to reaching their NRA. Finally, there are no adjustments to the Social Security benefits for the number of years worked; rather, only the top thirty years of income are considered.

[10]If an agent chooses to retire prior to the NRA, then their average earnings for non-working years prior to reaching the NRA are populated with zero. Additionally, if an agent chooses to work past the NRA then the additional years worked past the NRA are factored into their lifetime average earnings from which the ultimate Social Security benefits are computed.

piecewise-linear function of average past earnings observed at retirement age, x_R. The function allows the marginal replacement rate to vary over three levels of taxable income:

$$\begin{aligned} &\tau_{r1} && \text{for} \quad 0 \leq x_R < b_1 \\ &\tau_{r2} && \text{for} \quad b_1 \leq x_R < b_2 \\ &0 && \text{for} \quad x_R \geq b_2. \end{aligned} \tag{3}$$

The parameter b_1 is the first bend point; the parameter b_2 is the benefit-contribution cut-off point ($b_2 = \bar{y}$); and the parameters $\{\tau_{r1}, \tau_{r2}\}$ represent the marginal replacement rates for the pre-adjustment Social Security benefit.

Finally, an adjustment is made to the benefits to account for the number of years of payroll tax contributions. In particular, for each year that agents pay payroll taxes, their benefits are scaled up by the equivalent of one percent. As a result, the total Social Security benefit, b^{ss}, received by the retiree is defined as:

$$b^{ss} = b^{ss}_{base} \times (1 + \frac{R}{100}). \tag{4}$$

However, the benefit is subject to a minimum and a maximum, such that $b^{ss} \in [b^{ss}_{min}, b^{ss}_{max}]$.

3 Dynamic Program

For expositional convenience, this section introduces the dynamic program of an individual who enters the economy in the final steady state with Social Security. We present two separate dynamic programming problems: one for an agent who was not yet retired in the previous period, and one for an agent who was retired. In the initial steady state without Social Security, the dynamic programming problem is simplified by setting τ^{ss} and b^{ss} to zero. Appendix A provides a formal definition of the market equilibrium and the balanced growth path.

An agent who was not retired in the previous period and is indexed by type $(a, x, \alpha, \nu, j, D)$ solves the dynamic program:

$$V(a,x,\alpha,\nu,j,D) = \begin{cases} \max_{c,a',h}(u(c) + v(h,D)) + \beta s_j EV'(a',x',\alpha,\nu',j+1,D') & \text{if} \quad j \leq \underline{R}, \\ \max_{c,a',h,I=\{0,1\}}(u(c) + v(h,D)) + \beta s_j EV'(a',x',\alpha,\nu',j+1,D') & \text{if} \quad \underline{R} < j \leq \overline{R}, \end{cases} \tag{5}$$

subject to

$$
\begin{aligned}
c+a' &= (1+r)(Tr+a)+y-T(\tilde{y})-\tau^{ss}\min\{y,\bar{y}\} \quad &\text{if} \quad I=0,\\
c+a' &= (1+r)(Tr+a)-T(\tilde{y})+b^{ss} \quad &\text{if} \quad I=1.
\end{aligned}
\tag{6}
$$

by choosing consumption, $c > 0$, savings, $a' \geq 0$, the fraction of available time endowment spent on working, h, and whether to permanently retire, $I \in \{0,1\}$. Agents earn interest income $r(Tr+a)$ on the lump-sum transfer from accidental bequests, Tr, and on asset holdings, a. y represents the pre-tax labor income of the working agents and $\tilde{y}$ defines the taxable income on which the income tax, T, is paid. $D \in \{0,d\}$ is the state variable for the fraction of the period an agent is exogenously unemployed. The Social Security tax rate, τ^{ss}, is applied to the pre-tax labor income, y, up to an allowable taxable maximum, $\bar{y}$, and b^{ss} denotes the individual-specific constant Social Security benefit that is received by retired agents every period after reaching the NRA.

Retired agents are no longer affected by labor productivity or unemployment shocks because they no longer work. As such, a retired agents indexed by type (a,b^{ss},j) solves the dynamic program:

$$V_t(a,b^{ss},j) = \max_{c,a'} u(c)+\beta s_j EV'(a',b^{ss},j+1), \tag{7}$$

subject to

$$c+a' = (1+r)(Tr+a)+b^{ss}-T(\tilde{y}), \tag{8}$$

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. These agents who are older than the NRA also receive the constant per-period Social Security payment, b^{ss}, once the program is implemented.

4 Steady State Calibration

We begin by calibrating the initial steady state that excludes Social Security. Thus, to the extent that reliable data are available, we directly use historical data prior to the Great Depression and the subsequent adoption of the original Social Security program to parameterize the model. The remaining parameters in the model are calibrated such that the model reproduces key moments of the pre-Depression U.S. data. After calibrating the benchmark economy without Social Security, we parameterize the original Social Security program and compute the final steady state while keeping all other non-Social Security parameters constant. Table 1 summarizes the parameters used to parameterize the initial steady state. Table 2 parameterizes the original Social Security program.

Table 1: Parameters Used to Parameterize the Initial Steady State

Exogenous Parameters	**Value**	**Data Source**
Normal Retirement Age: NRA	65	U.S. SS Program
Minimum Retirement Age: $\underline{R}$	60	By Assumption
Maximum Retirement Age: $\overline{R}$	85	By Assumption
Maximum Age: J	93	By Assumption
Age-Specific Survival Probabilities: Ψ_j		Bell and Miller (2002)
Population Growth: n	1.6%	Conesa et al. (2009)
Capital Share Parameter: ζ	.32	Piketty and Saez (2003)
Total Factor Productivity: A	1	Normalization
Risk Aversion: γ	2	Conesa et al. (2009)
Frisch Elasticity: σ	0.5	Intensive Frisch= $\frac{1}{2}$
Disutility of Unemployment: ξ	0.00	Kaplan (2012)
Persistence Shock: σ_v^2	0.007	1940 Census
Persistence: ρ	0.990	1940 Census
Permanent Shock: σ_α^2	0.437	1940 Census
Unemployment Rate: p^u	4.1%	NBER Unemployment Series
Unemployment Duration: d	0.30	Palmer (1937)
Government Spending in Unproductive Sector: ϕ	2.8%	BEA
Tax Exemption Parameter: Υ_1	Avg. Earnings	Tax Policy Center
Endogenous Parameters	**Value**	**Target**
Determined through Calibration:		
Capital Depreciation Rate: δ	6.90%	$\frac{I}{Y} = 25.5\%$
Conditional Discount: β	0.993	$\frac{K}{Y} = 3.0$
Disutility to Labor: χ_1	72.9	Avg. h_j = .282
Fixed Cost to Working: χ_2	0.489	14.3% retired at age 65
Determined through Market Clearing:		
Income Tax Rate: Υ_0	0.128	Market Clearing

Notes: Ages are denoted in real world ages as opposed to model ages.

4.1 Demographics, Endowments, Unemployment Risk and Preferences

There are 74 overlapping generations of individuals of real-life ages ranging between 20 (i.e., $j = 0$) to 93 (i.e., $J = 74$). The population growth rate, n, is set to 1.6 percent to match the average U.S. annual population growth (reported by the Census Bureau) from 1920 through 1928. The conditional survival probabilities, Ψ_j, are derived from the U.S. life tables for the 1930s (Bell and Miller (2002)). To increase the computational tractability of the model, the minimum and

Table 2: Additional Parameters Used to Parameterize the Final Steady State

Exogenous Parameters	**Value**	**Data Source**
Marginal Replacement Rate: τ_{r1}	40%	U.S. SS Program
Marginal Replacement Rate: τ_{r2}	10%	U.S. SS Program
Bend Point: b_1	.57 x Avg Earnings	U.S. SS Program & NBER
Social Security Benefit-Contribution Cut-off: $\bar{y}^{***}$	2.84 x Avg Earnings	U.S. SS Program & NBER
Minimum Social Security Benefit: b^{ss}_{min}	0.11 x Avg Earnings	U.S. SS Program & NBER
Maximum Social Security Benefit: b^{ss}_{max}	0.97 x Avg Earnings	U.S. SS Program & NBER
Endogenous Parameters (Determined through Market Clearing)	**Value**	**Target**
Payroll Tax: τ^{ss}	4.46%	Market Clearing

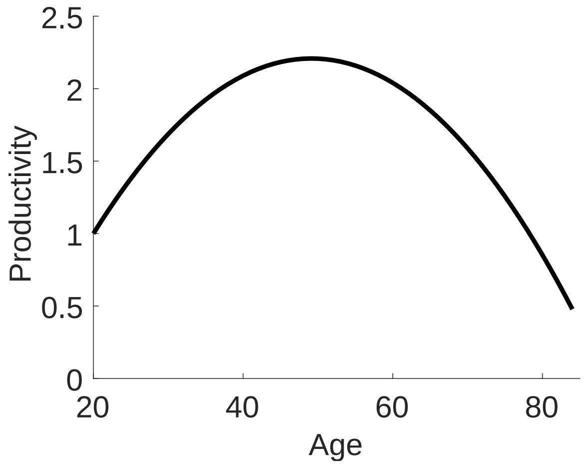
maximum ages at which an agent is allowed to retire ($\underline{R}$ and $\overline{R}$) in the model are set at a real world age of 60 (i.e., $j = 41$) and 85 (i.e., $j = 66$), respectively.[11]

Ideally, to calibrate the wage process, we would rely on panel data on wages. However, such historical data are not available. Given the lack of data, we follow Conesa et al. (2009) in calibrating the process for the labor productivity, ω, based on cross-sectional wage data from the 1940 Census.[12] We restrict the estimation sample to male household heads who were between ages 20 and 64, worked at least five weeks, and worked more than 1,248 hours over the year. To pin down the deterministic age-specific productivity profile, we regress natural log of average wages on a quadratic polynomial of age, and normalize the exponential transformation of this profile to one at the real world age of 20. This exponential transformation is shown in Figure 1. Having calibrated the deterministic age-profile, we next use the age-specific variance of the natural log of wage by age (shown in Figure 2) to infer the parameter values for the permanent and persistent shocks to the individuals' productivity. First, we set the variance of the permanent shock, σ^2_α, to 0.437 in order to match the minimum variance of the natural log of wages between ages 20 and 30 in the data. Second, turning to the persistent productivity shock, we set $\rho = 0.990$ to match the linear growth of the variance in wages over the life cycle, depicted by the solid line in Figure 2. Finally, we set

[11] Constraining the binary retirement decisions to 25 years reduces number of periods in which such decisions are made, thereby reducing the state space. That said, disallowing agents from retiring prior to age 60 in the model does not seem to be inconsistent with the data, as less than 10 percent of all male household heads were reported out of labor force in either the 1920 or the 1930 Census.

[12] Ideally, the productivity process would be calibrated from data prior to the Great Depression and the implementation of Social Security. Unfortunately, to the best of our knowledge, such data are not readily available prior to 1940. To reduce the effects of the adoption of Social Security in 1940 on our estimates, our analysis focuses on observations for individuals who were younger than the NRA in 1940. However, we are unable to control for the effects that the adoption of Social Security might have had on labor supply and wage dynamics of younger individuals.

Figure 1: Deterministic Age Profile of Productivity



Note: The data are from the 1940 Census. This deterministic age profile is calculated from a regression of average hourly earnings on a quadratic polynomial and normalized to 1 at age 20.

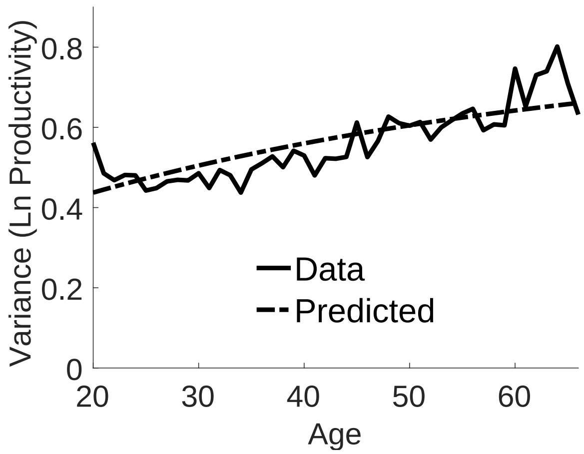
σ_v^2 so that its calibrated value minimizes the sum of squared percentage deviations between the empirical and simulated variance of wages at each age (plotted in Figure 2). In order to solve the model, we discretize the permanent and persistent shock with two and five states, respectively.[13]

To calibrate the unemployment shock we rely on the best available data which is the Philadelphia Labor Survey (Palmer (1937)), a historical survey of the Philadelphia labor market from 1929 to 1937. Using the 1929 data, we calibrate the unemployment shock $D \in \{0, d = 0.3\}$, so that each agent hit by an unemployment spell spends thirty percent of the period being involuntary unemployed. The unemployed agent can spend the remaining 70 percent of the period on work and leisure. Turning to the probability of an unemployment shock, we set p^U to match the national average unemployment rate of 4.1 percent over the period 1945-1950 in the NBER unemployment series.[14] Thus, agents have a 4.1 percent chance of being unemployed at any given time, with the unemployment spell lasting for 30 percent of the year.

[13]Given the highly persistent process, we use the Rouwenhorst method to discretize the productivity process.

[14]The NBER series compiles estimates from several different sources. The 1929-1944 estimates are based on Conference Board data, whereas the 1945-1946 estimates are from Census Bureau's "Current Population Reports." Finally, the estimates from 1947-1950 are from U.S. Bureau of Labor Statistics's "Employment and Earnings and Monthly Report on the Labor Force." See http://www.nber.org/databases/macrohistory/contents/chapter08.html for more details. The average estimate for the 1945-1950 period is fairly close to the available estimates for 1929 of about 3 percent from Darby (1975) and Lebergott (1964).

Figure 2: Unconditional Variance of Natural Log of Productivity



Note: The data are from the 1940 census. The variance from the data is calculated as the variance in average hourly earnings for each cohort.

In spirit of Kaplan (2012), household preferences are modeled as:

$$u(c)+v(h,D)=\frac{c^{1-\gamma}}{1-\gamma}-\chi_1\frac{((1-D)^{\xi}h)^{1+\frac{1}{\sigma}}}{1+\frac{1}{\sigma}}-\chi_2(1-I), \tag{9}$$

with the binary indicator $I=1$ denoting whether an agent is retired in the current period. The constant relative risk aversion preferences over consumption are characterized by the risk aversion coefficient, γ, which determines an agent's desire to smooth consumption across time and states. The existing estimates of γ (though generally based on more recent data) typically range between 1 and 3. Given the lack of historical estimates, we set $\gamma=2$ which is consistent with Conesa et al. (2009). The parameter σ represents the Frisch labor supply elasticity on the intensive margin. Past microeconometric studies estimate the Frisch elasticity to be between 0 and 0.5.[15] However, more recent research shows that these estimates may be biased downward.[16] We calibrate σ to 0.5—the upper range of the available estimates.

The parameter ξ determines the flow of disutility an agent receives during unemployment spells. In particular, when $\xi=1$ then an agent derives no disutility during unemployment spells

[15]See, for example, Kaplan (2012), Altonji (1986), MaCurdy (1981), Domeij and Floden (2006) or Browning et al. (1999).

[16]See Imai and Keane (2004), Domeij and Floden (2006), Pistaferri (2003), Chetty (2009), Contreras and Sinclair (2008), and Peterman (2016).

(i.e., time spent unemployed is treated equivalent to leisure). However, when $\xi < 1$ then time spent in unemployment is no longer equivalent to leisure. Consistent with estimates in Kaplan (2012), we set $\xi = 0$, meaning that the disutility experienced during an unemployment spell is proportional to the disutility from working experienced by an agent during employment.[17]

The remaining parameters are calibrated endogenously to match external data moments. Specifically, the scaling constant χ_1 is calibrated such that, agents spend on average 28.2 percent of their time endowment working prior to reaching the NRA, corresponding to the 1940 Census in which male household heads worked on average 1,760 hours per annum.[18] Additionally, consistent with the 1930 Census, the fixed cost of working, χ_2, is calibrated so that 14.3 percent of male head of households retire by the NRA.[19] The fixed cost $\chi_2 > 0$ implies that the disutility from working discontinuously increases when an agent goes from zero to positive hours worked. This discontinuity allows the model to match both estimates of the Frisch elasticity on the intensive margin and also the percent of agents retired at the normal retirement (see Rogerson and Wallenius (2009) for further discussion.) Finally, the discount factor, β, is calibrated to 0.993 to endogenously match the U.S. capital-to-output ratio of 3.0.[20]

4.2 Firm

The aggregate production function is Cobb-Douglas. The capital share parameter, $\zeta = 0.32$, is set to match the 1929-1930 average value drawn from Piketty and Saez (2003) (see their Figure 6). The depreciation rate is calibrated such that the investment to output ratio is 25.5 percent, as reported by the BEA in 1929 and 1930. TFP parameter, A, is normalized to unity in the baseline steady state, but varies along the transitional path in accordance with data (see Section 5).

[17]Kaplan (2012) estimates $\xi = -0.08$ but not statistically different from zero. Kaplan (2012) estimates ξ, along with γ and σ using the PSID data. The estimates for γ and σ are also in line with the calibration values we use in the model.

[18]Ideally hours would be calibrated to the data prior to the implementation of Social Security. However, hours data are not available from the Census until 1940. In order to get around the effects of Social Security on hours, we calibrate to hours worked for individuals who are too young to be eligible to collect Social Security benefits.

[19]Given that the Census data for this period does not directly report retirement status, individuals who are not in the labor force in the Census data are considered retired. This assumption seems reasonable since less than five percent of households under the age of 55 are reported as not in the labor force.

[20]Capital is calculated as the sum of private fixed assets and consumer durables reported by the Bureau of Economic Analysis. The values are not reported prior to 1929. However, the ratio is centered around 3 from 1929 through 1931.

4.3 Government

Government spending in the unproductive sector, ϕ, is set to 2.8 percent of GDP, consistent with the ratio of Federal Government expenditures to GDP reported by the BEA in 1929 and 1930. Turning to the income tax function, in the 1930s, the federal tax policy was much less progressive than the current system. In particular, a large fraction of taxable income was tax-exempt, and the rest of the income was subject to a fairly flat tax schedule with relatively low marginal rates.[21] Consequently, close to 50 percent of tax returns had zero or negative tax liability in the 1930s.[22] Thus, we model the stylized income tax policy as:

$$T(\tilde{y}_t; \Upsilon_0, \Upsilon_1) = \Upsilon_0 \max\{\tilde{y}_t - \Upsilon_1, 0\}, \tag{10}$$

where Υ_0 is the flat marginal tax rate and Υ_1 controls the level of the tax exemption. Υ_1 is calibrated so that 50 percent of tax filers do not pay any taxes in the initial steady state. Moreover, we calibrate Υ_0 such that the government budget constraint clears. We find that the marginal rate of 12.8 percent clears the government's budget, implying an average tax rate of 4 percent. This rate is generally consistent with the average historical income tax rates (defined as ratio of the total income to the total tax liability), which varied between 2.6 and 4.3 percent from 1923-1930 according to the from the Tax Policy Center.[23]

4.4 Social Security

In the final steady state with Social Security, we set the NRA to 65 and set marginal replacement rates (τ_{r1}, τ_{r2}) to their respective historical values of 0.4 and 0.1. Similarly, in the spirit of Huggett and Parra (2010), we set the bend point (b_1), the maximum earnings $(\bar{y})$, the maximum benefit (b^{ss}_{max}), and the minimum benefit (b^{ss}_{min}) so that they occur at 0.57, 2.84, 0.97, and 0.11 times mean

[21] The first \$2,500 of income for married households and \$1,000 for single filers was tax-exempt. Moreover, the marginal tax rate for the part of the first \$4,000 of income that was not exempt was flat at four percent, and then increased only very gradually for higher income. These exemption levels and the limit on the first tax bracket were quite high compared to the mean individual income of \$1,054 in 1929 (calculated from the Macroeconomic historical data from the National Bureau of Economic Research).

[22] Source: Tax Foundation (http://taxfoundation.org/article/federal-individual-income-tax-returns-zero-or-negative-tax-liability-1916-2010)

[23] See http://www.taxpolicycenter.org/taxfacts/displayafact.cfm?DocID=564&Topic2id=30&Topic3id=39

earnings in the economy.[24] In the final steady state, we set $\tau^{ss} = 0.045$, so that the Social Security program's budget is balanced.[25]

4.5 A Comparison of the Baseline Steady State Economy to the U.S. Data

As an external test of our benchmark steady state model, it is helpful to compare some of the endogenously generated moments summarizing households' retirement and savings decisions to the available historical data. Although limited by data, we are able to do two checks. Figure 3 plots the fraction of male household heads age 60+ who are not in the labor force in the data against the fraction of retired agents in the initial steady state without Social Security. Even though in the calibration we only directly target the fraction of retired households at age 65 (14.3 percent), the fraction of retired households endogenously generated by the model (the black dashed line) looks remarkably similar to the data (the black solid line) across most of the age range. The baseline model also generates a wealth to income ratio of 3.83, which is consistent with the estimate of the ratio of 3.79 for the ten years prior to the Great Depression from Saez and Zucman (2016).[26] Overall, the ability of the model to endogenously generate retirement and savings decisions that produce moments which match the pre-Depression data is encouraging.

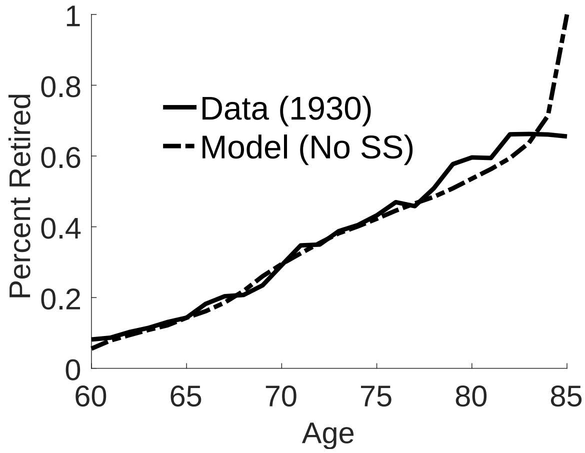
A comparison of retirement and savings decisions in the final steady state to the U.S. data is complicated by the fact that the model economy takes approximately 50 periods to converge from the initial to the final steady state once it sets on a transitional path. Over this transitional period, Social Security has expanded significantly and also become more progressive. Moreover, there were a number of other additional changes to the U.S. fiscal policy, such as increases in income taxes, changes to income tax progressivity, and increases in the size of government spending. These post-adoption changes to Social Security and fiscal policy—which were largely unforeseen by agents at the time of the inception of Social Security—are excluded from our experiments by design, as the purpose of this analysis is to study the welfare effects of the enactment of Social Security as they were likely perceived by the original cohorts. Excluding the economic effects of

[24] See http://www.nber.org/databases/macrohistory/contents/.

[25] In reality, the actual rate hovered around a slightly higher level of about 5 percent over this period. However, some of this revenue was used to fund other parts of the Social Security program that were not related to the retirement benefits, suggesting that our calibration likely represents a reasonable approximation of the world at the time.

[26] It would be interesting to compare the age-profile of savings and consumption to the data. Unfortunately, data allowing such a comparison are not available.

Figure 3: Percent Retired



Note: The data are from the 1930 Census. We limit the sample to males who are head of their household. Given that the Census data for this period does not directly report retirement status, in the data, individuals who are not in the labor force are considered to be retired. The model captures the percent of retired individuals in the steady state without Social Security.

these policy changes prevents us, however, from calibrating the final steady state to the historical U.S. data as they are not comparable.

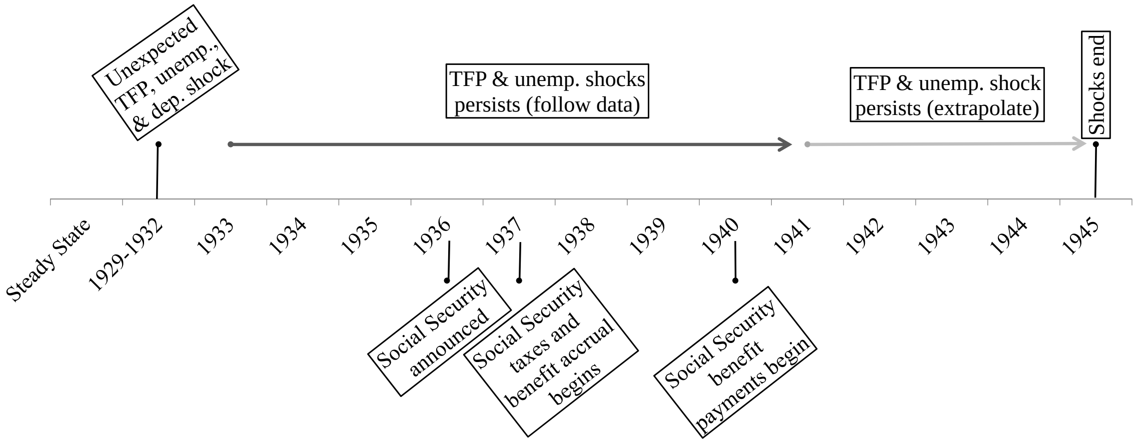
5 Calibration of the Transitional Path

Having parameterized the initial and final steady states, this section parameterizes (i) the economic shocks associated with Great Depression and (ii) the phase-in of the original Social Security program. Both the Great Depression and the phase-in of Social Security are incorporated in the model consistent with the actual historical experience. Figure 4 outlines the timeline of these events, which are subsequently discussed in Sections 5.1 and 5.2. Section 5.3 in turn compares the transitional path produced by the model to the evolution of the U.S. economy following the Great Depression and through the beginning of the World War II (WWII).

5.1 The Great Depression

We model the initial unexpected economic downturn associated with the Great Depression as one that affects the economy through three distinct channels: an adverse TFP shock, an adverse capital depreciation shock, and an adverse unemployment shock. We calibrate these shocks to match the

Figure 4: Timeline



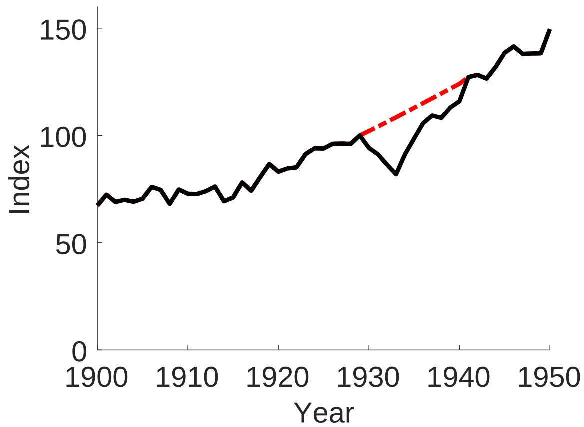
total changes in the available empirical estimates of the TFP, capital stock and unemployment rate between 1929 and 1932 (see timeline in Figure 4).[27] After these initial sudden and unexpected shocks, we model the rest of the Great Depression through elevated unemployment risk and depressed TFP that persist through 1945. Unlike the initial shocks, these persistent aggregate shocks after 1932 are no longer treated as a surprise.

Figure 5 shows the 1890-1950 historical estimates of TFP from Kendrick et al. (1961). With the exception of the Great Depression, Kendrick's TFP series generally increases throughout the first half of the 20th century. In order to isolate the change in TPF (or the TFP shock) due to the Great Depression, we control for the observed time trend by regressing Kendrick's TFP series on a third order polynomial in time and a binary indicator for the Great Depression (1930-1940). The red dashed line in Figure 5 depicts the predicted TFP from the regression (excluding the effect of the indicator variable for the Great Depression). For every year between 1930 and 1940, we define the TFP shock associated with the Great Depression as the difference between the actual TFP (black line) and the predicted counterfactual TFP (red dashed line) that excludes the effects of the Great Depression. After 1940, one complicating factor of our analysis is the presence of the economic effects associated with WWII that were probably not anticipated at the time when Social Security was adopted.[28] To exclude the potential extra boost to TFP from WWII, we assume that

[27]For computational convenience, the initial 1929-1932 changes in TFP, capital stock and unemployment are condensed into a single period.

[28]Although the United States did not enter the war until later, production for war activities aboard increased prior

Figure 5: Total Factor Productivity



Note: The solid black line is TFP reported in Kendrick et al. (1961). The dashed red line is predicted TFP using a regression that excludes the dummy for years during Great Depression.

instead of recovering immediately in 1940, TFP linearly recovers over the next five years.

Turning to the capital depreciation shock, according to the BEA, the value of fixed assets fell by 24 percent between 1929 and 1932. We implement this shock with a one-time increase of 24 percentage points to the depreciation rate, δ. This one-time increase in δ is assumed to be unexpected and immediately dissipates, though its effects on the economy persist as it takes time for the economy to rebuild the lost capital.

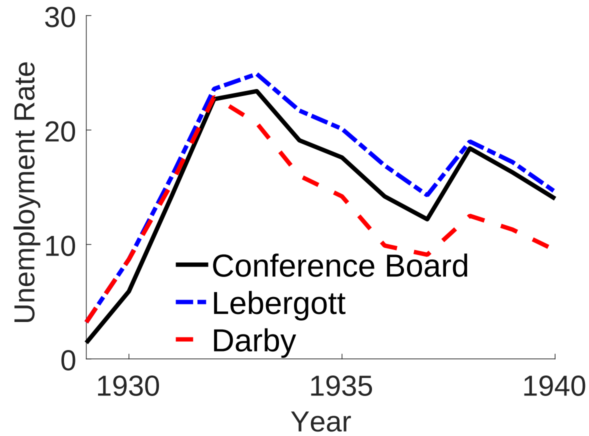
Finally, the unemployment shock is modeled through changes in the probability of becoming unemployed, p^U. Figure 6 plots several estimates of unemployment rate between 1929 and 1940 (the last year in the model that is treated as unaffected by the economic activity associated with WWII), sourced from the NBER–Conference Board, Lebergott (1964) and Darby (1975). Despite some differences caused in part by varying definitions of the unemployed, all three series indicate a sharp increase in unemployment of about 20 percentage points between 1929 and 1932.[29]

Table 3 displays the deviations (in percentage points) in unemployment rates from their initial steady state level throughout the Great Depression that we derive from the Conference Board data and incorporate in the model. Similar to TFP, we do not want to incorporate the decrease in the unemployment rates that are due to WWII, so we assume the shocks to the unemployment rates from 1941-1945 linearly decline to zero. The baseline transition abstracts from modeling the

to the U.S. entering the war.

[29] See Margo (1993) for a description of the differences between some of these estimates.

Figure 6: Unemployment During Great Depression



Note: The solid black line are the average monthly estimates from the Conference Board published in Moore (1961). The dashed blue line are the estimates from Lebergott (1964) which considers individuals in "work relief" as unemployed. The dashed blue line are the estimates from Darby (1975) which considers individuals in "work relief" as employed.

increase in the duration of unemployment, which was also associated with the Great Depression. The sensitivity of our quantitative findings to the increase in the unemployment duration (D) during the Great Depression is discussed in Section 6.5.

5.2 Social Security

Social Security was initially signed into law amidst the Great Depression in late 1935. According to the original law, all eligible agents were scheduled to start funding the system in 1937, with the first benefits payments being paid out in 1942. However, the 1939 amendments introduced three notable changes: (i) the program became more inclusive, (ii) eligible agents were allowed to receive benefit payments already in January 1940 (i.e., two years ahead of the initial schedule), and (iii) income earned by agents after reaching the NRA was included in the calculation of the Social Security benefits (b^{ss}). For computational tractability, we assume that agents learn about both the original law and these later amendments at the end of 1935.[30] Second, we ignore further amendments after 1940 which were not part of the initial program that was implemented.

During the initial phase-in, the program differed from the steady state version in three important

[30]Therefore, prior to 1936 agents are unaware that the program will be enacted and act as if the program will not exist.

Table 3: Increase in Unemployment Rate (in Percentage Points)

Year	Deviation from Baseline Unemployment
1932	18.6%
1933	19.3%
1934	15%
1935	13.5%
1936	10.2%
1937	8.1%
1938	14.3%
1939	12.3%
1940	10.5%
1941	8.4%
1942	6.3%
1943	4.2%
1944	2.1%
1945	0%

Note: Table presents increase in the unemployment rate, in percentage points, due to the economic downturn. To avoid the boost to economic activity from WWII, for 1941-1945, the deviations are extrapolated assuming that the shock recedes in a linear manner over this period.

ways. First, unlike in the steady state where all agents are eligible to collect Social Security after retirement because they paid into the system, not all agents from the original cohorts were eligible for Social Security benefits. In particular, along the transition, agents who did not contribute payroll taxes through at least 1940 were ineligible for Social Security.[31] Second, payroll tax rates during the phase-in were lower compared to the steady state. In accordance with the historical experience, we thus set the 1940-1945 payroll tax rates equal to their historical levels (see Table 4). After 1945 we let $\tau^{ss} = 0.045$, the rate at which the Social Security program's budget is balanced in the final steady state. Third, and highly importantly, benefits were calculated from the average lifetime earnings only after the program was adopted. Thus, along the transition equation 2 is altered to:

$$x_{j+1} = \frac{\min\{y_j, \bar{y}\} + (j-1-s)x_j}{j-s}, \tag{11}$$

[31] On exception to this general rule were agents who turned 65 between 1937 and 1940. These agents paid Social Security taxes until they turned 65, but did not qualify for the standard retirement benefit calculation as described in Section 2.4. Instead, these agents were reimbursed 175% of the amount they contributed in payroll taxes in a lump sum payout. We incorporate this exception for agents who retire between 1937 and 1940 into our model.

Table 4: Historical Payroll Tax Rates

Year	Payroll Tax Rate
1937	2.0%
1938	2.0%
1939	2.0%
1940	2.0%
1941	2.0%
1942	2.0%
1943	4.0%
1944	4.0%
1945	4.0%

Note: The payroll tax rates from 1937 through 1945 are equal to their historical values. After 1945 they are set at 4.5%, consistent with the rate that clears the Social Security budget constraint in the steady state.

where s is the agent's age in 1937 when agents began paying payroll taxes.

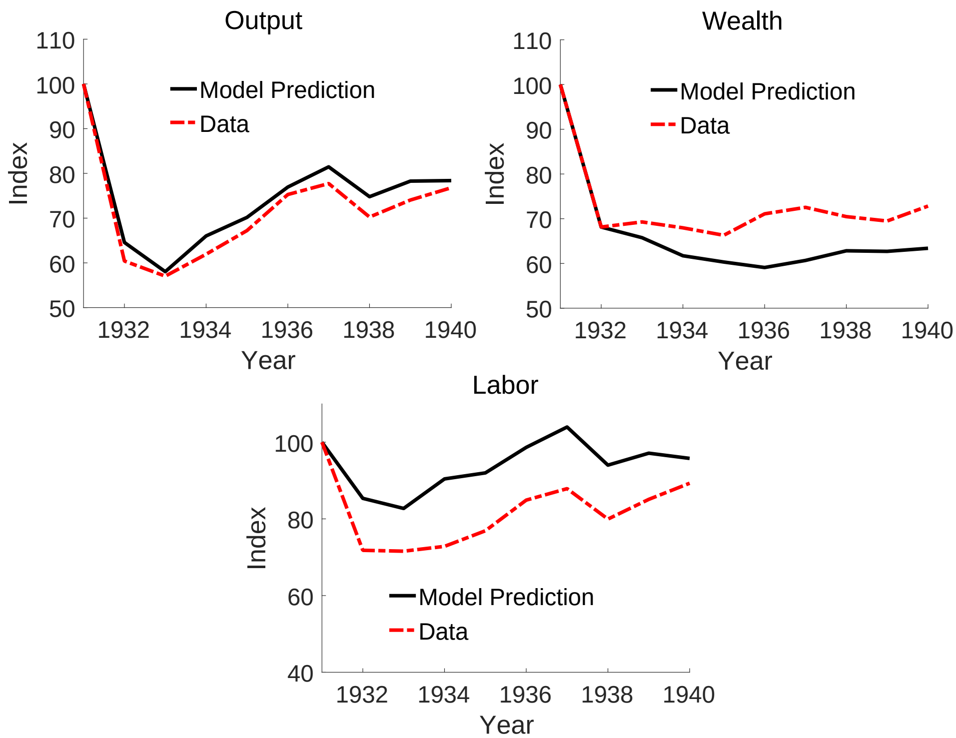
5.3 A Comparison of the Baseline Transitional Path to the U.S Data

Figure 7 compares the evolution of aggregate output, wealth, and labor in baseline transition (which includes the historical events of the Great Depression and the subsequent adoption of Social Security) to the fluctuations in the actual data.[32] We only compare the model to the data for the first ten years after the Great Depression because in 1940 the war build-up—not captured by our model—might have begun to affect these aggregates. Moreover, during the subsequent transitional years, there were a number of changes to Social Security and fiscal policy that are not included in our experiment (see Section 4.5). Overall, the model does a good job predicting the actual fluctuations in output and wealth during the comparable period. However, the model underpredicts the fluctuations in aggregate labor, likely because the model does not incorporate underemployment during the Great Depression.[33]

[32] Appendix D examines how the evolution of these macroeconomic aggregates differs within our model when Social Security is not adopted.

[33] As such, our welfare results may underpredict the total harm from the Great Depression.

Figure 7: Predicted Fluctuations versus Actual Fluctuations



Note: The black lines capture the simulated changes in economic aggregates along the transition path relative to their original values in the steady state without Social Security. The red lines capture the actual changes in the aggregate economic variables relative to their trend. The trends are calculated using a second order polynomial using data from 1900 through 1929. All values are indexed to 100 in 1929, which is considered the steady state. All three historical data series comes from Kendrick et al. (1961).

6 Results

This section presents our welfare results. In Section 6.1, we start by presenting standard results that compare welfare in the steady states with and without Social Security. Next, in order to assess the welfare effects of adopting Social Security for the original cohorts, we calculate two separate transitional paths. First, we simulate the baseline transition from the initial steady state without Social Security to the final steady state with Social Security along which the Great Depression happens. Second, we simulate a counterfactual transition in which Social Security is not adopted, but the Great Depression still occurs. Comparing the welfare of agents between these two transition paths pins down the welfare effects from adopting Social Security. In Section 6.2, we define our two transitional welfare measures calculated from these transitional paths. Section 6.3 present our key transitional welfare results. Sections 6.4 and 6.5 examine how these welfare effects differ by

Table 5: Decomposition of Steady State Welfare Effects from Social Security

	Total Effect	Contribution From: Direct Effect	G.E. Effect
Welfare (CEV)	-2.8%	1.5%	-4.3%

Note: CEV measures the uniform change in expected per-period consumption that an agent would require to be indifferent between living in an economy without Social Security and an economy with Social Security. The direct effect is determined by comparing the welfare of agents born into the steady state without Social Security and with Social Security, holding factor prices constant at the levels of the steady state without Social Security. The general equilibrium effect is calculated as a difference between the overall and direct effect.

age and conduct sensitivity analyses.

6.1 The Steady State Welfare Effects

Our steady state welfare findings are standard. Consistent with the existing studies (reviewed in the introduction), Column (1) in Table 5 confirms that Social Security is associated with lower long-run welfare in general equilibrium. Specifically, newborn agents in the steady state economy with Social Security would be willing to give up approximately 2.8 percent of their expected future per-period consumption in order to be born into an economy without Social Security (i.e., consumption equivalent variation (CEV)).[34] Two standard, competing channels produce the net welfare loss: the direct effect and the general equilibrium effect. With respect to the direct effect, Social Security improves welfare by providing both inter- and intra-generational insurance. Working in the opposite direction, payroll taxes make it harder for younger and low-wage agents to earn enough after-tax income to accumulate precautionary savings and smooth consumption, and the progressive contribution-benefits formula distorts agents' labor supply decisions. With regard to the general equilibrium channels, the program crowds-out private savings, thereby reducing aggregate capital and distorting marginal products of capital and labor in the general equilibrium. This general equilibrium effect is known to contribute negatively to the overall welfare.

Columns (2) and (3) in Table 5 decompose the overall steady state welfare loss into effects

[34]That said, the reduction in welfare due to the presence of the original program is substantially lower than that associated with the current Social Security, largely because the original program was much smaller. Peterman and Sommer (2014) estimate welfare losses from the current program of about 13 percent in a comparable modeling framework.

that are transmitted through the direct versus general equilibrium channels. The direct effect is determined by comparing the welfare of agents born into the steady state without Social Security and with Social Security, holding factor prices constant at the levels of the steady state without Social Security. The general equilibrium effect is calculated as a difference between the overall and direct effects. The direct effect from Social Security increase welfare by 1.5 percent of CEV, indicating that—at least for the original program—the positive welfare effect from the insurance are larger than the negative direct welfare effect from the distortions on agents' decisions and from the adverse effect of payroll taxes on budget constraints. However, the general equilibrium effect is associated with a reduction in welfare of 4.3 percent of CEV, resulting in a net welfare loss of 2.8 percent.

6.2 Transitional Welfare Measure

We use two welfare metrics to gauge the transitional welfare effects from adopting Social Security for the original cohorts. First, we calculate the likelihood that an agent will experience—ex-post—greater total lifetime utility in the benchmark transition in which Social Security is adopted than in the counterfactual transition in which Social Security is not adopted. We refer to this likelihood as Π, and define it as:

$$\begin{aligned}\Pi = \text{Probability}\Big[& u\big(c_s^{\mathrm{B}}\big) + v\big(h_s^{\mathrm{B}}, D_s\big) + \sum_{j=1}^{J-s} \beta^j \big[u\big(c_{s+j}^{\mathrm{B}}\big) + v\big(h_{s+j}^{\mathrm{B}}, D_{s+j}\big)\big] \\ & > u\big(c_s^{\mathrm{C}}\big) + v\big(h_s^{\mathrm{C}}, D_s\big) + \sum_{j=1}^{J-s} \beta^j \big[u\big(c_{s+j}^{\mathrm{C}}\big) + v\big(h_{s+j}^{\mathrm{C}}, D_{s+j}\big)\big]\Big],\end{aligned} \tag{12}$$

with c_s^{B} and c_s^{C} denoting the per-period consumption levels in the benchmark transition and the counterfactual transition, respectively, and s denoting the agent's age in 1937.

Second, we define *transitional* CEV (or CEV^T) as the uniform percent increase in *expected* consumption in each period over the *remainder* of an agent's lifetime that makes the agent indif-

Table 6: Decomposition of Transitional Welfare Effects from Social Security

	Total Effect	Contribution From: Direct Effect	G.E. Effect	Great Depression
CEV^T	5.7%	8.5%	-1.1%	-1.7%

Note: All welfare effects are calculated as the difference in the welfare for agents living in an economy where Social Security is adopted and where Social Security is not adopted. The total effect captures the average welfare gain across all living cohorts. The Great Depression effect is calculated as the difference between the total welfare effect when the Great Depression is included and the welfare effect in simulations when the Great Depression is not included. The direct effect is calculated as the welfare effect in simulations where the Great Depression is eliminated and factor prices are held constant at their initial steady state levels throughout the transition. The general equilibrium effect is calculated in simulations that exclude the Great Depression. In particular they are calculated as the difference in the welfare effects when factor prices are allowed to fluctuate and when they are held constant at their initial steady state levels.

ferent between experiencing the benchmark and the counterfactual transitions:

$$E\Big[u\big(c_s^{\mathrm{B}}\big)+v\big(h_s^{\mathrm{B}},D_s\big)+\sum_{j=1}^{J-s}\beta^j\big[u\big(c_{s+j}^{\mathrm{B}}\big)+v\big(h_{s+j}^{\mathrm{B}},D_{s+j}\big)\big]\Big]$$
$$=E\Big[u\big((1+\frac{\text{CEV}^T}{100})c_s^{\mathrm{C}}\big)+v\big(h_s^{\mathrm{C}},D_s\big)+\sum_{j=1}^{J-s}\beta^j\big[u\big((1+\frac{\text{CEV}^T}{100})c_{s+j}^{\mathrm{C}}\big)+v\big(h_{s+j}^{\mathrm{C}},D_{s+j}\big)\big]\Big]. \tag{13}$$

A positive CEV^T implies a welfare gain from the program's adoption.

When examining the welfare effects for specific cohorts, we index *living* cohorts by their age, s, at the time when Social Security is announced in 1937, and *future* cohorts by the number of years after the announcement that they enter the economy.

6.3 Transitional Welfare Effects

Column (1) in Table 6 shows CEV^T for the original living cohorts.[35] In contrast to the welfare-reducing effects of Social Security in the steady state in Table 5, the adoption of the original program is associated with large welfare gains for the original cohorts. Specifically, the average expected welfare gain, CEV^T, from Social Security for agents in the economy at the time of an-

[35]The economy-wide average of the transitional welfare effects is calculated as the population-weighted average of the CEV^Ts for each cohort.

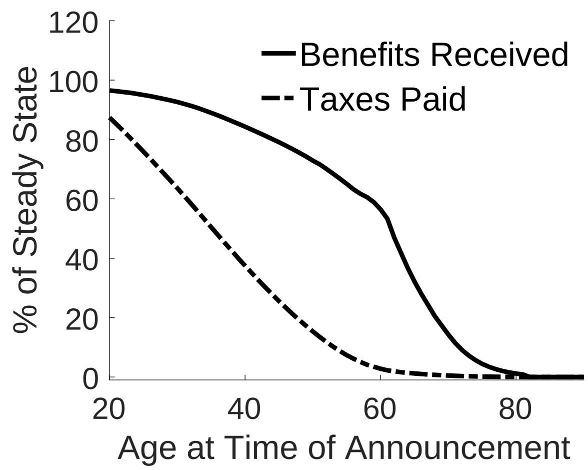
nouncement is the equivalent of 5.7 percent of expected future consumption, compared to a steady state welfare loss of 2.8 percent of CEV. Moreover, the likelihood that these agents gain welfare from the adoption of Social Security, Π, is 89.1 percent, compared to a similar measure of only 9.2 percent in the steady state.

In Section 6.1, we decomposed the total steady state welfare effect into two sub-components: the welfare effect transmitted through general equilibrium versus direct effects. In what follows, we conduct a similar decomposition for the transitional wealth welfare effect; however, we isolate the welfare effect of the Great depression into its own separate category. All three sub-components are calculated as the difference in the welfare for agents living in an economy where Social Security is adopted and where Social Security is not adopted. First, the Great Depression effect is calculated as the difference between the total welfare effect when the Great Depression is included and the welfare effect in simulations when the Great Depression is not included. The effect is meant to partial out the contribution of the Great Depression to the total welfare gain experienced by the original cohorts. Second, the direct effect is calculated as the welfare effect in simulations where the Great Depression is eliminated and factor prices are held constant at their initial steady state levels throughout the transition. The effect is designed to partial out the contribution of direct effect from the adoption of Social Security to the overall welfare gain. Third, the general equilibrium effect, calculated in simulations that exclude the Great Depression, are determined by calculating the difference in the welfare effect when factor prices are allowed to fluctuate and when they are held constant at their initial steady state levels. This effect partial-outs the negative contribution of capital crowd-out.

Column (2) in Table 6 shows that, on net, the direct effect is associated with large welfare gains for the original cohorts. The primary reason for this difference is that the program was relatively more generous for the original cohorts. To illustrate this, the solid and dashed lines in Figure 8 plot the average lifetime Social Security benefits received and taxes paid by living cohorts in the benchmark transition (expressed as a fraction of their final steady state values), respectively. The difference between the two lines demonstrates that most agents in the economy during the transition received far more benefits relative to their Social Security contributions than what they would have been if they lived their entire life in the steady state with Social Security.

The original cohorts contributed relatively less into the Social Security system for two reasons.

Figure 8: Effect of Gradual Implementation



Note: The values indicate the average percent each agent pays into and receives from Social Security compared to the value the respective values if these agents lived in the steady state with Social Security. The values are the average within a cohort.

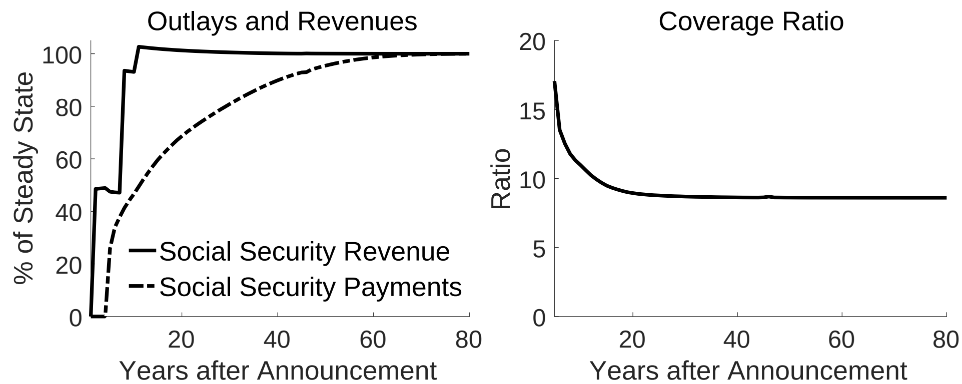
First, the payroll tax rates were initially introduced at the low level of 2 percent (less than half of the steady state level), and stayed low for a number of years. Second, the original cohorts did not start paying into the system until the program was adopted, part way through their life. In contrast, the benefits were fully implemented immediately, though the scaling factor based on years of employment somewhat lowered the benefits for the transitional agents because these agents did not pay as many years into the system. Overall, this implies that the Social Security benefits were on net more generous relative to agents' contributions for these original cohorts.

Although the program is structured such that the taxes are more gradually implemented than the benefits, we find that the program does not run a deficit. The left panel in Figure 9 plots the total outlays and revenues for Social Security in each year after the program is announced (as a percent of their respective final steady state values). We find that in all periods revenues either equal or exceed outlays, largely because the number of individuals contributing payroll taxes exceeds the number of Social Security beneficiaries in a given period by roughly a factor of 10 (right panel in Figure 9).[36]

As expected, Column (3) in Table 6 shows that the general equilibrium effect has a negative

[36]Similarly, through 1960 annual total expenditures from the Old Age Survivorship Disability Insurance (OASDI) trust fund were less than annual revenues. However, making this comparison in the data and the model is not completely equivalent for two reasons. First, both revenues and expenditures in the data include parts of OASDI other than just the old-age consumption insurance. Second, further amendments of Social Security made the program larger.

Figure 9: Social Security Outlays and Revenues

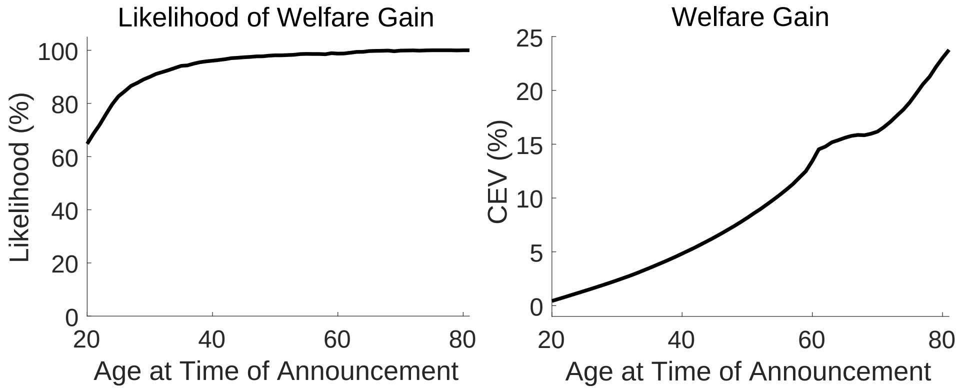


Note: The values in the left panel are the total outlays or revenues received in a particular year. The values are normalized as a percent of the total outlays and revenues received in the steady state with Social Security. Outlay equal revenues in this steady state. The right panel is the ratio of agents paying payroll taxes to the number of agents receiving benefits.

contribution to the overall welfare effect because the program crowds out capital. However, along the transition, this effect is much smaller because it takes many periods for agents to adjust their savings levels in response to the program's adoption, so the crowd-out of capital takes a long period of time to be fully realized (see Figure 18 in Appendix D). Thus, along the transition, the general equilibrium effect merely mutes the overall welfare gain from the program's adoption for the original cohorts.

Perhaps surprisingly, Column (4) demonstrates that adopting the program during the Great Depression tapered the potential overall welfare benefit from adopting the program. This result may seem counterintuitive since the old-age consumption insurance that Social Security provides would seem to be more beneficial in the midst of the Great Depression when large amounts of wealth and income were lost. However, while the adoption of Social Security during the Great Depression increased the welfare gains from the program's adoption for some (generally older) agents relative to its adoption during "normal times," adopting Social Security during the Great Depression exacerbated welfare losses caused by the economic downturn for most agents. These agents did not receive Social Security payments for many years to come, but had to start funding the system immediately, at a time when economic conditions were especially weak.

Figure 10: Welfare Effect for Eligible Agents from Implementing Social Security by Age



Note: The values are the average within each cohort for agents that are eligible to receive Social Security benefits.

6.4 Transitional Welfare Effects by Age

Next, we examine how the welfare effects from adopting Social Security vary by the agent's age at the time of the announcement. We separate the agents into three groups: (i) agents eligible for Social Security who are in the model at the time of the announcement, (ii) agents ineligible for Social Security who are in the model at the time of the announcement (because they had already retired), (iii) agents who have not entered the model at the time of the announcement.

6.4.1 Eligible Agents

We start by focusing on the welfare effects from the adoption of Social Security for agents in the model who were eligible for Social Security benefits at some point in their lifetimes: over 90 percent of all agents alive at the time of the program's announcement. The fraction of agents eligible for Social Security is high for two main reasons. First, the fraction of the population eligible was largely determined by the share of agents who worked at the time of the program's announcement. Prior to the adoption of Social Security, many worked until advanced ages and some (especially lower-income agents) worked until they died.[37] Second, the Great Depression caused some agents to further delay their retirement to make up for the lost wealth and income.

The left panel in Figure 10 plots each eligible cohort's likelihood of gaining welfare due to the

[37] In the initial steady state without Social Security, the average age of death (conditional on agent's surviving through age 20) is 66 in the model, whereas the average retirement age (for agents who do not die prior to them retiring) is 76 in the model.

implementation of Social Security. Perhaps not surprisingly, the likelihood of welfare gains rises with the cohort's age at the time of the program announcement. In particular, the likelihood of an increase in welfare due to the adoption of the program is just above 60 percent for households age 20 at the time of the program's announcement, whereas the likelihood increases to close to 100 for households ages 50+. The likelihood of gains rises for two reasons. First, individuals who are younger at the time of the program's announcement are more likely to be adversely affected by the payroll taxes because they tend to be more liquidity constrained. Second, the older an agent was at the time of the program's adoption the fewer years of payroll taxes the agent contributed prior to receiving Social Security benefits. While fewer years of contributed payroll taxes lower the post-retirement benefit size, this reduction in benefits is relatively smaller than the decrease in total payroll tax liability, meaning that essentially all eligible agents in age cohorts 50+ enjoyed higher welfare due to the adoption of the program. For example, an agent who retired five years after the inception of Social Security would face a lifetime payroll tax burden that was approximately 95 percent lower than that of the same agent who paid payroll taxes throughout their entire working lifetime.[38] Yet, despite paying considerably less payroll taxes, this agent would be entitled to a Social Security benefit that was only 40 percent lower.[39]

The right panel shows each cohort's expected ex-ante gain from the adoption of Social Security (CEV^T). Similar to the left panel, the profile rises for all cohort.[40] However, unlike in the left panel, the speed of the increase in the CEV^T slows temporarily for cohorts age 62 to 70. What causes the CEV^T to rise less rapidly for cohorts in this particular age range? To understand these dynamics, one has to examine the composition of the welfare effects from the program by agents' wealth and age.

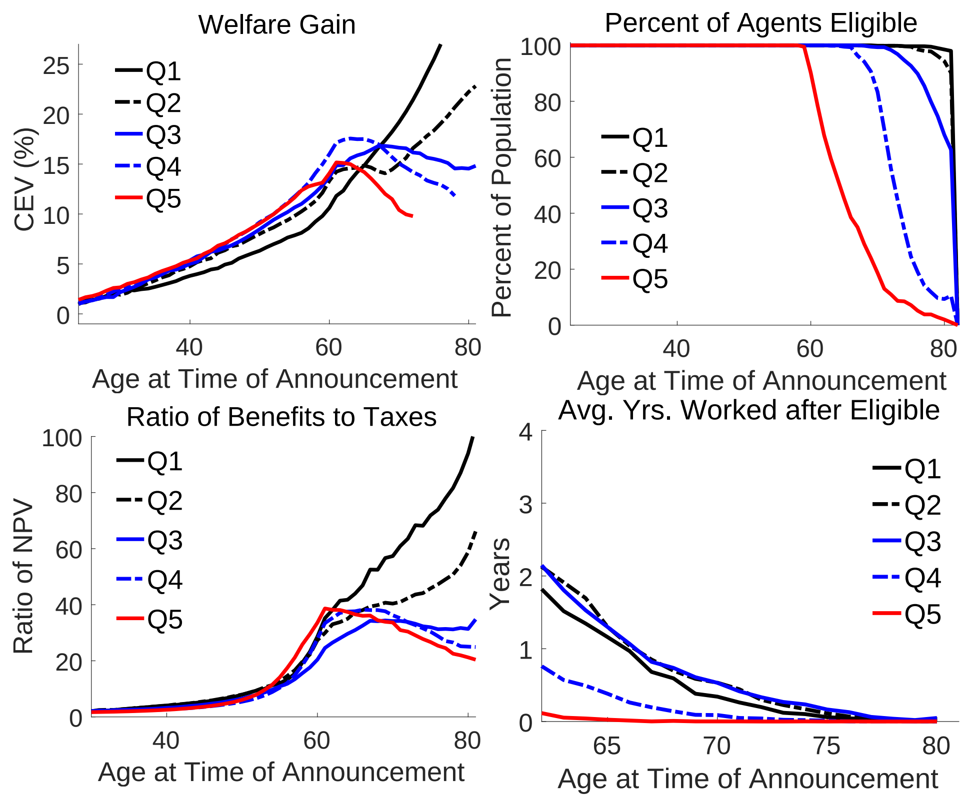
The upper-left panel of Figure 11 plots the CEV^T by age for each quintile of the wealth distri-

[38]This tax burden would be reduced for two reasons. First, the agent would only pay payroll taxes for five years, as opposed to 45 years if they lived in the steady state. Second, the payroll tax rates began at a much lower rate and were phased in over a number of years.

[39]The 40 percent reduction represents the agent paying into the system for 40 less years and thus receiving a scale up factor of only 5 percent as opposed to 45 percent. For the convenience of exposition of this argument, in this example we assume that an agent's income was constant across his working life cycle, the discount rate is one, and the agent retires at age 65.

[40]Our transitional welfare measure, CEV^T, quantifies the welfare gain from the adoption of Social Security relative to the rest-of-life welfare. However, one could measure the transitional welfare in terms of total lifetime welfare. Using total lifetime welfare, the transitional CEV is hump-shaped, reaching its peak of roughly 2.5 percent for agents who are 50 years of age at the time of the program's announcement. For further discussion about the distinction between these two measures see Auerbach and Kotlikoff (1987) (pp. 154 of their study).

Figure 11: Effect by Age and Wealth



Note: The upper-left panel plots the welfare gain in terms of CEV by age and wealth quintile. The upper-right panel describes the percent of agents who are eventually eligible to receive benefits. The lower-left panel plots the ratio of the net present value of the lifetime benefits received from the program relative to the lifetime payroll taxes paid. The lower-right panel describes the number of years agents work after becoming eligible to start receiving Social Security benefits.

bution.[41] After age 62, the welfare gains from the adoption of Social Security decline for agents in the top two quintiles. In contrast, the welfare gains continue to rise or hold steady for cohorts ages 62+ in the lowest three quintile. To fix intuition, higher-wealth individuals who have amassed more savings for post-retirement consumption tend to retire earlier. Consequently, cohorts who are older at the time of the announcement are disproportionately made up by low-wealth agents (see upper-right panel in Figure 11). Thus, among cohorts who are in their sixties at the program's announcement, the fraction of wealthy agents, whose CEV^T decreases with age, is large enough to cause a slowing in the increase in the aggregate CEV^T. However, among cohorts who are in their seventies, the lower wealth quintile makes up a large enough fraction of the eligible agents in these cohorts so that the CEV^T rises at an increasing speed.

The different dynamics of the CEV^T by age for the different wealth quintiles can be explained by the relative size of the total benefits received compared to the total payroll taxes paid. The lower-left panel in Figure 11 plots the discounted net present value (NPV) of the ratio of the expected benefits to payroll taxes for these agents by wealth quintile. For the bottom wealth quintile, the NPV benefits-contribution ratio rises monotonically with age at the time of the adoption. In contrast, for the top wealth quintiles, the ratio peaks around age 62 and subsequently falls for agents older at the time of the adoption.

Why does the NPV benefits-contribution ratio rise for the bottom wealth quintiles even as it falls for the top quintile? The different dynamics are primarily driven by the differences in retirement decisions across wealth quintiles. The lower-right panel in Figure 11 plots the average number of years that a transitional agent works after becoming eligible to collect Social Security benefits by wealth quintile. Irrespective of their age at the time of the program's announcement, agents in the top wealth quintile generally retire immediately after becoming eligible for benefits (i.e., after contributing three years of payroll taxes).[42] As a result, the NPV of these agents' Social Security contributions is quite similar irrespective of their age at the announcement. In contrast, the NPV of the total benefit received declines the older an agent is at the time of the program's adoption primarily due to rising mortality risk.[43] Thus, the overall welfare gain for these high-

[41] The wealth quintiles are determined for each agent by comparing the total wealth at the time of the announcement of Social Security within each cohort.

[42] These three years are from the beginning of the taxes being collected in 1937 until benefits begin being paid in 1940.

[43] The decline in the NPV is because the older an agent is, in expectation, the fewer years he has to live and to collect

wealth individuals' decreases the older an agent is at the time of the program's adoption. In a marked contrast, for low-wealth agents, the number of years that a transitional agent works after becoming eligible to collect benefits declines with the agent's age at the time of the program's adoption. For these older low-wealth agents, the NPV of the benefits-contribution ratio tends to rise because the ratio of expected years receiving Social Security benefits vs. contributing payroll taxes rises with their age at the time of the program's announcement.

Overall, Figure 11 demonstrates that there is considerable heterogeneity in the welfare effects on eligible agents both between and within the cohort. The past literature has highlighted the role that Social Security plays at (i) providing within-cohort insurance, (ii) redistributing within the cohort, and (iii) redistributing between cohorts. Each of these three roles contributes to the heterogeneity in the welfare effects. In order to determine the relative importance of these roles for our transitional welfare findings, we calculate the transitional welfare effects of Social Security in a counterfactual model without any idiosyncratic productivity risk.[44] Since this counterfactual model no longer contains this risk, there are no longer any welfare effects from Social Security providing within-cohort insurance. Thus, in this counterfactual model, Social Security only redistributes resources within the cohort (between ability types) and between cohorts (due to differences in age at the time of the adoption).

The left panel of Figure 12 plots the average welfare effect for eligible agents both in the benchmark model and in the counterfactual model.[45] Generally, the average welfare effects are qualitatively similar in both models with and without idiosyncratic labor productivity risk. On average, all eligible agents alive when the program is adopted experience an increase in welfare regardless of whether idiosyncratic risk exists in the model. Moreover, agents who are older when the program is adopted tend to experience larger welfare benefits. However, the welfare benefits tend to be a bit larger (especially for older agents) in the counterfactual model without idiosyncratic risk.[46] Overall, these findings suggest that the transitional welfare gains from the introduction of

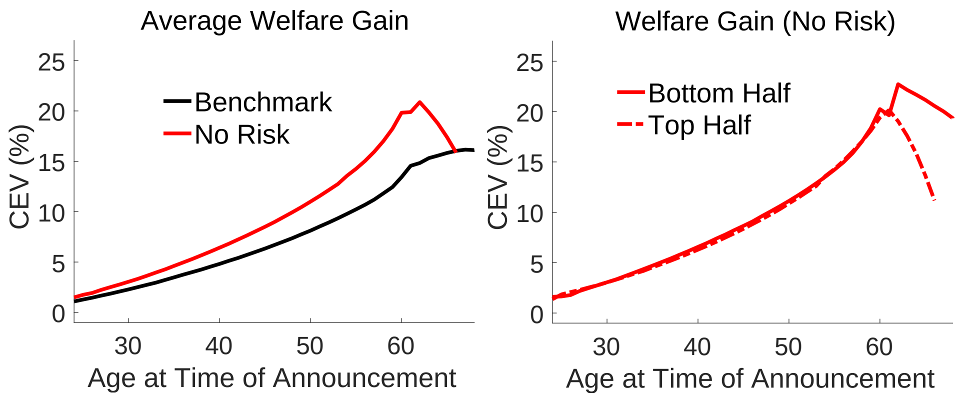
the benefits. Moreover, on average older agents receive lower wages causing the eventual Social Security payment to be lower at the time of retirement.

[44]We continue to include mortality shocks.

[45]We choose to focus on the ages in which there are eligible agents in both halves of the distribution. In particular, after the age of 68, all agents in the top half of the distribution are retired in the counterfactual model without idiosyncratic productivity shocks. Similar to the benchmark model, the welfare effects in the counterfactual model are driven by number of years worked prior to receiving benefits, the relative productivity of agents, and the mortality risk.

[46]This is because, agents who experience bad idiosyncratic shocks in the benchmark model find the introduction

Figure 12: Welfare Effects with and Without Idiosyncratic Risk



Note:The values are the averages within each cohort for agents that are eligible to receive Social Security benefits. The black lines are the values in the benchmark model with idiosyncratic labor productivity risk and the red lines are in the counterfactual model without this risk.

Social Security are due to redistribution from Social Security, rather than from insurance.

Next, we ask whether the welfare benefits are due to redistribution between ability types (within cohort) or across generations (between cohorts). Intuitively, it seems likely that the transitional welfare gains are—to a significant extent—driven by the redistribution between cohorts because the original cohorts received relatively larger payments compared to the payroll taxes they contributed. To confirm this result, the right panel of Figure 12 plots the average welfare effects by age from adopting Social Security for the low and high ability types (which represents the bottom and top halves of the wealth distribution, respectively) in the counterfactual model without idiosyncratic risk. The near-perfect, pre-retirement age alignment of the average welfare gains for the low and high ability types suggests that the intra-generational redistribution across ability types plays a minimal role in determining our results. Instead, the main contributor to these welfare gains for the original is the redistribution across generations.[47]

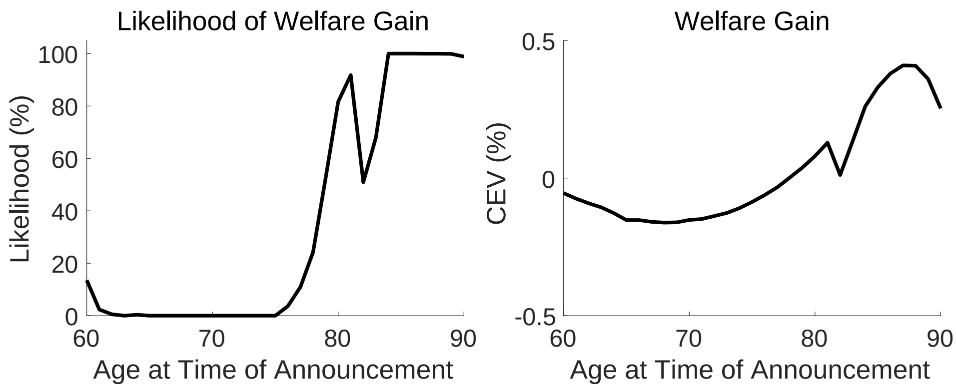
6.4.2 Ineligible Agents

This section focuses on the welfare effects of the program's adoption on agents who are alive at the time of the program's enactment but are already retired and, therefore, ineligible to collect

of the payroll tax associated with Social Security particularly painful. In the counterfactual model, agents do not experience bad idiosyncratic shock.

[47]This finding is consistent with the analytical insights obtained from earlier studies summarized in Feldstein and Liebman (2002).

Figure 13: Welfare Gain from Implementing Social Security For Ineligible Cohorts



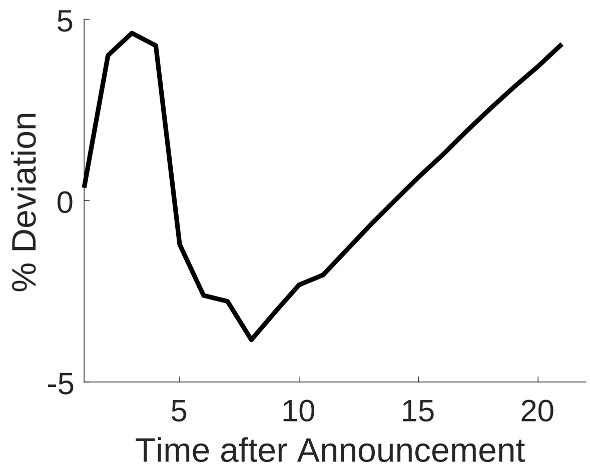
Note: The values are the average within each cohort for agents that are ineligible to receive Social Security benefits.

benefits: less than 10 percent of the living population. Figure 13 shows that the welfare effects of the program's adoption on these agents are overall small and largely depend on these agents' age when the program is announced. In particular, for ineligible agents below age 80, the program's adoption is generally associated with a small reduction in welfare, compared to a small increase in welfare for agents ages 80+.[48]

Through which channels are ineligible agents affected? Given that these agents are already retired, they are not affected by the direct effects from Social Security nor are they affected by the relative dynamics of the wage rate. Instead, the driving factor behind the measured welfare effects is the relative change in the rental rate between the benchmark and counterfactual transitions, shown in Figure 14. The figure shows that the relative return to savings rises but subsequently dips for a few periods in the benchmark transition in which Social Security is implemented compared to the counterfactual transition in which it is not. The relatively higher rental rate following the program's announcement causes the small welfare gain for the ineligible agents ages 80+. These agents benefit from the increase in the return to savings, but generally do not live long enough to also experience its subsequent decline. In contrast, the subsequent dip in the relative rental rate causes the small welfare loss for ineligible agents below age 80 for whom the negative welfare

[48]There is a kink in the welfare effects for age 80 cohorts. This kink arises because the composition of ineligible agents is different for cohorts who were under 80 at the time of the adoption versus older cohorts. In particular, since agents with higher incomes tend to retire earlier (see lower-right panel of Figure 11), they make up a relatively larger fraction of the ineligible agents in cohorts under 80. Moreover, these higher income agents tend to benefit more from the higher rental rate.

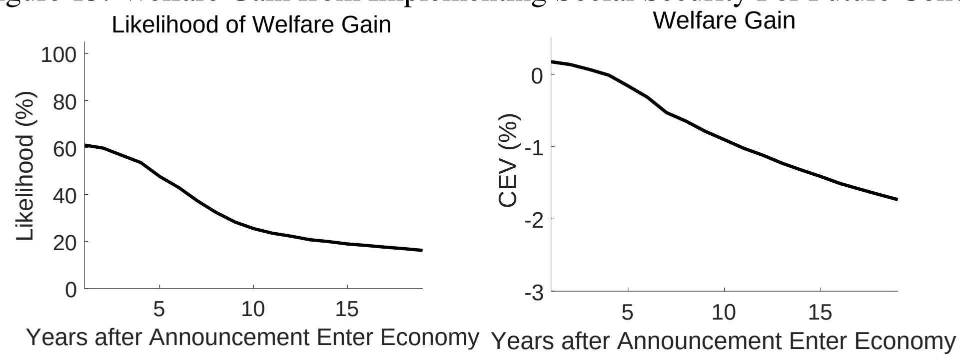
Figure 14: Fluctuations in rental Rate due to Social Security



Note: The figure represents the percent difference in the rental rate between the transition with Social Security and the counterfactual transition without Social Security.

effect of the experienced relative decline in the interest rate more than offsets the positive effect of its initial relative increase.[49] The higher rental rate in the baseline transition relative to the counterfactual transition following the program's announcement is caused by an increase in the relative amount of labor supplied: when the program is announced, eligible agents work more as their labor income is being counted toward their future Social Security benefits. After this initial increase, two competing effects determine the subsequent dynamics of the relative rental rate. First, agents tend to retire earlier in the baseline transition when Social Security is adopted, thereby lowering the relative level of aggregate labor.[50] Second, agents tend to hold relatively less savings in the baseline transition since they no longer have to fund all of their post-retirement consumption with private savings. The first effect initially dominates since agents' labor supply decisions are more flexible, causing the temporary decrease in the relative rental rate. However, the de-accumulation of capital is eventually large enough that the second effect dominates in the long run and the rental rate in the baseline transition returns to its relatively higher original level.

Figure 15: Welfare Gain from Implementing Social Security For Future Cohorts



Note: Likelihood of gaining welfare is calculated as the percent of the cohort who experiences a welfare gain due to the implementation of Social Security. The cohorts are indexed by the number of periods after the announcement that they enter the economy (20 years old).

6.4.3 Future Cohorts

Finally, we turn to agents who enter the model after the program is implemented. We find that agents who enter the model immediately after the implementation of Social Security on average expect to experience a small welfare gain from the program. We find that the likelihood of a welfare gain for these agents is just slightly above 60 percent. As time passes, the likelihood of experiencing a welfare gain decreases for new entrants, and on average the agents experience a decrease in welfare due to the adoption of Social Security. This is because cohorts who enter the model many periods after the adoption of Social Security tend to pay relatively more in payroll taxes than agents who enter the model immediately after the announcement as the payroll tax rate is phased in only gradually over a period of ten years. Over time, both the likelihood of a welfare gain and the size of the average welfare losses trend towards their steady state values.

6.5 Sensitivity Analysis

Finally, we test sensitivity of our results along five dimensions. Table 7 presents both the likelihood and average level of welfare gains for transitional agents for each experiment. As is the case in the rest of this paper, the welfare results reported in the table are derived from an experiment that

[49]The subsequent increase in the relative rental rate has limited effect on ineligible agents since it takes place more than 15 years after the program is announced when these ineligible agents are either already dead or have very little savings since they will only live for a few more periods.

[50]Early retirement does not affect aggregate labor in the first few periods after the program is announced because agents must work until 1940 before they can start collecting benefits.

compares welfare in the baseline transition in which both the Great Depression and the adoption of Social Security occur to the alternative transition in which the Great Depression takes place but Social Security is not adopted.

In the first sensitivity experiment, we compute the welfare effects under an alternative scenario wherein Social Security is adopted immediately at the onset of the Great Depression, as opposed to the midst of it. This experiment is of interest since Social Security might have been adopted in part to ease the burden of the Great Depression. Perhaps not surprisingly, our welfare results are largely unchanged when Social Security is counterfactually adopted at the onset of the Great Depression, suggesting that adopting the program in the midst of the recovery had only very models effects on household welfare.

In the second experiment, we compute the welfare effects in a scenario where only agents under age 65 at the time of the program's announcement are eligible to participate in Social Security. The original law announced in 1936 made agents over the age of 65 ineligible to participate in Social Security. However, as discussed in Section 5.2, the 1939 amendments expanded the program eligibility to all non-retired agents. When the program eligibility is restricted to agents who are under the age of 65 at the time of the program's announcement (in keeping with the original stipulations), the welfare gains from the program adoption are reduced relative to the baseline results, largely because fewer older agents (for whom the welfare gains from the program's adoption are the largest) are eligible for the retirement benefits.

In the third experiment, we allow for increases in the duration of the unemployment spell during the Great Depression. As opposed to being held constant at $d = 0.3$ in the benchmark transition, we allow the duration, d, to increase to 1.0 at the onset of the Great Depression. The increase persist through 1941, before receding linearly to its benchmark level by 1945.[51] The experiment results in a small net increase in welfare, with two partially offsetting forces. On the one hand, increasing the duration of the unemployment shock tightens budget constraints, increasing the burden from payroll taxation. On the other hand, the insurance from the program becomes more valuable when the spells become longer. On net, the insurance channel dominates by a small margin.

[51] Over the period 1932-1941, the average duration in the Philadelphia labor market increased, ranging approximately from one to two years (see Palmer (1937)). For tractability, we cap the duration is capped one year, as allowing the duration to last more than one period in the model would require an increase in the size of the state space vector to include whether agents were unemployed in the previous period.

Table 7: Sensitivity Exercises

	CEV^T	Π
Benchmark	5.7%	89.1%
Immediate Adoption	5.9%	88.8%
65+ Excluded	3.8%	81.6%
Duration Shock	6%	90.5%
Unemployment Insurance	9.8%	96.3%
TFP Growth	9.5%	97%

In the fourth sensitivity experiment, the Social Security program is expanded to include a reduced-form unemployment insurance that replaces 35 percent of average earnings in the economy.[52] Once the unemployment insurance is included, the program contains an extra insurance component targeted towards working-aged agents, leading to even greater and more wide-spread welfare gains for the initial cohorts.

Finally, we introduce TFP growth of 1.06 percent. Introducing this rate of TFP growth while maintaining population growth implies that total growth in the economy will be just over 3 percent which is consistent with estimated output growth from 1919 until 1929 (see Kendrick et al. (1961)). Since adding TFP growth has have notable effects on savings, we recalibrate this model to ensure it matches match the empirical targets (see Appendix B for the description of the balanced growth path with TFP growth). Specifically, in the model with TFP growth, agents incur an additional opportunity cost to saving from a growing wage. Since a typical agent will have higher labor income at age $j+1$ than at age j, an additional unit of savings at age j constitutes a larger fraction of a typical agent's budget than an additional unit of savings at age $j+1$. Thus, in order to calibrate the model with TFP such that it matches the historical capital output ratio of 3.0 it is necessary to use a larger β. The larger β in turn implies that agents value the future utility flows more relative to the benchmark model where β is lower. Since the Social Security benefits are concentrated over the second half of the lifetime, an increase in the relative value of future consumption associated with a higher β boosts the welfare gains from the enactment of Social Security compared to the

[52]Between 1943 and 1960, the ratio of the average unemployment benefit within the economy compared to the average earnings was 35%. See The Employment and Training Financial Data Handbook 394 Report from the United States Department of Labor.

benchmark model.[53]

7 Conclusion

This paper quantifies the welfare effects of Social Security for transitional agents who experienced the program's adoption. We find that the adoption of the program benefited a vast majority of these transitional agents. In particular, we estimate that the program benefited households alive at the time of the program's adoption with a likelihood of almost 90 percent, and increased these agents' welfare by the equivalent of 5.7 percent of their expected future lifetime consumption. The result that the program was quite beneficial for living agents is robust to a number of sensitivity analyses.

Through a quantitative decomposition of the overall welfare effects, we find that the adoption of the program was beneficial because most transitional agents received far greater monetary benefits in a form of Social Security payments than the amount they contributed to the system through payroll taxes. Moreover, the standard negative general equilibrium welfare effect of Social Security associated with capital crowd-out was also smaller during the transition than in the steady state, largely because it took many periods for agents to adjust their savings levels in response to the program's adoption. Perhaps interestingly, we find that adopting the program in the midst of the Great Depression had only a modest effect on the welfare implications of the program's adoption and, if anything, reduced the welfare gains from Social Security for the transitional agents.

This paper highlights that the welfare implications for agents alive when the program is adopted were quite different than the steady state welfare effects. Overall, the divergent welfare benefits for agents who experienced the program's enactment versus those experienced by agents born into the steady state with Social Security might offer one explanation for why a program that potentially reduces welfare in the steady state was originally adopted.

[53] Another channel through which TFP growth could affect welfare is through the adjustment of the payroll tax. If Social Security budget clears every period (PAYGO) then with wage growth the payroll tax rate would decline and funding today's retirement entitlements would be relatively cheaper. However, as discussed in Section 5.2, we do not require a balanced budget for Social Security along the transition, and instead use historical tax rates. Thus, this effect is not of first-order for the original cohorts who primarily live during the transitional path.

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A Equilibrium

Here we define a stationary steady state competitive equilibrium with Social Security.[54] An agent's state variables, Ξ are assets (a), average past earnings (x), age (j), ability (α), persistent shock (ν), unemployment shock (D), retirement status (I). For a given set of exogenous demographic parameters (n, Ψ_j), a sequence of age-specific productivity ($\{\theta_j\}_{j=1}^{\overline{R}}$), government tax function ($T : \mathbb{R}_+ \to \mathbb{R}_+$), Social Security tax rate τ^{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 5 - 8, with c, h, a', and I as the associated policy functions.

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

3. The Social Security policies satisfy:
$$\sum \min\{w(1-D)\omega h, \bar{y}\}\tau^{ss}\,\mu(\Xi) = \sum b^{ss}\,I\,\mu(\Xi).$$

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

5. Government budget is balanced:
$$G = \sum T^y[r(a+Tr) + w(1-D)\omega h - .5\tau^{ss}\min\{w(1-D)\omega h, \bar{y}\}]\,\mu(\Xi).$$

[54] Condition 3 is not relevant in a steady state with no Social Security.

6. Markets clear:

$$K = \sum a\, \mu(\Xi),\; N = \sum (1-D)\omega h\, \mu(\Xi) \text{ and}$$

$$\sum c\, \mu(\Xi) + \sum a\, \mu(\Xi) + G = AK^{\zeta}N^{1-\zeta} + (1-\delta)K.$$

7. The distribution of $\mu(x)$ is stationary, that is, the law of motion for the distribution of individuals over the state space satisfies $\mu(x)(1+n) = Q_{\mu}\mu(x)$, where Q_{μ} is a one-period recursive operator on the distribution.

In the absence of TFP growth (which is considered only as part of Section 6.5), the balanced growth path is a competitive equilibrium in which all aggregate variables grow at the same rate as output. Thus, all per capita variables and functions are constant, and aggregate variables grow at a constant rate of n, where n is the constant rate of population growth.

In Section 6.5 we introduce neutral technology growth (as opposed to labor augmenting TFP growth). Peterman and Sager (2017) provide a detailed discussion of the balanced growth path in a similar model. With technology growth, all aggregate variables, except labor, grow at the same rate as output on the balanced growth path. In particular, per capita consumption, savings, output, and government consumption grow at the same rate as wages, while per capita labor is constant. The wage growth rate is $(1+g_z)^{\frac{1}{1-\zeta}} - 1$, where g_z is technology growth. In order to construct this balanced growth path, we make four assumptions that differ from our model without technology growth. First, in order for growth to be balanced, we assume that labor disutility grows at the same rate as the utility from consumption, meaning that $v_{t+1}(h,D) = (1+g_w)^{1-\gamma}v_t(h,D)$.[55] Second, we assume that the bend points, the maximum and minimum Social Security benefits, and the tax exemption level all grow at the same rate as wages. Third, the discount factor and budget constraint change such that the dynamic programming problem for an agent who is not yet retired is:[56]

$$V(a,x,\alpha,\nu,j,D) = \begin{cases} \max_{c,a',h}(u(c)+v(h,D)) + \beta(1+g_w)^{1-\gamma}s_jEV'(a',x',\alpha,\nu',j+1,D') & \text{if} \quad j \leq \underline{R}, \\ \max_{c,a',h,I=\{0,1\}}(u(c)+v(h,D)) + \beta(1+g_w)^{1-\gamma}s_jEV'(a',x',\alpha,\nu',j+1,D') & \text{if} \quad \underline{R} < j \leq \overline{R}, \end{cases} \tag{14}$$

[55] This alteration is needed since the utility function is non-homothetic. See Peterman and Sager (2017) for details of these assumptions and a formal definition of this balanced growth path.

[56] Similar alterations are made for the dynamic programming problem of a retired agent.

subject to

$$\begin{aligned} c + a'(1+g_w) &= (1+r)(Tr+a) + y - T(\tilde{y}) - \tau^{ss}\min\{y, \bar{y}\} \quad \text{if} \quad I = 0, \\ c + a'(1+g_w) &= (1+r)(Tr+a) - T(\tilde{y}) + b^{ss} \quad \text{if} \quad I = 1. \end{aligned} \tag{15}$$

Finally, asset market clearing conditions and the resource constraint also reflect that wages grow.

B Solution Algorithm and Accuracy

To determine the steady state equilibrium, we use a modified algorithm based on algorithm 6.2.2 in Heer and Maussner (2009) for computing a stationary equilibrium for the overlapping generations model. The algorithm consists of the following steps:

1. Make initial guesses of the steady state values of the aggregate variables (e.g. capital, labor, and accidental bequests), market clearing tax rates, and the Social Security benefits in the steady state with Social Security.

2. Solve for the factor prices using the marginal product of capital and labor.

3. Compute the value function for agents on the state space of ability, idiosyncratic shocks, savings, age, average lifetime earnings, and retirement status using backward induction.[57]

4. Simulate the life cycles of 3,000 agents to calculate the distribution of agents across the state space. Each agent enters the model with zero capital and faces its own unique set of idiosyncratic shocks. We draw these individual shocks from distributions consistent with our labor productivity and unemployment processes. Given these shocks and the policy functions for labor, consumption, savings, and retirement (from the value function in step 3), we iterate forward to solve for the time paths of the choice variables for each agent over his life cycle.

5. Compute the tax rates that clears the government budget constraints. Integrate over the distribution of agents to calculate aggregate variables such as capital, labor, and accidental bequests.

[57] We discretize the savings and average lifetime earnings grids and interpolate the value function between savings grid points.

6. Check if the tax rates and the aggregate variables calculated in step 5 are within the tolerance of guesses in step 1. If the difference is larger than the tolerance, then update the guesses in step 1 using a weighted average of the previous guess and the new values from step 5 and return to step 2.

Once we have calculated the initial and final steady states using the previous algorithm, we use a shooting algorithm based on Heer and Maussner's algorithm 7.1.1 to compute the transition path between these steady states:

1. Set the number of transition periods to 100.[58]

2. Guess a time path for the transition of the aggregate variables (e.g. capital, labor, and accidental bequests).

3. Solve for path of factor prices.

4. Compute the value function for $t = T-1$ using the value function in the final steady state as the continuation value for period $t = T$. Continue to iterate backwards in time, $t = T-2$, $t = T-3$, and so on using the previously solved value function as the continuation value.

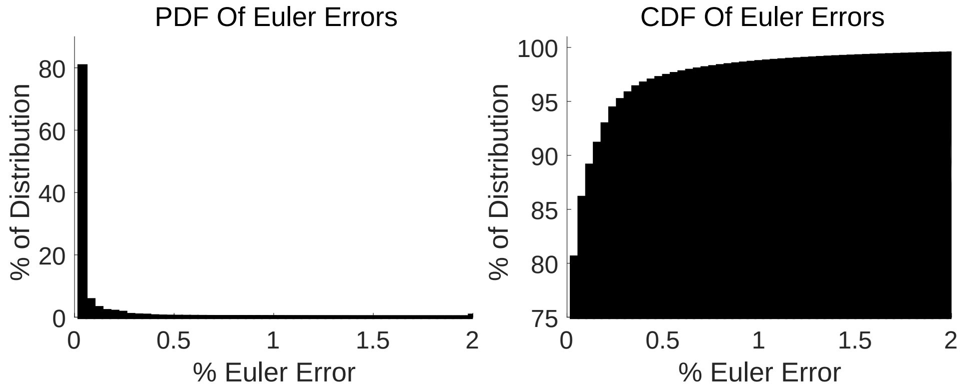
5. Use the distribution of agents in the initial steady state to initialize the distribution of agents across the state space for time period $t = 1$.

6. In each period $t > 1$ of the transition, simulate the life cycles of 3,000 agents to calculate the distribution of agents across the state space in that period. Each agent enters the model with zero capital and faces its own unique set of idiosyncratic shocks. We generate the individual shocks that are consistent with our labor productivity and unemployment processes. Given these shocks and the policy functions for labor, consumption, savings, and retirement (from the value function in step 4), and the time paths for the factor prices (from step 3), we iterate forward to solve for the time paths of the choice variables for each agent over his life cycle.

7. Integrate the individual values of capital and labor over the distribution of agents in each time period of the transition to compute the time paths of the aggregates such as capital, labor, and accidental bequests.

[58] We check whether this is a sufficient number of periods and find that the transition occurs in less than 100 periods.

Figure 16: Transitional Euler Errors



Note: The left panel plots the population weighted probability distribution function for Euler errors over the transition. The right panel plots the cumulative distribution function of these errors.

8. Check if the aggregate variables calculated in step 7 are within the tolerance of the guesses for each period from step 2. If the difference is larger than the tolerance, update the guesses in each period using a weighted average of the previous guesses and the new values solved for in step 7. Return to step 2.

Although Kirkby (2017) provides some discussion of the existence of equilibrium transitional paths, no proof exists for our specific model.[59] Thus, it is useful to provide an accuracy analysis. We use the standard Euler equation accuracy test (for example see Section 3.4 of Den Haan (2010)). In particular, assume $c(\cdot)_{i,j,t}$ is the consumption value associated with agent i, at age j, and time t from our numerical solution. Let $\overline{c}(\cdot)_{i,j,t}$ be the consumption choice implied by the calculated conditional expectation and the inverted Euler equation. We define the Euler equation error for that agent at age j and time t as $100\times \mid \frac{c(\cdot)_{i,j,t}-\overline{c}(\cdot)_{i,j,t}}{c(\cdot)_{i,j,t}} \mid$. Figure 16 examines the distribution of these errors from the transitional path which includes the introduction of Social Security.[60] Generally, the size of these errors are small. In particular, examining the population-weighted distribution of the errors pooling across the entire transition, we find that over 85 percent of the distribution of the errors are less than one-tenth of a percent. Moreover, we find that less than 1.5 percent of the errors in consumption are larger than one percent.

[59] One complicating factor is the retirement decision. In order to find an equilibrium it is necessary for us to assume that there is a continuum of agents.

[60] Generally, we find that the Euler equation errors without Social Security are smaller and thus only present accuracy results in the model with Social Security.

Table 8: Aggregates in the Steady States

Aggregate	No S.S.	With S.S.
Y	0.78	0.75
K	2.34	2.13
N	0.47	0.46
w	1.14	1.11
r	0.04	0.04
tr	0.06	0.05
τ^{ss}	0	0.04
Avg. Retirement Age	76.4	64.2

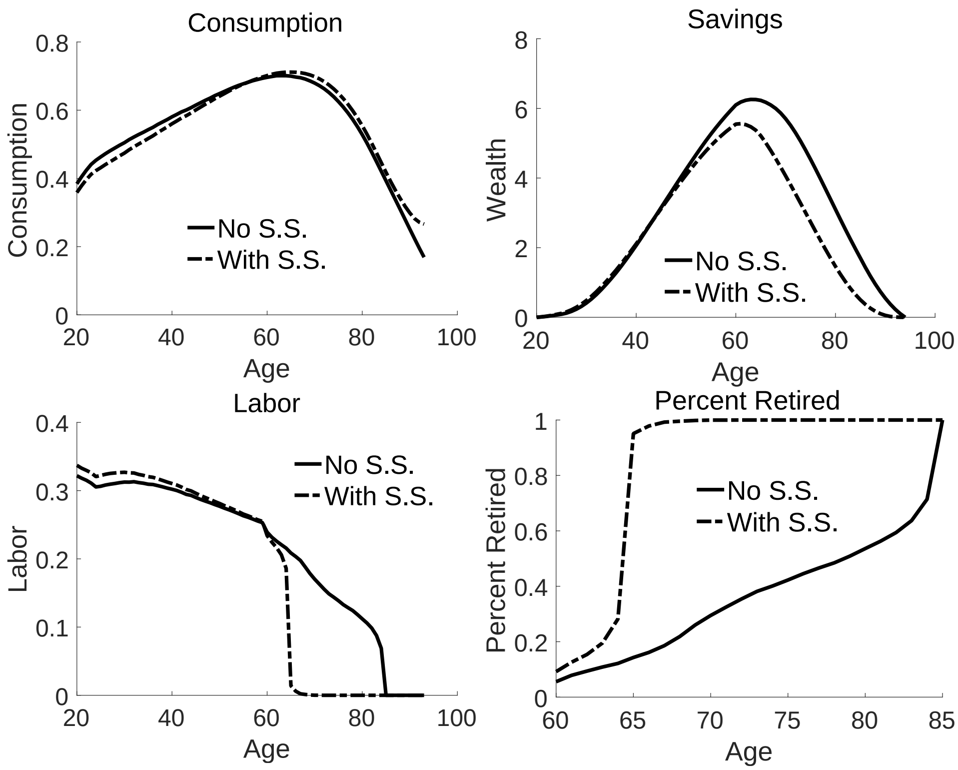
C Comparison of Steady States With and Without Social Security

This section compares the steady state economies without Social Security (the initial steady state) and with Social Security (the final steady state). Table 8 shows the aggregate variables in each economy while Figure 17 depicts the life cycle profiles. As shown upper-right panel of Figure 17 and in Table 8, the average savings profile as well as the level of aggregate capital K is lower in the final steady state. This is because, in the steady state with Social Security, agents only finance part of their post-retirement consumption from private funds, as some is financed with Social Security benefits. The lower K, paired with the aggregate labor supply N that is only marginally lower, translates into a higher return to capital r and lower market wage w. In turn, the higher return r in the steady state with Social Security affects the inter-temporal allocation of consumption and leisure, inducing agents to consume less and to enjoy less leisure early in life (upper-left and lower-left panels of Figure 17). Finally, in the steady state with Social Security, agents retire earlier, on average 10 years, than in the steady state without Social Security.

D Transitional Dynamics of Aggregates

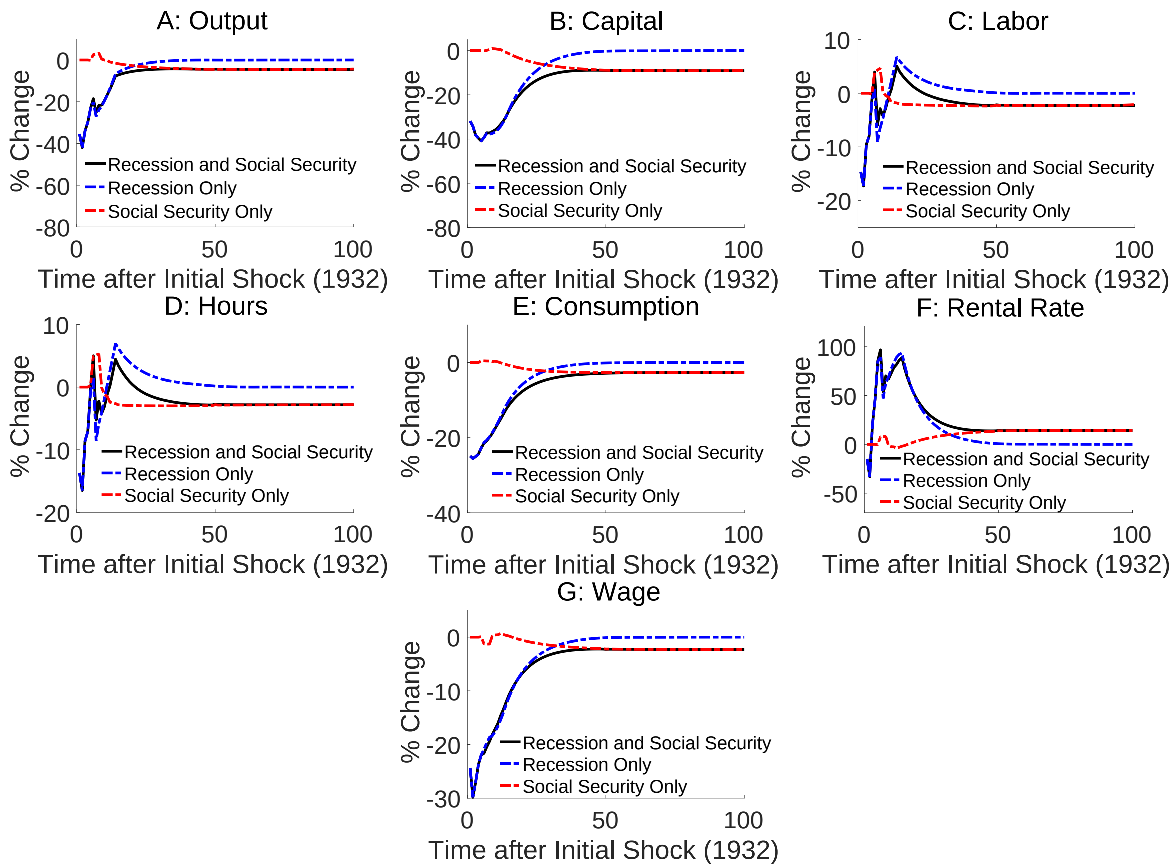
This section examines the benchmark transition of the economy from the steady state without Social Security to the new steady state with Social Security. The black lines in Figure 18 plots the

Figure 17: Life Cycle Profiles in Steady States



Note: "No S.S." denotes the steady state without Social Security. "With S.S." denotes the steady state with Social Security.

Figure 18: Aggregate Fluctuations Over Transition



Note: The black lines capture the changes in economic aggregates along the transition path from the original steady state without Social Security to the new steady state with Social Security during the Great Depression. The red dashed lines capture the changes in economic aggregates along the transition path when the economy suffers the Great Depression but Social Security is never implemented. The blue dashed lines capture the changes in the economic aggregates along the transition path when Social Security is adopted but there is no Great Depression. All the values are percentages relative the initial value in the steady state without Social Security.

transition of output, capital, labor, hours, consumption, rental rate, and wage, respectively, over the transition. Even though by 1945 the business cycle shocks dissipate and the Social Security program is fully implemented, the economy does not complete its transition to the new steady state for approximately an additional 25 years (i.e., until the year 1970).

Over the transition, aggregate output, aggregate capital, aggregate consumption, and the wage rate all fall drastically immediately upon the shock's impact, continue to decline for a few extra periods, and then gradually transition back to their new steady state values. The remaining aggregates—labor, hours, and the rental rate—suffer two sharp declines over the transition before eventually ending up at their new steady state values. The fluctuations in the aggregate economic variables over the transition come from two channels: (i) the economic shocks associated with the Great Depression, and (ii) the adoption of Social Security. In order to decompose these two effects, Figure 18 determines the percentage changes in the aggregate economic variables relative to their initial values in the steady state without Social Security under two alternative transitions. First, the blue dashed lines plot the evolution of the aggregates in a counterfactual transition when the economy suffers through the Great Depression but Social Security is not adopted. Second, the red dashed lines describe the evolution of the aggregates in a second counterfactual transition when Social Security is adopted but there is no business cycle episode.

Turning to Panels A, B, E, and G of Figure 18, the fluctuations in the benchmark transition (black line) and the transition which only includes the Great Depression (blue line) are similar for output, capital, consumption, and wages during the first 15 years of the transition. In these transitions, the initial declines in output, capital, consumption, and wages and the subsequent recovery are primarily caused by the shocks associated with the Great Depression. The subsequent fluctuations in these aggregates in the benchmark transition and the counterfactual transition which only includes the business cycle fluctuations tend to diverge. These later fluctuations are primarily driven by the adoption of Social Security and not the shocks to savings, TFP, and the unemployment rate.

Turning to Panels C, D, and F, the transition of labor, hours, and the rental rate has multiple peaks and troughs. Comparing the fluctuations of these three aggregates over all three transitions, the original declines are primarily driven by the business cycle shocks. The initial fall in all three aggregates is due to the drop in TFP and increase in the unemployment rate,[61] while the quick initial recoveries in these aggregates are due to the decline in the size of the shocks and also due to the implementation of Social Security (see the blue and red lines in Figure 18).[62] In particular, as the unemployment rate declines and TFP increases, agents tend to increase their hours. Additionally, in these first few periods after Social Security is announced, older agents increase their future Social Security benefit by working more. Both of these factors drive up the aggregate labor supply and rental rate. However, these increases are short-lived, as the increase in the unemployment rate in period 7 of the transition (corresponding to 1938) causes a second fall in aggregate hours,

[61]The fluctuations in the rental rate are primarily driven by the changes in the ratio of aggregate labor to output.

[62]Note that unemployment temporarily decreases over this period but increases again in period 7 (1938).

aggregate labor, and the rental rate. The second spike occurs in period fourteen. Since this spike is primarily due to the business cycle episode (the shocks to unemployment and TFP shocks finally recede), it does not occur in the counterfactual transition without the shocks (see the red line in Figure 18). After the second spike in labor, hours, and the rental rate, all three aggregates slowly decrease for another 25 periods when they reach their new steady state values which are lower due to the implementation of Social Security.

E Qualifying the Importance of Endogenous Labor Supply

As discussed in Section 6.3, the welfare gains from the adoption of Social Security for the original cohorts stem from the fact that the NPV of Social Security benefits exceeds that of contributions for the original cohorts. Since our baseline model allows for endogenous response of labor hours and retirement decisions to the introduction of Social Security, the ratio of benefits to contributions (in NPV terms) will differ from one produced by a model without endogenous labor supply response. In this section, we explore the quantitative importance of allowing for the endogenous labor supply response, by comparing the ratio of average benefits to contributions produced by our baseline model to one that is derived holding retirement and labor decisions fixed to those observed in the initial steady state without Social Security.[63]

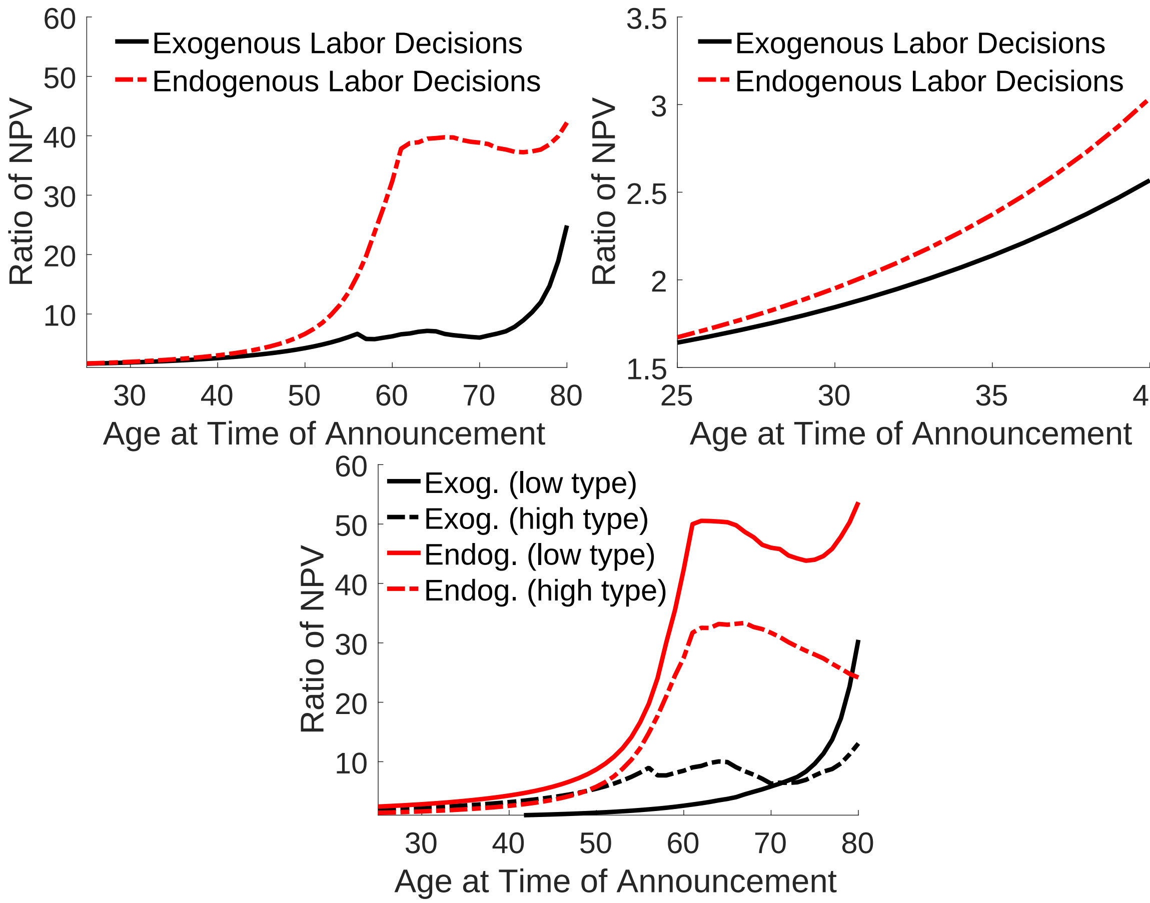
Figure 19 displays the key results. The upper-left panel shows the ratios of average benefits to average contributions (in NPV terms) produced by the endogenous vs. exogenous labor supply frameworks for all ages at the program's announcement (i.e., ages 20-80), while the upper-right panel zooms in on ages 25-40 only. The bottom panel breaks out the effects separately for high and low types. As the two panels show, the ratio of Social Security benefits to contributions produced by the baseline model with endogenous labor response is always above that generated by the alternative calculation where labor supply is not allowed to adjust in response to the enactment of Social Security. In our benchmark model, agents accelerate their retirement once Social Security is introduced, thereby contributing relatively less Social Security taxes and reaping more years of

[63]To demonstrate that the discrepancy in the results is driven by the labor supply response to the introduction of Social Security rather than the Great Depression, the calculations (shown in Figure 19) are based on the transitional path where the Great Depression does not occur. However, the effects of the endogenous decisions are similar when the Great Depression is considered; these results are available at request.

benefits than the same agents who do not adjust their labor supply in response to the program's adoption.[64] This effect is particular pronounced for agents who are old enough so that they can retire (and start collecting benefits) after paying just a few years of taxes. Moreover, we find that this difference is even more pronounced for low types as opposed to high types (see bottom panel) since these are the agents that tend to make the largest adjustments to their retirement decisions in response to the introduction of Social Security. Our experiments leads us to conclude that endogenizing labor supply decisions (and retirement decisions in particular) is a quantitatively important feature of our model, particularly for older and lower ability agents.

[64]The ratio rises with age at the program's announcement largely mechanically, as the number of years of contributed taxes falls with this age, whereas the number of years during which benefits are received is unchanged, all else equal. However, the increase in the ratio of benefits to contributions is relatively larger for agents in the baseline model with endogenous labor supply who retire earlier. The larger increase arises because the same-size reduction in the number of years of contributing Social Security taxes represents a larger reduction in the fraction of total years paying taxes.

Figure 19: Ratio of Benefits to Contributions



Note: The red lines are the ratio of the net present value of benefits to contributions for the model with endogenous labor. The black lines are a similar ratio when labor decisions are fixed so they do not incorporate the addition of Social Security.