Quantifying the Distortionary Fiscal Cost of 'The Bailout'*

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Abstract

We utilize an overlapping generations model with endogenous production and incomplete markets to quantify the distortionary costs associated with financing the increase in government expenditures directed to investments in the private sector in 2008 and 2009 (a.k.a. 'the bailout'), and its differential impact on different groups of the population (in the U.S.A.). In our baseline calibration, this distortion corresponds to a loss of approximately $300 billion dollars in total household consumption. This number is very robust to assumptions about the net benefits of the bailout itself. For plausible alternative assumptions regarding both the expected and actual duration of this increase in expenditures, or the willingness of foreign institutions and/or investors in absorbing additional government debt, this number can increase to $800 billion.

We find that the cost falls more dramatically on those households which are either older and/or wealthier. Retirees face approximately 50% of the cost, as younger agents are more likely to still be alive when the economy has returned to its steady-state. Across wealth groups, the top 25% of the wealth distribution bears almost two thirds of the cost.

JEL Classification: E21, E62, G12.

Key Words: Government Debt, Fiscal Policy, Tax Distortions, Bailout, Incomplete Financial Markets.

1 Introduction

The years of 2008 and 2009 were characterized by unprecedented major investments on the part of several OECD governments into private sector companies. In the USA these investments were particularly sizeable. First, there were significant investments by the US government on an individual basis in multiple financial firms such as Fannie May ($34B), Freddie Mac ($51B), and AIG ($70B). Second, as part of an organized effort to repair capital ratios, hundreds of banks received substantial infusions in the form of preferred stock adding up to a total of over $200B (the TARP program).[1] Finally, there was also a non-trivial investment of $83B in the automotive industry (GM, Chrysler, their finance arms and part suppliers), and substantial investments made by the Federal Reserve in debt and mortgage-backed securities issued by Fannie Mae and Freddie Mac. This set of expenditures became publicly known as 'the bailout'.

Naturally these investments have prompted an important discussion on the costs and benefits of such interventions. It is *not* the goal of our paper to offer a comprehensive evaluation of all those costs and benefits. Our goal is a more modest yet still very important one: to provide a quantitative assessment of one important source of costs associated with these interventions: the distortionary impact of the changes in taxation and government debt required to finance those investments. To the extent that our results identify distortionary costs in the order of 200 to 800 billion dollars (in the USA), these should be viewed as one element in the computation of an overall net present value of 'the bailout'. If the value of all other benefits minus all other costs is less (more) than our number, then this net present value should be viewed as negative (positive).

More precisely, in our baseline calculations we make a relatively neutral assumption that the government's asset purchases occur at "fair" market prices. In reality some of these investments might have been made at above-market prices (different forms of guarantees and/or buying "bad assets"), while others might result in direct gains for the government from buying assets in potentially depressed markets (due to fire-sales and extreme asymmetric information). In our paper we do not attempt to measure these gains or losses (Veronesi and Zingales (2009) perform this exercise for the government guarantees of private bank debts), instead we assume they average to zero, and measure the distortionary impact of financing the overall investments. However, it is straightforward to repeat the analysis under different assumptions about the direct net present value of these investments. In fact we repeat our calculations for an alternative scenario in which we assume that government investments generate a *positive externality* on the economy, increasing both overall

[1] While some major banks were allowed to repay these investments relatively quickly, the majority still remained in the support program throughout 2009.

output and the return on capital. When we measure the distortionary cost in such a setting we obtain almost the same exact value as in our baseline calculations. So, although the government intervention now represents a clear net benefit to the economy, it still carries a distortionary component, which is almost identical in size to the one measured in our baseline calculations. Therefore, regardless of the overall impact of the 'bailout', we can be confident that we have a good measure of its distortionary cost.

It is important to mention that we only consider government expenditures directly related to investments in the corporate sector. We explicitly exclude all elements of the stimulus package which were directly aimed at increasing household-level net worth and consumption, such as the Economic Stimulus Act of 2008, or even the American Recovery and Reinvestment Act (which also includes some infrastructure investments). Naturally, including these expenditures would increase our measure of the distortionary cost, but those interventions are not so unusual in periods of recession, and here we are only interested in the less orthodox measure: government capital investments and related expenditures.

Government investments need to be financed, either by increases in government debt or increases in taxes, or both.[2] Both of these policy options have distortionary costs on the economy, and our goal is to measure these distortions in the context of the government interventions of 2008 and 2009. We find non-trivial values for these costs. After calibrating an overlapping-generations DSGE model with incomplete markets and heterogenous agents to the US economy we find, in our baseline calculation, a distortionary impact of these fiscal decisions equivalent to a one time loss of 2.75% of aggregate consumption, approximately $300 billion US dollars. Depending on the exact assumptions on how we discount future gains and losses, the exact number changes, but very marginally. Naturally, the magnitude of the cost will depend on the duration of the fiscal shock, which is not currently known. As we increase the expected duration, our calculations rapidly increase to more than 6% of annual consumption ($600 billion dollars). Finally, to the extent that in our model we specify a well-defined government intervention our calculations still ignore one additional source of distortion: the uncertainty about future fiscal policy (see Croce, Kung and Schmid (2010) or Pastor and Veronesi (2010)).

[2] Another option, which was also used during the crisis, relies on significant increase of the money supply. This is typically viewed as a last resort, because of inflationary fears. Most developed countries have therefore avoided this form of financing other than in extraordinary circumstances. Throughout 2008 and 2009, the US Federal Reserve has substantially increased the provision of loans to companies and financial institutions and widened the range of financial securities it accepted as collateral for those loans. It also provided financing for the bulk of the GSE-issued mortgage-backed securities and GSE debt. In addition, the Fed supported a program of purchasing treasury debt which began to wind down at the end of summer 2009. Later in the paper, when we calibrate the magnitude of government intervention in capital markets, we will discuss the Fed's expenditures in more detail.

Moreover, we find that the cost falls disproportionately on those households which are either older and/or wealthier. If we equally weight the percentage consumption losses of all agents in the economy, retirees face approximately 50% of the cost. After a few years of higher output and consumption, due to the initial public investment, the crowding out effects start to dominate and the distortionary effects of the fiscal expansion will still be noticeable in the economy for approximately two to three decades. Therefore, during a significant fraction of their remaining lives, retirees are faced with the prospect of lower capital accumulation due to the crowding out effect of taxes. On the other hand, younger agents still expect to be alive when the economy has returned to its steady-state, and therefore their remaining life-time wealth is less affected. If we perform the same calculation across wealth groups, the top 25% of the wealth distribution bears almost 2/3 of the cost. Interestingly, the impact on middle class households is relatively uniform, regardless of whether they are stockholders or not, and not much higher than the impact on the poorer households. This is driven by the high concentration of wealth among the right tail of the distribution, and highlights the importance of capturing this feature of the data within the model, a point which we will re-empashize below.

Currently, a significant fraction of US government bonds is being held by non-US investors and institutions (e.g. other central banks). However, it is not clear how much additional US debt these investors will be willing to absorb. Some of them have in fact already suggested that they would not be interested in increasing their holdings much further. This is naturally one crucial element for determining the economic impact of the fiscal expansion program, and consequently the fiscal distortion that it implies. As we consider alternative scenarios, where foreign investors are less willing to buy additional US bonds, the increase in domestic interest rates and the decrease in private investment are both naturally much larger. In those settings, the total distortionary impact is now closer to one trillion US dollars.

We conduct our analysis using a detailed DSGE model which captures reasonably well many important features of aggregate economic variables and cross-sectional behavior of households. More precisely, we consider an overlapping-generations general equilibrium production-economy model with incomplete markets, heterogeneous agents and limited stock market participation. A production economy set-up is obviously crucial since we want to measure the impact of government decisions on investment and capital accumulation. As discussed in Aiyagari (1994) or Castaneda et al. (2003), for example, market incompleteness is crucial to match the wealth distribution in the data with a realistic calibration of the underlying structural parameters.[3] Capturing this dis-

[3]In our economy markets are incomplete due to aggregate uncertainty, idiosyncratic productivity shocks and limited stock market participation. The idiosyncratic shocks are not perfectly diversifiable due to the presence of

tribution is very important for providing an accurate assessment of the household-level responses to the fiscal policy decisions, and for allowing us to study the differential impact of fiscal interventions across realistically calibrated heterogeneous groups of households (see Domeij and Heathcote (2004)). Finally, considering an overlapping-generations model provides us with a set-up to study the differential impact across age cohorts.[4]

The magnitude and importance of multiple 'government bailouts' across several countries has generated a growing number of academic papers analyzing government actions in response to the financial and economic crisis of 2008/2009. Naturally, there is an even larger literature analyzing the causes and consequences of the financial crisis of 2008-2009, but our work belongs in the first group. We take the financial crisis as given and analyze the distortionary impact of the government intervention in this context.[5] Existing papers have focused on alternative aspects of the stimulus, mostly in the US. Villaverde (2010), Cogan, Cwik, Taylor and Wieland (2009), Christiano, Eichenbaum, and Rebelo (2009) and Hall (2009) evaluate the effectiveness of economic stimulus on GDP and employment. They compare the effects of a fiscal stimulus and reach different conclusions. Cogan et al. (2009) conclude that the effect of the stimulus is likely to be small, while the other two papers find it to be potentially quite large. We differ from these papers by looking at the effect of capital investments financed by the government, not government consumption expenditures per se, and we are interested in the distortionary impact of debt and taxes used to finance capital investment expenditures.[6]

To the extent that we consider the impact of tax changes, our paper complements the recent study by Barro and Redlick (2009). They construct a marginal tax rates series for the U.S. and use it to empirically determine how a change in the marginal tax rate affects macroeconomic variables. They find that reducing the marginal tax rate by one percentage point raises next year's GDP

borrowing constraints. These are features that have been identified as important for matching quantitatively the wealth distribution.

[4]It is important to mention that, following a standard practice of neoclassical macroeconomics we do not include an explicit financial sector in the model. It is true that a significant portion of government investments occurred in the financial sector, but given our focus on the distortionary impact of the government fiscal intervention, it is hard to see the benefit of modeling directly the sectors that received funding (or any bias in our analysis as a result of not doing this), which would then also have to include the insurance and automotive sectors.

[5]Not all government interventions in the private markets during the crisis were accompanied by direct capital investments. For example, Veronesi and Zingales (2009) consider an episode which did not involve immediate increased spending or fiscal distortions. They compute the costs and benefits of government guarantees of private bank debts using CDS pricing data and conclude that the guarantees represented a transfer of wealth from taxpayers to banks through the reduction of bankruptcy probabilities. However, the total effect of the intervention was positive creating a net present value of almost $100 billion dollars.

[6]For the same reason, our paper differs from the recent literature that uses structural VARs (for instance, Blanchard and Perotti (2002) or Ramey (2009)) or variants of new Keynesian models (for example, Gali et. al. (2007)) to analyze fiscal policy shocks.

growth by around 0.6% per year. Our quantitative experiments focussing on raising the marginal tax rate on capital income are broadly consistent with their estimates.

The paper is structured as follows. Section 2 presents the model, the fiscal policy variables and their behavior, while section 3 describes the calibration. Section 4 reports the baseline unconditional results of the model economy that is being used to conduct the experiments. Section 5 presents the responses to the fiscal expansion in the context of our baseline calibration, while section 6 considers alternative scenarios. Section 7 provides the concluding remarks. Technical details of the computational procedure are provided in the appendix.

2 The Model Economy

The model is solved at an annual frequency. Households have a finite horizon divided in two main phases: working life and retirement. During working life they receive a wage income subject to uninsurable shocks, and against which they cannot borrow. At retirement they receive a pension, financed by taxes on current workers' wages. There are two types of agents: non-stockholders and stockholders. The former can only invest in riskless government bonds, while stockholders can also invest in claims to the risky capital stock (equity).

Firms are perfectly competitive, and combine capital and labor, using a constant returns to scale technology, to produce a non-durable consumption good. The government taxes wages, capital gains and consumption expenditures (sales) to finance government expenditures (including capital investments) and the interest payments on public debt. As previously discussed, and following the standard practice in fiscal policy models, we do not include a financial sector. For the purpose of measuring the distortionary impact of government debt and taxes we do not need to model the financial intermediation process.

2.1 Firms

2.1.1 Production function

The technology in the economy is characterized by a standard Cobb-Douglas production function, with total time-t output given by[7]

$$Y_t = Z_t K_t^{\alpha} {L_t}^{1-\alpha} \tag{1}$$

[7] This is equivalent to the labor-augmenting formulation

$$Y_t = K_t^{\alpha} (\widetilde{Z}_t L_t)^{1-\alpha}$$

with $Z_t = (\widetilde{Z}_t)^{1-\alpha}$, we just need to consider a different normalization factor to obtain stationary variables.

where K is the total capital stock in the economy, L is the total labor supply, and Z is a stochastic productivity which follows the process

$$Z_t = G_t U_t,\, G_t = (1+g)^t$$

Secular growth in the economy is determined by the constant g (>0), while the productivity shocks U_t are stochastic.

Firms make decisions after observing aggregate shocks. Therefore, they solve a sequence of static maximization problems with no uncertainty, and factor prices (wages, W_t, and return on capital, R_t^K) are given by the first-order conditions

$$W_t = (1-\alpha) Z_t (K_t/L_t)^{\alpha} \tag{2}$$

and

$$R_t^K = \alpha Z_t (L_t/K_t)^{1-\alpha} - \delta_t \tag{3}$$

where δ_t is a stochastic depreciation rate, as discussed in the next section.

2.1.2 Stochastic depreciation

Standard frictionless production economies cannot generate sufficient return volatility, since agents can adjust their investment plans to smooth consumption over time (see Jermann (1998) or Boldrin, Christiano and Fisher (2001)). This usually motivates adjustment costs for capital, which create fluctuations in the price of capital and increase return volatility. Since we have incomplete markets, stockholders stochastic discount factors are not equalized, and they will therefore disagree on the solution to the optimal intertemporal decision problem of the firm (see Grossman and Hart (1979)). This is not a concern here because there is no intertemporal dimension to the firm's problem, but introducing adjustment costs would change that. Recent papers with production economies and incomplete markets have therefore captured the effect of adjustment costs by assuming a stochastic depreciation rate for capital (e.g. Gomes and Michaelides (2008), Storesletten et al. (2007), Krueger and Kubler (2006), and Gottardi and Kubler (2004)). Here we follow the same route and assume that the depreciation rate is given by

$$\delta_t = \delta + s \times \eta_t \tag{4}$$

where η_t is a two-point approximation to an i.i.d. standard normal, and s is a scalar. Therefore, δ_t is a general measure of economic depreciation, combining physical depreciation, adjustment costs, capital utilization and investment-specific productivity shocks.[8]

[8] We assume that η_t is uncorrelated with the productivity shock U_t since, as shown by Gomes and Michaelides (2008), introducing (moderate) correlation between these two variables would have a negligible impact on results.

2.2 Government sector

We define two different periods of government ”behavior” in our economy: normal periods and periods of fiscal intervention. In normal periods the government simply finances government consumption and interest payments on pre-existing bonds, with tax rates that are kept constant. So, the government does not own any capital and the supply of bonds is also kept constant at a “normal” level.

2.2.1 Government Interventions

In periods of fiscal intervention, the government expands the supply of bonds to finance investments in the private sector (capital purchases). Therefore the total capital stock in the economy is now given by

$$K = K^{private} + K^{G} \tag{5}$$

where $K^{privtate}$ denotes privately-owned capital and K^{G} denotes state-owned capital.

The investment are followed by an increase in taxes. Since the government is buying the assets at their fair value one might assume that the return on those assets is sufficient to pay for the interest on the new bonds and therefore no change in taxes is required. However, this would only be true in a world where Ricardian equivalence holds. In our economy the change in government debt has real distortionary impacts which therefore lead to a reduction in government tax revenues. As a result, the government is forced to increase tax rates to finance its expenditures, and since these taxes are also distortionary, the increase is non-trivial. Finally, we assume that the interventions will only occur in response to negative economic shocks, and will persist for a while, until the government decides to revert the bond supply (and taxes) back to the “normal” level.

This specific policy combination, public investment in capital and increase in tax rates (particularly those on asset income) might seem slightly odd, but this is very much in line with what we have observed in several countries. In the US it is yet unclear which taxes will ultimately be increased to prevent a public debt spiral, so we have to take a stand, but the current political dynamics suggest that at least previous reductions of capital taxes under the Bush administration will not be extended, and thus capital income tax rates are likely to rise compared with their pre-recession levels.

2.2.2 Value of the interventions

Finally, as previously discussed, in our baseline case we assume that the government acquires these assets at their fair value, thus abstracting from any potential gains from buying in currently

depressed markets and/or losses from overpaying for "bad assets". Likewise we also ignore any positive *direct* externalities from the government investment. It is however relatively straightforward to change this assumption and allow for a net gain or positive externality or even for a negative externality (for example, due to moral hazard considerations). In fact, in one of our comparative statics exercises, we will specific allow for this possibility by letting the marginal productivity of government-owned capital differ from the marginal productivity of privately-owned capital. More specifically, we will re-write the production function as:

$$Y_t = Z_t(K_t^{private} + \alpha^* K^G)^\alpha {L_t}^{1-\alpha} \tag{6}$$

With this set-up, if $\alpha^* > 1$ then output is higher during interventions, thus capturing potential benefits/externalities from the government's intervention.

We assume all investors receive the same return on capital, in other words, we assume that the return is distributed equally across all types capital, so that private investors also benefit directly from the extra productivity. Marginal productivity of capital, *per unit of capital*, is then given by

$$MPK = \alpha Z_t \left(\frac{L_t}{K_t^{private} + \alpha^* K^G} \right)^{1-\alpha} /(K_t^{private} +$$

because there is no household labor-leisure decision. As a result we will simply refer to them as lump-sum taxes, which is what they effectively are.[10]

Now we can extend the previous budget constraint to include state-owned capital. More precisely, denoting state-owned capital by K_t^G, equation (8) is replaced with

$$(1 + R_t^B)B_t + G_t^c = T_t + B_{t+1} + R_t^K K_t^G - (K_{t+1}^G - K_t^G) \tag{9}$$

where we take into account two additional elements. First, part of the government's increases (decreases) in tax rates and bonds are being used to increase (decrease) its investments in physical capital. Second, the government also earns a return on the capital stock that it (potentially) owns.[11]

2.2.4 Interventions: transition probabilities

As previously discussed, in the model the government might choose to issue government bonds to stimulate the economy, by investing the proceeds in additional capital stock, which will then be followed by an increase in taxes. Therefore, both the tax rate on capital and the supply of government bonds are stochastic variables. Each of these is characterized by two potential states: a "normal" state and an "intervention" state. In the "normal" state the capital income tax rate ($\tau_{K,t}$) is equal to $\overline{\tau}_K$, but it can increase by Δ_τ (i.e. to $\tau_{K,t} = \overline{\tau}_K + \Delta_\tau$) according to a set of conditional probabilities: Π^τ. Likewise, bond supply alternates between a "normal" level, ($\overline{B}$) and a high level ($\overline{B} + \Delta_B$), based on another set of conditional probabilities: Π^B.

In the model government interventions will only occur following negative economic shocks, so the transition dynamics for the bond supply is a Markov Chain where the transition probabilities also depend on the realization of the stochastic depreciation shock, $\Pi^B = \Pi^B(B_{t+1}, B_t, \eta_t)$, and in particular:

$$\begin{aligned} \pi^B(B_{t+1} &= \overline{B} + \Delta_B, B_t = \overline{B}, \eta_t = 1) = \pi^B_{HLL} > 0 \\ \pi^B(B_{t+1} &= \overline{B} + \Delta_B, B_t = \overline{B}, \eta_t = -1) = \pi^B_{HLH} = 0 \end{aligned}$$

so that $\pi^B_{HLL}/2$ effectively determines the unconditional probability of an intervention occurring. In addition, we will also assume that the expected duration of the increase in bond supply is

[10] It would also be interesting to study the possibility of financing the government expenditures with distortionary labor income taxes, however this would require the inclusion of a labor supply decision, a substantial additional complexity. In addition, as we discuss below, models with labor taxes and endogenous labor supply face an important calibration problem, unless different complex features of the tax code are carefully modeled, making this an even more formidable computational task. Therefore, in this paper, we only consider alternative combinations of capital income taxes and debt as sources of financing government interventions.

[11] As previously discussed the capital purchases and sales are assumed to take place at market prcies. In addition, the government is assumed to re-invest to off-set depreciation, thus keeping the value of its capital stock constant over time.

independent of state of the economy following the intervention date:

$$\pi^B(B_{t+1} = \overline{B}, B_t = \overline{B} + \Delta_B, \eta_t = 1) = \pi^B_{LHL} = \pi^B(B_{t+1} = \overline{B}, B_t = \overline{B} + \Delta_B, \eta_t = -1) = \pi^B_{LHH} > 0$$

It would be trivial to change this set-up, and consider different probabilities here, but that would add one more parameter to calibrate.

With regards to the capital income tax rate, the transition probabilities in the Markov Chain depend on the bond supply ($\Pi^\tau = \Pi^\tau(\tau_{K,t+1}, \tau_{K,t}, B_{t+1})$), since tax rates only increase in the years following a bond issuance

$$\begin{aligned} \pi^\tau(\tau_{K,t+1} &= \overline{\tau}_K + \Delta_\tau, \tau_{K,t} = \overline{\tau}_K, B_t = \overline{B} + \Delta_B) = \pi^\tau_{HLH} = 1 \\ \pi^\tau(\tau_{K,t+1} &= \overline{\tau}_K + \Delta_\tau, \tau_{K,t} = \overline{\tau}_K, B_t = \overline{B}) = \pi^\tau_{HLL} = 0 \end{aligned}$$

and revert back to normal when government debt reverts back to $\overline{B}$:

$$\begin{aligned} \pi^\tau(\tau_{K,t+1} &= \overline{\tau}_K, \tau_{K,t} = \overline{\tau}_K + \Delta_\tau, B_t = \overline{B} + \Delta_B) = \pi^\tau_{LHH} = 0 \\ \pi^\tau(\tau_{K,t+1} &= \overline{\tau}_K, \tau_{K,t} = \overline{\tau}_K + \Delta_\tau, B_t = \overline{B}) = \pi^\tau_{LHL} = 1 \end{aligned}$$

To summarize, across the two Markov Chains we only have two transition probabilities to calibrate:

1) The unconditional probability of an intervention: $\pi^B_{HLL}/2$

2) The expected duration of the intervention (higher bonds and taxes): $\pi^B_{LHL}(= \pi^B_{LHH})$

2.2.5 Foreign-held government bonds

In the data, not all of government debt is owned by national residents. In the US, between 1970 and 2003, on average 20% of debt held by the public is held by foreign investors. While this number was relatively stable throughout 1990's, in the last 15 years there has been a substantial upward trend and this percentage more than doubled. This motivates our baseline calibration of $\overline{B}$ to the actual percentage of bonds held by US households. However, when we increase the supply of bonds we now need to make an assumption regarding the percentage of these new bonds that will be bought by foreigners. In the US in particular, there is currently significant concern that this percentage will be much lower than in the past. Therefore, while in our baseline calibration we set this percentage (later on denoted by b^F) equal to 25%, we will also consider a scenario where this number is lower.

2.3 Households and financial markets

Households have Epstein-Zin preferences (Epstein-Zin (1991)) defined over a single nondurable consumption good. Let C_t denote consumption in period t, then preferences are defined by

$$V_t = \left\{ (1-\beta) C_t^{1-1/\psi} + \beta \left(E_t(V_{t+1}^{1-\rho}) \right)^{\frac{1-1/\psi}{1-\rho}} \right\}^{\frac{1}{1-1/\psi}} \tag{10}$$

where ρ is the coefficient of relative risk aversion, ψ denotes the elasticity of intertemporal substitution and β is the discount factor. Household have a finite horizon divided in two main periods: working life and retirement.

We let i index individual households, and a denote age/cohort. The stochastic process for individual labor income (H_{at}^i) is then given by:

$$H_{at}^i = W_t L_a^i \ , \tag{11}$$

where L_a^i (the household's labor productivity) is a function of age. This productivity is specified to match the standard stochastic earnings profile in life-cycle models. More precisely, labor income productivity combines both permanent (P_a^i) and transitory (ε^i) shocks with a deterministic age-specific profile:

$$L_a^i = P_a^i \varepsilon_i \tag{12}$$

$$P_a^i = \exp(f(a)) P_{a-1}^i \xi^i \ , \tag{13}$$

where $f(a)$ is a deterministic function of age, capturing the typical hump-shape profile in life-cycle earnings. We assume that $\ln \varepsilon^i$, and $\ln \xi^i$ are each independent and identically distributed with mean $\{-.5 * \sigma_\varepsilon^2 \ , -.5 * \sigma_\xi^2\}$, and variances σ_ε^2 and σ_ξ^2, respectively.

Retirement is exogenous and deterministic. All households retire at age 65 ($a^R = 46$) and retirement earnings are given by: $\lambda P_{a^R}^i W_t$, where λ is the (exogenous) replacement ratio. The retirement income is funded by a proportional social security tax τ_s discussed later.

Households receive labor income during working life and pension payments during retirement, and can invest in two financial assets: a one-period riskless asset (government bond), and a risky investment opportunity (capital stock). The riskless asset return is $R_t^B = \frac{1}{P_{t-1}^B} - 1$, where P^B denotes the government bond price. The return on the risky asset is denoted by R_t^K. We assume that households cannot borrow against their future labor income, and cannot short the risky asset. In appendix A we formally state the household dynamic programming problem.

2.4 Equilibrium

Households are price takers and maximize utility given their expectations about future asset returns and aggregate wages. Under rational expectations, the latter are given by equations (2) and (3): returns and wages are determined by future capital and labor, and by the realizations of aggregate shocks. Labor supply is exogenous, as are the distributions of the aggregate shocks. The capital stock, however, is endogenous. Forming rational expectations of future returns and wages is, therefore, essentially equivalent to forecasting the future mean capital stock (from equation (3)). As shown by Krusell and Smith (1998), for this class of incomplete market economies, it is possible to forecast the one-period ahead aggregate capital stock extremely accurately by using its current value (K_t) and the state-contingent realizations of the aggregate shocks. We use this methodology to solve for the equilibrium of the model. The definition of the equilibrium is given in appendix A and the numerical solution method is outlined in appendix B.

3 Calibration

Households and firms make decisions on an annual frequency. The household earnings processes and social security are calibrated from evidence based on micro-economic data (PSID), while the other parameters are used to match several empirical moments. The government sector variables are calibrated to match the ratios of government bonds, government expenditures and tax revenues to GDP. The technological parameters and preference parameters are chosen to try to replicate, as close as possible, multiple different moments such as the consumption and investment shares of GDP, consumption volatility, wealth distribution, limited participation, and the mean and volatility of returns.

3.1 Labor income and social security

Agents begin working life at age 20, retire at 65, and can live up to age 90. The parameters for the household earnings processes are taken from previous studies using the PSID. More specifically, the variances of the idiosyncratic shocks are taken from Carroll (1992): 10 percent per year for σ_ε and 8 percent per year for σ_ξ, while the parameter values for the deterministic labor income profile, reflecting the hump shape of earnings over the life-cycle, are taken from Cocco, Gomes and Maenhout (2005).

For tractability we assume that the social security budget is balanced in all periods. Given a value for the replacement ratio of working life earnings (λ), the social security tax rate (τ_s)

is determined endogenously. This tax rate ensures that social security taxes are equal to total retirement benefits, taking into account the demographic weights. Consistent with the empirical evidence with regards to median replacement rates from the U.S. social security system, we use a 40% replacement rate (as in Cagetti and De Nardi (2006)), which implies an endogenous social security tax (τ_s) of approximately 17.5% to maintain social security balance period by period, consistent with the findings of life-cycle models.

3.2 Technology

Capital's share of output (α) is set to 34%, and the average annual depreciation rate (δ) is 8% to match the investment to output ratio. To match asset return volatility we set the standard deviation of the stochastic depreciation shock at 13%. The aggregate productivity shock follows a two-state Markov Chain and its unconditional standard deviation (2.5%) is chosen to match the standard deviation in aggregate output (taken from the NIPA tables, published by the BEA). The transition probability of changing states is calibrated to 0.4 to match the average duration of business cycles (as in Storesletten, Telmer and Yaron (2007)), and deterministic growth is set at 1% ($G = 1.01$)

3.3 Government sector

3.3.1 "Normal-period" parameters

The aggregate supply of bonds is set to 35% of GDP, which is the average value of U.S. Treasury securities held by the U.S. public, reported by the Congressional Budget Office (from 1962 to 2003). We only include the debt held by U.S. households because in the model this number will also correspond to domestically-held debt. This ignores the interest payments on foreign-held bonds in the government's budget constraint. However, we can simply interpret these as an additional exogenous source of government expenditures (G). Using the average historical values for both the cost of debt and total debt outstanding, this corresponds to an additional 0.6% of GDP, which has a fairly negligible impact on our baseline calibration of G. In our analysis, when we increase government debt within the model, we explicitly keep track of the total supply of bonds (rather than just the one held domestically) in the government's budget constraint.

We also need to match the share of government expenditures in GDP, which is an endogenous quantity in the model. This is achieved through an appropriate calibration of the tax rates. However, even ignoring this extra constraint, the calibration of each tax rate already (potentially) requires a compromise between matching two different features of the data: the tax rate itself or the corresponding share of tax revenues in GDP. We compute the tax shares using data from the

Bureau of Economic Analysis from 1929 until 2006.[12] For capital income taxes we set the "normal" tax rate ($\overline{\tau}_K$) to 40%, following Trabandt and Uhlig (2006), Carey and Rabesona (2002) and Mendoza, Razin and Tesar (1994). We discuss the calibration of the higher tax rate and the transition probabilities in the next section.

With respect to the tax rate on labor income, the calibration decision is clear: since we do not have a labor supply decision in the model, then these are effectively lump-sum taxes, and therefore we want to match the revenue share, as opposed to the tax rate. As shown in table 2, a flat rate of 10% generates tax revenues which are in line with the empirical numbers.[13] Note that, our marginal tax rate on labor income is much lower than the one faced by most households. This result is actually very general. Quite simply, with Cobb-Douglas technology labor income as a fraction of GDP is simply $1-\alpha$, and with a linear tax schedule the share of labor revenues in GDP becomes $\tau_l(1-\alpha)$.[14] Therefore, in this class of models, researchers can either match the marginal tax rate and dramatically over-estimate the importance of labor tax revenues in the data, or match the revenues themselves and significantly under-estimate the distortion at the margin.[15]

This still leaves us with one parameter left to calibrate: the tax rate on consumption. We set $\tau_C = 13\%$ which delivers an almost perfect match of the share data. This number might seem slightly high, but it is important to remember that this is an average across all consumption goods in the data, and some items (namely luxury ones) face fairly high tax rates. In addtion, we also want the model to match the share of government expenditures in GDP, and we find that the combination of these different tax rates and B/Y delivers an almost perfect match (shown in Table 1).

3.3.2 Intervention parameters

In our analysis we only consider government expenditures directly related to investments in the corporate sector, and therefore exclude the stimulus package aimed at increasing household-level net worth and consumption. Naturally, if we also include this set of expenditures the distortionary

[12]The BEA data does not provide a disaggregation of total personal income taxes, and therefore we combine it with data from the IRS to compute the relative percentages of labor income and capital income taxation included in this category.

[13]As we can see from the table, the ratio of labor tax revenues to GDP has increased over time. Although in most of our calibration we have considered long time-series as much as possible, we want the fiscal policy conditions in our baseline economy to be fairly close to the current values, so that our results are directly applicable to the current US economy. Therefore, here we put more emphasis on matching the 2006 value (8.71%) than the 1929-2006 average (6.80%).

[14]In our model the numbers are actually slightly different because we also have retired households.

[15]This naturally reflects the multiple sources of deductions and exemptions that are not being modeled with a linear tax schedule. These issues and trade-offs are discussed in more detailed in Castaneda et al. (2003).

cost would be higher, but this type of interventions are not so unusual in periods of recession, and we are only interested in the potentially less orthodox measure: government capital investments and related expenditures.

In the baseline version we set the percentage increase in bonds ($\Delta_B/\overline{B}$) to 25%, corresponding to 8.75% of GDP, and the increase in the capital income tax rate (Δ_τ) to 1.5 percentage points. This tax rate increase is determined by trial and error so that government consumption is equal across the two scenarios, with and without intervention. To calibrate the amount of debt increase during the intervention we aggregate investments administered in 2008-2009 through several government programs. In our baseline calibration we take a slightly conservative approach, since some of these programs were financed by the Treasury and others by the Federal reserve, and the former were not immediately financed by additional debt. However, we will consider alternative scenarios in our experiments.

We include the following items in our calculations[16]: conservatorship of Fannie Mae ($34.2B) and Freddie Mac ($50.7B); assets purchases from collapsed Bear Sterns ($26.4B); takeover of American International Group ($118.9B); capital infusion program for banks ($204.7B, part of TARP); additional TARP funds for Citigroup and Bank of America ($40B); TARP funds ($83.5B) for restructuring of automotive industry (GM, Chrysler) and affiliates (GMAC, Chrysler Financial, autoparts suppliers). These investments amount to $558.4B or 3.9% of GDP of $14.3 trillion (as of 4-th quarter 2007). In addition, the Federal Reserve supported Fannie Mae and Freddie Mac by purchasing $139.8B of GSE's debt and through the summer of 2009 purchased $776.9B of mortgage-backed securities issued by them. While these transactions are not supported by issuing treasury debt, they substitute the traditional function of private capital markets. Including them brings the total government intervention to $1,479B or about 10.3% of 2007Q4 GDP. Given that we calibrate the debt to GDP ratio to its long run average of 35%, this expansion of debt would correspond to the ratio rising to 45.3%. We consider a somewhat more conservative calibration and assume that outstanding debt is increased by 8.75% of GDP (25% of its current value) bringing the total debt during the intervention to 43.7% of GDP. An alternative way to assess this number is to consider that public debt has grown from 35.7% GDP in 2007Q4 to 50.2% in 2009Q2, a change of 14.5 percentage points.[17] As previously mentioned, we calibrate the increase in debt by 8.75% of GDP, thus

[16]These numbers are available from the US Treasury, Board of Governors and the New York Federal Reserve. An updated recent summary is provided on the web by CNN Money: http://money.cnn.com/news/storysupplement/economy/bailouttracker/index.html., and as previously mentioned, we exclude all items related to stimulus package for consumption.

[17]As reported by the US Department of the Treasury (series FYGFDPUN available from the St. Louis Fed data wesite), debt held by the public at in 2007Q4 was $5.13T and rose by about $2 trillion to $7.17T by 2009Q2.

attributing about 60% of the actually observed increase in debt to direct government intervention in capital markets, which we view as a slightly conservative estimate.

As previously discussed, a substantial portion of the US national debt (about 20% in the 1990's and over 40% in recent years) is held by non-residents and there is a concern that this percentage will be much lower in the future, as foreigners will be unwilling to buy as many bonds as they have done in the past. This could result from foreign governments redirecting financial resources to stabilize their own economies or it could be due to the benefits from diversifying into non-dollar denominated bonds. Therefore, while in our baseline calibration we assume that 25% of the new bonds will be bought outside of the US ($b^F = 25\%$) , we will also consider a scenario where this number is significantly lower ($b^F = 10\%$).

Finally we still have to calibrate the transition probabilities for bonds and taxes (Π^B and Π^τ). When describing the model we discussed a set of assumptions that impose tight restrictions on most of these parameters. Namely, we assumed that: i) an intervention only occurs following a negative economic state; ii) capital income taxes increase in the year following the intervention; iii) tax shocks revert back to their normal level once the same has happened to the bonds; and iv) the expected duration of the increase in bond supply is independent of state of the economy following the intervention date. In section 2.2, we explained how these assumptions imply several zero/one or equality restrictions on different parameters of the transition matrices Π^B and Π^τ, leaving only two free parameters to calibrate. These are:

1) the unconditional probability of an intervention ($\pi^B_{HLL}/2$): we set this equal to 0.01 in the baseline case, implying a 1 in 100 years probability of an intervention. In the US we could argue that we had one or two such scenarios (now and maybe following the Great Depression), in a period of just over 100 years, but clearly those are too few observations to infer an expected probability. However, this variable does not play a significant role in any of our results, as long as we keep this value relatively small, which is perfectly reasonable.

2) the expected duration of the intervention, with both higher bonds and taxes ($1/\pi^B_{LHL}(= 1/\pi^B_{LHH})$): in the baseline case we set this equal to 5 years, but we will also consider longer lasting interventions.

3.4 Preference heterogeneity and limited participation

We consider two groups (A and B) of households in the model: stock market participants and non-participants. In the recent data, the two groups are almost identical in size (55% and 45%

respectively, using the data from the 2001 SCF).[18] However, they have very different wealth accumulation profiles: the participation rate is 88.84% among households with wealth above the median, and only 15.21% for those with wealth below the median. In the model we treat limited participation as exogenous for tractability reasons, but make sure that the wealth accumulation differences are consistent with the data.[19] We use ex-ante preference heterogeneity in the discount factor and the elasticity of intertemporal substitution to endogenously generate different wealth accumulation profiles, and we assume stockholders make up 50% of the population, consistent with the empirical magnitudes in the U.S. economy. Type-A (non-stockholders) have a very low discount factor ($\beta = 0.7$) and never accumulate much wealth over the life cycle, while type-B (stockholders) have a higher discount factor ($\beta = 0.99$) chosen to match the historical risk free rate.[20] There is strong evidence that stockholders have a higher EIS than non-stockholders (see, for example, Vissing-Jorgensen (2002)). Therefore, we assume that non-stockholders have a lower EIS in the model as well. We pick $\psi^A = 0.45$ to match the wealth accumulation of this group, in combination with the discount factor. The value of the EIS stockholders is chosen to match, as close as possible, two different moments: the volatility of consumption growth for this group, and the volatility of the riskless rate. This gives us $\psi^B = 0.7$ and, as we will see later, a good calibration of both of these moments. Finally, both types have the same risk aversion coefficient ($\rho = 5$).

4 Unconditional baseline results

4.1 Macroeconomic variables and asset prices

Table 1 reports the main macroeconomic quantities. The shares of consumption, investment and government expenditures and debt relative to GDP match their empirical counterparts quite accurately (panel A). The empirical moments are taken from the National Accounts reported by

[18] These numbers take into account households that participate in the stock market indirectly through pension funds.

[19] Given the low wealth accumulation of non-stockholders, a small one-time entry cost would suffice to endogeneize the non-participation decision. For example, Alan (2006) estimates a structural participation model and finds that a one-time entry cost equal to approximately 2-3% of average annual income explains limited stock market participation. Gomes and Michaelides (2008) show that a one-time cost of 5% of average annual income would deter participation for the poorer households while matching the conditional wealth accumulation of both stockholders and non-stockholders. We leave such an entry cost out of the model to reduce the computational burden.

[20] We emphasize that the quantitative results are almost identical regardless of the method we use to generate "poor" non-stockholders. What really matters is that we replicate poor households within the model. The same *quantitative* results would be obtained under alternative specifications, as long as these two groups are calibrated to match the same heterogeneity in wealth accumulation. For example, Gomes and Michaelides (2008) consider heterogeneity in risk aversion and EIS, with $\beta = 0.99$ for both groups, among other combinations.

Bureau of Economic Analysis, from 1929 until 2007. Following Castaneda et al. (2003) we classify 75% of durable consumption expenditures as investment and 25% as consumption. Panel B shows that the volatilities of aggregate consumption and output growth in the model (3.02% and 3.92%, respectively) match extremely well with the ones in the data (3.28% and 4.28%, respectively). Panel B also shows that consumption growth of stockholders is more volatile than the consumption growth of non-stockholders, consistent with the empirical evidence in Malloy, Moskowitz and Vissing-Jorgensen (2009).

Table 2 compares the different tax revenues as a percentage of GDP relative to the 2006 data and relative to the average tax revenues over the 1929-2006 period. The tax revenues from capital income taxation are 5.45 percent of GDP relative to 5.78 percent in the 2006 data and 5.26 percent in the longer run average (1929-2006). Labor income and consumption tax revenues are also similar in magnitude to the data, providing some comfort that the tax base is captured at some level by the model.[21]

Table 3 reports the main asset pricing moments implied by the model, along with their empirical U.S. counterparts. The returns series are taken from CRSP. The equity return is the real return on the CRSP value-weighted index (including dividends), and the rate of return on government bonds is the real return on 1-year government bonds.[22] Since firms in the model are not levered, our return on capital corresponds to the return of unlevered equity in the data. Therefore, we adjust the moments of our return series by the average leverage of US corporations to make them comparable with the CRSP data.[23] The equity premium in the model is relatively close to its empirical counterpart (5.23% versus 6.54%), and the same applies to the risk free rate (1.81%

[21]The model does not feature progressive taxation. We view this as an interesting extension of independent interest in the face of large changes in government debt that need to be financed by large increases in the highest marginal tax rate.

[22]We consider 1-year bonds because we have a yearly model and, in the model, government bonds are risk free over 1 period. In the data, the average maturity for government debt has changed over time, but it is close to 5 years. The rates of return on this debt however, also include a potentially non-trivial risk premium. Nevertheless, if we use the price series for 5-year government bonds, we would actually obtain a very similar average return (1.66% versus 1.23%), and the main difference would be the standard deviation: 6.10% versus 3.83%.

[23]Since we are implicitly assuming risk-free corporate debt, expected levered returns are computed using the simple Modigliani-Miller formula:

$$r^{equity} \equiv r_K^{levered} = r_K^{unlevered} + \frac{D}{E}\left(r_K^{unlevered} - r_f\right)$$

Along the same lines, the Sharpe ratio on levered equity must be identical to the Sharpe ratio on unlevered equity, allowing us to compute the standard deviation on the levered claim from:

$$\sigma_K^{Levered} = \sigma_K^{unlevered} \frac{r_K^{levered} - r_f}{r_K^{unlevered} - r_f}$$

versus 1.23%). Likewise the return standard deviations (respectively, 19.74% and 1.21% for equity and bonds) are also very similar to those observed in the data.[24]

4.2 Cross-sectional inequality and life-cycle profiles

The combination of idiosyncratic shocks, preference heterogeneity and differences in stock market participation status induces significant cross-sectional heterogeneity in wealth accumulation and consumption. The model generates gini coefficients for wealth and consumption of 0.7 and 0.29, respectively, which compare very well with 0.8 and 0.25 in the data.[25] Table 4 reports the shares of wealth held by different percentiles of the wealth distribution both in the model and in the 2001 SCF.[26] Overall, the model captures relatively well the wealth distribution. In particular, it replicates the fact that wealth below the median is negligible, while households in the top quintile hold 69% of total assets in our economy versus 83% in the data. For stockholders, the wealth distribution is not as skewed as in the data, since our economy does not capture the rich entrepreneurs that dominate the top end of the distribution.[27]

Figure 1 plots life cycle gini coefficients of consumption. Consistent with the empirical evidence in Deaton and Paxson (1994), and more recently in Krueger and Perri (2006), consumption inequality increases with age, and is much more pronounced during retirement because a significant fraction of the population (mostly non-stockholders) saves very little wealth during working years, due to their high discount rate. Figure 2 plots wealth inequality over the life cycle. For non-stockholders wealth inequality is mostly driven by the inequality in labor income, with a strong fanning out over the life cycle. After age 65 there is a significant decrease as they quickly run down their limited savings. Stockholders, on the other hand, save aggressively from early on, leading to a slight reduction in the gini coefficient in the first few years of working life. Wealth inequality then rises from age 25 onwards as they accumulate substantial amounts of wealth. As a whole, there is substantial wealth dispersion in the economy reflecting the differential savings behavior across the

[24]The target risk-free rate volatility is about 2% rather than the historical realized volatility, since we do not have inflation in the model.

[25]The wealth gini coefficient is computed from the 2001 Survey of Consumer Finances, while the consumption gini coefficient is taken from Krueger and Perri (2006).

[26]In the SCF, wealth is defined as liquid assets net of all non-real estate loans plus real estate equity. Liquid wealth is made up of all types of transaction accounts, certificates of deposit, total directly-held mutual funds, stocks, bonds, total quasi-liquid financial assets, savings bonds, the cash value of whole life insurance, other managed assets (trusts, annuities and managed investment accounts) and other financial assets. Home equity is defined as the value of the home less the amount still owed on the first and 2nd/3rd mortgages and the amount owed on home equity lines of credit. Debts include all uncollateralized loans (credit cards, consumer installment loans) and loans against pensions.

[27]In the data, stockholders are defined as households owning stocks directly or through mutual funds either in taxable accounts or in pension plans.

two different groups.

5 Response to government intervention: baseline scenario

Given the reasonable empirical implications of the quantitative model, we can now use the model to assess its implications both for aggregate and cross-sectional outcomes. We consider a scenario similar to the sequence of events in 2007-09, where two years of bad economic shocks depleted the aggregate capital stock. In the model, the negative stochastic depreciation shocks capture this event. A fiscal intervention takes place in the following year, when a third consecutive negative realization of the economic shock occurs.

Overall in the two years prior to the fiscal intervention our economy suffers a cumulative 7.3% reduction in output, and a 19.93% reduction in the capital stock. These deviations from steady-state compare are very similar to the cumulative detrended loss in GDP in the 2008-2009 period: US GDP growth was 0.4% in 2008 and -2.4% in 2009, which converts into a 8.1% cumulative loss relative to the post-war average growth rate. Moreover, in our economy we assume yet another negative aggregate shock in year 3 ("2010"), and the government intervention only takes place in year 2 ("2009"), when the cumulative reduction in capital stock is much more severe, thus increasing its potential benefit on the economy. We have also considered alternative "recession scenarios" in our analysis but the results were almost identical.[28]

5.1 Aggregate Results

5.1.1 Counterfactual Impulse Responses

The counterfactual impulse responses are shown in figure 3. The figure plots the counterfactual difference between the outcomes of otherwise identical simulated economies with and without a fiscal expansion. In the year of the fiscal expansion the government issues bonds, and in order to be able to absorb them households cut down on private investment quite dramatically: aggregate private investment falls by 31.3%. The net effect on investment is still positive, due to the large increase in public investment, and therefore the capital stock increases.[29] This leads to higher aggregate wages, while the cost of capital falls by 15 basis points. This reduction in the cost of capital softens the pressure on the riskless rate resulting from the large increase in bond supply. Nevertheless, the

[28]Naturally the actual individual responses will depend on the recession scenario being considered, but the difference between the responses *with* and *without* fiscal intervention is very similar in all cases considered.

[29]The capital stock increases relative to the no-intervention case, which is what is being plotted in the figure, but not in absolute terms.

net result is still positive with the riskless rate increasing by 6 basis points (approximately 3% of the unconditional average)[30].

With higher wages consumption increases, although mostly for non-stockholders, as stockholders also have to pay higher capital income taxes. Aggregate consumption also responds positively in the first period of fiscal intervention, being the weighted average of the stockholder and non-stockholder consumption increases. Over the next few years, with private investment being crowded-out through the distortionary higher capital tax rates, the capital stock starts falling and this leads to a mirror-image reduction in wages and non-stockholder consumption. The drop in the capital stock is associated with an increase in the cost of capital. Stockholder consumption now decreases as well, as the aggregate capital drops, capital gains taxes have risen and wages have also fallen.

Once the fiscal expansion is concluded, the capital stock drops by almost 0.5% du408.1(c)3440.rW9(t)1

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These results are consistent with Laubac's (2008) empirical estimates.

invested in the capital stock which becomes productive next period. This then implies a decrease in the equity return and consequently also the risk-free rate as (an imperfect) substitute for capital. The following periods we start to register the crowding out of the capital stock which gradually raises the return on equity, and therefore the return on the government bonds as well. When the fiscal expansion ends, the government-owned part of the capital stock reverts to zero causing a drop in the aggregate capital stock *next period* and a *current* decrease in the amount of bonds outstanding (to the pre-intervention level). A drop in the current amount of bonds generates a decrease in the current risk free rate while the subsequent increase in the equity return generates an increase in next-period's risk free rate to clear markets. From then on, the equity and risk free rate move in the same direction as the aggregate capital stock reverts to its pre-intervention steady state.

5.1.2 Average responses

As previously discussed, since we have an incomplete markets economy, we do not have a well-defined social welfare function that will allow us to quantify the impact of these decisions on individual welfare. Moreover, we are interested in how observable variables are affected by policy actions. Therefore, as a guidance, we report the impact on important aggregate measures such as GDP, capital stock, aggregate consumption, and the total consumption of both stockholders and non-stockholders. In our baseline calculation we do not discount future period outcomes, for the simple reason that this is an overlapping generations economy and therefore we should treat all generations identically.[31] The results are shown in Table 5.

In the short-term the fiscal expansion induces additional investment in capital thus increasing aggregate output. Cohorts living in the economy during the first ten years following the government intervention will observe GDP to be higher by an average of 0.04% each year, and 0.45% over the ten-year period. However, for the average consumer, this extra investment is not desirable with aggregate consumption below its steady-state level by 0.6% over the same period. This is particularly the case for stockholders, who suffer from the lower return on capital and the higher taxes, and for whom average consumption falls by 1.42%. The average non-stockholder actually benefits in the short-run, with average consumption for this group actually increasing because of the higher aggregate wages. However, as we consider the welfare of future generations, the results become negative for all groups and all variables. Just by expanding the analysis to consider the

[31] Growth is already "taken out" because we report differences in outcomes across two alternative scenarios. For completeness, later on we will also report results obtained when we discount future outcomes/generations, and the differences are negligible in most cases.

generations present in the economy over the next 20 years we now find lower average output (-0.43%), and lower average consumption for both groups: -0.43% for non-stockholders and -3.06% for stockholders. If we go even further, and consider all cohorts in the economy over the next 50 years, (roughly the period until the impulse responses "die out"), we find non-trivial overall losses of -2.75% of consumption, which converts into approximately $300 Billion.

These results also identify a redistributive effect, with stockholders significantly more affected than non-stockholders. Even though this was expected given the increase in capital income taxes, this is only part of the story. The tax rate is only higher during the fiscal expansion period (the first five years), but stockholders' financial income (private capital stock times the return on capital) remains low for much longer, and in particular it falls by more than wage income. This is driven by the direct crowding-out effect and therefore it is mostly unrelated to our assumptions about the form of taxation used to finance the additional deficit during the intervention.[32]

5.1.3 Average responses with discounting

In Table 6 we now report the results for different discount rates for future outcomes. We consider three cases for the discount rate: 0 (our baseline, and preferred choice), 2% (slightly higher than our riskless rate, but close to the risk premium on an unlevered aggregate consumption claim in this economy), and r^K (which we view as an absolute upper bound on a sensible discount rate, since all of these variables have weakly lower risk).

As we consider a higher discount rate the average decreases in aggregate consumption are only slightly reduced. In fact, with a 2% discount rate the numbers are almost identical. For those variables that take positive values early on (aggregate output, aggregate capital and consumption of non-stockholders), the responses are now actually higher, because the positive values occur exactly in the very first years, and only later on do they become negative. Nevertheless, with a 2% discount rate the numbers are very close to the baseline values, and even with the extreme discount rate (r^K) the differences are quite small. The only exception occurs for the 10-year response of the capital stock, because of a sharp change from early large positive numbers to very large negative ones.

5.2 Cross-Sectional Implications

As briefly discussed above, stockholders and non-stockholders, for example, are differently affected by the fiscal expansion. Now we study in more detail the differential impact of this intervention on various groups of households.

[32]In practice, even if the interest on the bonds is financed (partially) by labor income taxation, the direct effect is still likely to affect shareholders mostly, as in most countries labor taxation is progressive.

5.2.1 Differential Impact by Wealth Levels

In Table 7 we report the average changes in consumption for different quartiles of the wealth distribution, at horizons of both 20 and 50 years. Below each of these we also report the percentage of total consumption change that is coming from the response in each individual quartile. This number is computed by equally weighting the percentage changes in each household's individual response, thus giving the same weight to all agents in the economy.[33] We find that the cost is borne disproportionately by the richer households: almost two thirds of the drop in consumption

the consumption change across all 50 years of the simulation (when we are essentially back at the steady-state levels) because some of those cohorts will not be alive anymore. In Table 8, panel B, we report the results for 4 specific cohorts: the cohorts of households aged 30, 45, 60 and 75 at the time of the fiscal intervention. We report the consumption changes over the following 15 years, during which all of these are still alive, thus making the comparison meaningful. The results are very similar to the ones reported in table 8, panel A, thus confirming the previous conclusions.

6 Response to government intervention: alternative scenarios

6.1 Duration of fiscal intervention period

One important determinant of the magnitude of the distortionary cost is the length of the time period during which government debt and taxes will differ from their "steady-state" values. Nevertheless, in a rare event like the current situation, we do not know for how long this will be the case in reality. We therefore consider alternative scenarios in our analysis. Along these lines, we now assume a longer lasting fiscal expansion. More precisely we set (both the expected and the actual) duration of the expansion ($1/\pi^B_{LHL} = 1/\pi^B_{LHH}$) equal to 10 years. The average results are shown in Table 9, while Figure 4 plots some of the impulse responses.[35]

During the first ten years we now have a much stronger increase in the capital stock and consequently aggregate output, but nevertheless consumption is still falling, even though the fiscal expansion is in progress during all this period. Figure 4 plots the impulse response of aggregate consumption and we can see that it becomes negative already in year 5, long before the fiscal expansion is concluded. Moreover, we also see that both aggregate output and aggregate capital are almost exactly back to their initial levels by year 10. Thus, even before the intervention is concluded, not only is consumption already significantly lower, but in addition the fiscal expansion is only generating a marginal increase in output. This confirms that a longer-lasting intervention is not a solution for keeping the economy on a positive growth path with high consumption. On the contrary, as the expansion continues, it becomes more and more ineffective, since households eventually re-adjust their own savings and allocations. In addition, the average longer-term impact on all variables is significantly more negative than in the baseline case, with a total present-value consumption loss of 6.26% of annual consumption (approximately $600 Billion).

[35] All others are available upon request.

6.2 Foreign demand for additional government debt

Another important determinant of the fiscal impact of the 'bailout' will be the government's ability to sell additional debt to foreign investors. If those investors are not simply willing to increase their holdings of US bonds in the same proportion, then a larger fraction will have to be absorbed by US households, implying a higher increase in the interest rate. Motivated by this we now consider an alternative scenario regarding the foreign demand for the new government bonds. More precisely, we assume that only 10% of the new bonds will be taken up by foreign entities, as opposed to the 25% value in the baseline calculations.

In this scenario, in the first year, the risk-free rate increases by 7.8 basis points while private investment falls by 38%, compared with 5.8 basis points and 31% respectively, in the baseline case. Over the five years of the fiscal expansion the risk-free rate is now 6.9 basis points higher, on average, as opposed to 2.3 basis points higher in the original experiment. As a result, short term growth is more short-lived and the average changes in output and capital are already negative in the first 10 years, as shown in Table 10. The long term effects are very similar because, once the debt reverts back to its steady-state level, the difference in foreign holdings also disappears.

6.3 Magnitude of fiscal intervention

As previously discussed, our baseline calibration takes a slightly conservative estimate of total level of government investment-related expenditures, since some of these were actually implemented by the Federal Reserve, and therefore did not immediately imply new debt issues. However, we now consider a alternative scenario, a fiscal expansion that will match more closely the total amount actually spent, regardless of the institution.[36] Therefore, we now assume that government debt increases by 35%, instead of 25% as in the baseline case. The results are shown in Table 11. Naturally the short-term expansions both in GDP and in the capital stock are more significant, but even in the first 10 years the consumption response is virtually identical despite the large fiscal policy boost. As we consider subsequent periods there is now a stronger decline in consumption, particularly for stockholders. These results help to further quantify the trade-off between short-term expansion and medium to long-term costs.

6.4 Benefits of the intervention

In our final experiment we relax our assumption of neutrality of the intervention, and instead assume that there was a positive externality induced by the government's investment as discussed in section

[36] Nevertheless, as before, we are still excluding expenditures related to consumption stimulus packages.

2.2.2. More specifically the production function is now given by equation (6), while the marginal productivity of capital *per unit of capital* is given by equation (7), so that all investors receive the same return on capital and therefore stockholders also benefit directly from the extra productivity. By calibrating the externality parameter, α^*, we can vary the net-present value of the intervention.

In this calibration we chose α^* so that, all else equal, the government intervention will lead to an increase of 10% in GDP during its five-year duration, relative to the counterfactual of no intervention. In such a scenario the government intervention leads to an overall net increase in consumption of 1.4 trillion dollars. However, naturally there is still a distortionary impact and this is what we want to measure. To measure this component we need to compare this simulated economy with the simulation of an otherwise equivalent economy without any government investment but where the same exact amount of private capital would have registered this same increase in productivity. By comparing those two economies we remove the benefit of the externality, and thus measure the distortionary cost alone. Table 12 reports the corresponding numbers. We find that the distortionary cost is almost unchanged relative to our baseline values: 2.73% consumption loss, versus 2.75% in the baseline case. In other words, even though we are considering a scenario where the net-present value of the 'bailout' was 1.4 trillion dollars, this number would have been 300 million higher if we didn't have the distortionary costs of financing the government expenditure. More importantly, we can conclude that our estimates of the distortionary cost of these interventions seem to be very robust to alternative assumptions regarding its overall benefits to the economy.

7 Conclusion

We have used an incomplete markets, heterogenous agent model that generates empirically plausible aggregate and cross sectional implications to quantify the effects of large fiscal interventions during a pronounced downturn in the economy. We have found that the required increase in government debt and taxes required to fund the government investments in capital stock, can have a large welfare cost (300 billion US dollars in our baseline calibration). This measure is shown to be very robust to different assumptions regarding the overall net benefits of the 'bailout' itself. Moreover, the cost falls dramatically on those households near the end of their working lives and on retirees. Thus, fiscal interventions of this magnitude can have substantial distortionary and distributional implications, and our work provides some guidance in evaluating quantitatively this equity-efficiency tradeoff.

We believe that future research on this topic should aim at measuring the benefits and other potential costs of this intervention, so that an overall assessment can be made and used to provide

guidance on how future potential government interventions of this form can be structured in order to maximize social welfare.

Appendix A Household Problem and Equilibrium definitions

A.1 Wealth accumulation

There are two financial assets: a one-period riskless asset (government bond), and a risky investment opportunity (capital stock). The riskless asset return is $R_t^B = \frac{1}{P_{t-1}^B} - 1$, where P^B denotes the government bond price. The return on the risky asset is denoted by R_t^K. Total liquid wealth (cash-on-hand, X_t^i) can be consumed or invested in the two assets. At each age (a), households enter the period with wealth invested in the bond market, B_{at}^i, and (potentially) in stocks, K_{at}^i, and receive $L_a^i W_t$ as labor income. Before retirement ($a < a^R$) cash-on-hand at time t is given by:

$$(1+\tau_C)C_{a,t}^i + K_{a+1,t+1}^i + B_{a+1,t+1}^i = X_{at}^i = K_{at}^i(1+(1-\tau_{K,t})R_t^K) + B_{at}^i(1+(1-\tau_B)R_t^B) + L_a^i(1-\tau_s-\tau_L)W_t \tag{A.1}$$

Households cannot borrow against their future labor income ($B_{at}^i \geq 0$), and cannot short the risky asset ($K_{at}^i \geq 0$).

In the presence of deterministic growth we need to normalize the non-stationary variables in this economy. This can be achieved by normalizing wealth and consumption by $P_a^i G_t^{\frac{1}{1-\alpha}}$, for example: $k_{a,t+1}^i = \frac{K_{a,t+1}^i}{P_a^i G_t^{\frac{1}{1-\alpha}}}$. Then, defining $\omega_t = \left(\frac{G_t}{G_{t-1}}\right)^{\frac{1}{1-\alpha}}$ and $w_t = \frac{W_t}{G_{t-1}^{\frac{1}{1-\alpha}}}$, the individual budget constraint (A.1) becomes:

$$(1+\tau_C)c_{at}^i + k_{a,t+1}^i + b_{at+1}^i = x_{at}^i = (1+R_t^K(1-\tau_{K,t}))\frac{k_{at}^i}{\omega_t\omega_a} + (1+R_t^B(1-\tau_B))\frac{b_{at}^i}{\omega_t\omega_a} + \varepsilon_t^i w_t(1-\tau_s-\tau_L)\frac{1}{\omega_t} \tag{A.2}$$

where $\omega_a = \exp(f(a))\xi^i$. After retirement, the equation looks the same except for the retirement benefit (and $\omega_a = 1$):

$$x_{at}^i = (1 + R_t^K(1-\tau_{K,t}))\frac{k_{at}^i}{\omega_t\omega_a} + (1 + R_t^B(1-\tau_B))\frac{b_{at}^i}{\omega_t\omega_a} + w_t\lambda(1-\tau_L-\tau_s)\frac{1}{\omega_t}$$

A.2 The dynamic programming problem

Households are price takers and maximize utility given their expectations about future asset returns and aggregate wages. Under rational expectations, the latter are given by equations (2) and (3):

returns and wages are determined by future capital and labor, and by the realizations of aggregate shocks. Labor supply is exogenous, as are the distributions of the aggregate shocks. The capital stock, however, is endogenous. Forming rational expectations of future returns and wages is, therefore, essentially equivalent to forecasting the future mean capital stock. As shown by Krusell and Smith (1998), for this class of incomplete-markets economies, it is possible to forecast the one-period ahead capital stock extremely accurately by using its current value (k_t) and the state-contingent realizations of the aggregate shocks, in our case the productivity shock (U_t), the stochastic depreciation (η_t), the capital income tax rate ($\tau_{K,t}$), and the supply of government bonds (B_t) leading to the following forecasting rule

$$k_{t+1} = \Gamma_K(k_t, U_t, \eta_t, \tau_{K,t}, B_t) \tag{A.3}$$

Since government bonds are only riskless over one period, households must also forecast future bond prices (P_t^B). The forecasting rule for P_t^B is

$$P_{t+1}^B = \Gamma_P(P_t^B, k_t, U_t, \eta_t, \tau_{K,t}, B_t) \tag{A.4}$$

This process introduces six additional state variables in the individual's maximization problem (P_t^B, k_t, U_t, η_t, $\tau_{K,t}$, and B_t).

The individual optimization problem then becomes:

$$\begin{aligned} & V_t(x_t^i; k_t, U_t, \eta_t, \tau_{K,t}, B_t, P_t^B) \qquad\qquad (\text{A.5}) \\ = \; & \underset{\{k_s^i, b_s^i\}}{Max} \left\{ (1-\beta)(C_t^i)^{1-1/\psi} + \beta \left(E_s \left[(\omega_s)^{1-\rho} V_s(x_s^i; k_s, U_s, \eta_s, \tau_{K,s}, B_s, P_s^B)^{1-\rho} \right] \right)^{\frac{1-1/\psi}{1-\rho}} \right\}^{\frac{1}{1-1/\psi}} \end{aligned}$$

with $s = t+1$, and subject to the constraints $k_{t+1}^i \geq 0$, $b_{t+1}^i \geq 0$, (A.2), and the aggregate laws of motion and expectations.

A.3 Equilibrium

The equilibrium consists of endogenously determined prices (bond prices, wages, and equity returns), a set of cohort-specific value functions and policy functions, ($\{V_a, b_a, k_a\}$), and rational expectations about the evolution of the endogenously determined variables, such that:

1. Firms maximize profits by equating marginal products of capital and labor to their respective marginal costs: equations (2) and (3).
2. Individuals choose their consumption and asset allocation by solving Equation (A.5).

3. Markets clear and aggregate quantities result from individual decisions (k^i_{at} and b^i_{at}), government's capital holdings (k^G_t), and the increase in foreign holdings of government bonds ($b^F \Delta b_t$).[37] Specifically

$$k_t = \int_i \int_a P^i_{a-1} k^i_{at} da di + k^G_t, \quad b_t - b^F \Delta b_t = \int_i \int_a P^i_{a-1} b^i_{at} da di. \tag{A.6}$$

4. Aggregate labor supply is normalized to one.

5. Once (3) and (4) are satisfied, Walras' law implies that total expenditure (government consumption, investment, and household consumption) must equal total output:

$$c^G_t + \ k_{t+1} - \frac{(1-\delta_t)k_t}{\omega_t} + \int_i \int_a P^i_a c^i_{at} da di = U_t k^\alpha_t L^{1-\alpha}_t \frac{(1+g)}{\omega_t} \ . \tag{A.7}$$

6. The social security system is balanced at all times:

$$\int_i \int_{a \in I_W} \tau_s L^i_a w_t da di = \int_i \int_{a \in I_R} [\lambda \exp(f(a^R)) w_t P^i_{a^R}] da di \ , \tag{A.8}$$

where the left-hand side is integrated over all workers ($a \in I_W$), while the right-hand side is integrated over retirees ($a \in I_R$). This equation determines τ_s for a given value of λ.

7. The government budget [equation (9)] is balanced every period to sustain a given ratio of government debt to GDP. Specifically

$$b_{t+1} = \frac{(1+R^B_t)b_t}{\omega_t} + \frac{(1+R^K_t)k^c_t}{\omega_t} + c^G_t - \frac{k_t R^K_t \tau_{K,t}}{\omega_t} - \frac{b_t R^B_t \tau_B}{\omega_t} - \frac{w_t(1-\tau_s)\tau_L}{\omega_t} + \frac{(k^G_{t+1} - (1-\delta_t)k^G_t)}{\omega_t}$$

and the law of motion for government-owned capital stock is

$$k^G_{t+1} = (1-\delta_t)\frac{k^G_t}{\omega_t} + (1-\chi)\Delta b_t$$

8. Market prices expectations are verified in equilibrium.

Analytical solutions to this problem do not exist and we therefore use a numerical solution method. The details are given in Appendix B.

Appendix B Numerical solution of the OLG model

B.1 Solution method outline

The solution method builds on Krusell and Smith (1997, 1998), Storesletten et al. (2007) and Gomes and Michaelides (2008). We start by presenting the outer loop of the code and discuss the details afterwards.

[37] We calibrate the baseline value of government bonds to math the holdings of US residents alone, and therefore, in this market clearing condition, we must include only the *increase* in foreign bond holdings.

The numerical sequence works as follows:

i. Specify a set of forecasting equations (Γ_K and Γ_P).

ii. Solve the household's decision problem, taking prices as given, and using the forecasting equations to form expectations (details in B.2).

iii. Given the policy functions, simulate the model (5100 periods) while computing the market clearing variables at each period (details in B.3).

iv. Use the last 5000 periods to update the coefficients in the forecasting equations (details in B.4).

v. Repeat steps 1, 2, 3, 4, with the new forecasting equations until convergence. We have two convergence criteria:

   - Stable coefficients in the forecasting equations.

   - Forecasting equations with regression R^2 above 99.9%.

B.2 Solving the household's decision problem

B.2.1 Discretization of the state space

Age (a) is a discrete state variable taking 71 possible values. We discretize the cash-on-hand dimension (x_t^i) using 51 points, with denser grids closer to zero to take into account the higher curvature of the value function in this region. The discrete aggregate state variables (the depreciation shock (η_t) and the aggregate productivity shock (U_t)) each take only two possible values. With respect to the other two continuous aggregate state variables, we use an adaptable grid that takes into account the availability of capital in the economy and allows higher accuracy with a fewer number of grid points. We use 15 points to discretize k_t, and 15 points to discretize P_t^B. The grid range for the continuous state variables is verified ex-post by comparing with the values obtained in the simulations, and with the results obtained when this range is increased. A smaller number of grid points for k_t and for P_t^B would not affect the policy functions directly. It would, however, affect the R-squared of the forecasting equations and the convergence of their respective coefficients.

B.2.2 Maximization

We solve the maximization problem for each agent type using backward induction. For every age a prior to A, and for each point in the state space, we optimize using grid search. We need to

compute the value associated with each set of controls (consumption and share of wealth invested in stocks). From the Bellman equation,

$$V_a(x^i_{at}; k_t, U_t, \eta_t, \tau_{K,t}, B_t, P^B_t) = \underset{\{k^i_{a+1,t+1}, b^i_{a+1,t+1}\}^A_{a=1}}{Max} \Bigg\{ (1-\beta)(c^i_{at})^{1-1/\psi} \tag{B.9}$$

$$+\beta \left(E_t \left[(\omega_{a+1}\omega_{t+1})^{1-\rho} p_a V^{1-\rho}_{a+1} \left(x^i_{a+1,t+1}; k_{t+1}, U_{t+1}, \eta_{t+1}, \tau_{K,t+1}, B_{t+1}, P^B_{t+1} \right) \right] \right)^{\frac{1-1/\psi}{1-\rho}} \Bigg\}^{\frac{1}{1-1/\psi}}$$

these values are given as a weighted sum of current utility ($(c^i_{at})^{1-1/\psi}$) and the expected continuation value ($E_a V_{a+1}(.)$), which we can compute once we have obtained V_{a+1}. We use the forecasting equations (Γ_K and Γ_P) to form expectations of the aggregate variables, and we perform all numerical integrations using Gaussian quadrature to approximate the distributions of the innovations to the labor income process (ε^i and ξ^i) and the aggregate shocks (η_t and U_t). For points which do not lie on state space grid, we evaluate the value function using a cubic spline interpolation along the cash-on-hand dimension, and a bi-linear interpolation along the other two continuous state variables (k_t and P^B_t). Bi-linear interpolation works well along these two dimensions because households are price takers, and therefore these state variables are not affected by the control variables.

B.3 Simulating the model and clearing markets

B.3.1 Simulation

We use the policy functions for the two agent types (A and B) to simulate the behavior of 250 agents of each type in each of the 71 cohorts over 5100 periods. The realizations of the aggregate random variables (stochastic depreciation η_t, aggregate productivity U_t, capital income tax rate, $\tau_{K,t+1}$, and bond supply, B_t) are drawn from their original two-point distributions, while the idiosyncratic productivity shocks (ε^i and ξ^i) are drawn from the corresponding log-normal distributions. All other random variables are endogenous to the model. The realizations of the exogenous random variables are held constant within the outer loop, i.e. across iterations, so as not to affect the convergence criteria.

B.3.2 Market clearing

For every time period we simulate the households' behavior for every possible bond price (i.e. every point in the grid for P^B_t). We then aggregate the individual bond demands and use a linear interpolation to determine the market clearing bond price. All household equilibrium allocations

(consumption and asset holdings) are then obtained from a linear interpolation with the same coefficients, while the aggregate variables (capital and output) are computed by aggregating these market clearing allocations. This then determines the state variables for simulating the next period's decisions.

B.4 Updating the forecasting equations

Using the simulated time-series (after discarding the first 100 observations) we estimate the following OLS regressions, for every pair of productivity shock (U_t), depreciation shock (η_t), tax rate ($\tau_{K,t}$) and bond supply (B_t) realizations,

$$\ln(k_{t+1}) = q_{10} + q_{11} \ln(k_t) \tag{B.10}$$

and

$$\ln(P^B_{t+1}) = q_{20} + q_{21} \ln(k_t) + q_{22} \ln(P^B_t) \tag{B.11}$$

This gives us 32 equations and 32 sets of coefficients that forecast *state-contingent* capital (k_{t+1}) and bond prices (P^B_{t+1}). We iterate the code until we have converged on the coefficients and on the R-squared of these regressions. For the first set of equations (B.10) we obtain R-squared values around 99.99%. For the second set of equations (B.11), the R-squared values are in the $90\% - 95\%$ range when we only use $\ln(k_t)$ as a regressor, but increase to more than 99% when we add $\ln(P^B_t)$.

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Table 1: Panel A reports values from the baseline model and aggregate U.S. data. Government debt is the U.S. federal debt held by the public between 1952 and 2002. Panel B reports the standard deviation of consumption (Campbell, 1999 annual data) and output (National Income and Product Accounts data). Panel B also reports the standard deviation of stockholders' and non-stockholders' consumption growth rates from the baseline model and from the data (Consumer Expenditure Survey, numbers are from Malloy, Moskowitz and Vissing-Jørgensen (2005) and annualized).

Panel A: Share of Output (percent)		
	Model	Data
Consumption	58.7	59.4
Investment	20.7	20.2
Government	20.5	20.4
Government Debt	35.2	35.8
Panel B: Standard deviation of growth rates (percent)		
	Model	Data
Aggregate Output	3.9	4.3
Aggregate Consumption	3.0	3.2
Stockholders Consumption	4.4	6.9
Non-Stockholders Consumption	3.2	2.7

Table 2: Table reports tax revenue (in percent of output) by source from the baseline model and aggregate U.S. data from the BEA National accounts.

	Model	Data (1929-2006)	Data (2006)
Capital	5.45	5.26	5.78
Labor	8.00	6.80	8.71
Consumption	7.64	8.53	7.77

Table 3: Unconditional asset pricing moments from the baseline model.

Variable	Moment	Model	Data
r_f	Mean	1.81	1.23
	Std. Dev.	1.21	3.83
r_m	Mean	7.04	7.77
	Std. Dev.	19.74	20.11
$r_m - r_f$	Mean	5.23	6.54

Table 4: Wealth Distribution. The table reports the percentage of each group's total wealth held within a given percentile range. Data source: 2001 Survey of Consumer Finances. Wealth is the net worth of households as defined in the text and stockholders are defined as households who own stocks directly or through mutual funds either in taxable accounts or in tax-deferred pension plans.

	Non-stockholders		Stockholders		All	
Percentile	Model	Data	Model	Data	Model	Data
10th	0.00	0.009	0.50	-0.021	0.00	-0.080
20th	0.00	0.009	2.50	0.41	0.00	-0.007
50th	0.39	2.42	20.73	5.60	0.12	2.90
50th-80th	6.05	18.03	36.81	16.62	30.93	14.55
80th-100th	93.56	79.55	42.46	77.78	68.96	82.54
90th-95th	9.69	14.56	10.70	11.83	17.45	12.20
95th-99th	42.59	22.26	10.69	25.94	18.35	25.26
99th-100th	34.11	26.42	3.59	26.86	6.57	32.14

Table 5: Counterfactual responses to fiscal expansion over different horizons, without discounting. The table reports the difference in realizations across two alternative simulated paths: with and without government intervention at year 0 (intervention is defined in the text). Each column reports the differences in cumulative responses over different time periods after year 0.

Time	10 years	20 years	50 years
dC	-0.60	-1.91	-2.75
dY	0.45	-0.43	-0.88
dK	1.24	-1.30	-2.59
dCns	0.45	-0.43	-0.87
dCs	-1.42	-3.06	-4.22

Table 6: Counterfactual responses to fiscal expansion over different horizons for different discount rates. The table reports the difference in realizations across two alternative simulated paths: with and without government intervention at year 0 (intervention is defined in the text). Each column reports the differences in cumulative discounted responses over different time periods after year 0.

Time	10 years			20 years			50 years		
r	0%	2%	r^k	0%	2%	r^k	0%	2%	r^k
dC	-0.60	-0.49	-0.34	-1.91	-1.49	-0.99	-2.75	-1.98	-1.20
dY	0.45	0.48	0.51	-0.43	-0.19	0.07	-0.88	-0.46	-0.05
dK	1.24	1.33	1.43	-1.30	-0.60	0.17	-2.59	-1.38	-0.18
dCns	0.45	0.48	0.51	-0.43	-0.19	0.08	-0.87	-0.45	-0.04
dCs	-1.42	-0.49	-0.34	-3.06	-2.49	-1.81	-4.22	-3.16	-2.10

Table 7: Counterfactual cross-sectional impact for different wealth cohorts to baseline intervention scenario over different horizons. The table reports the difference in realizations across two alternative simulated paths: with and without government intervention at year 0 (intervention is defined in the text). Each entry is the difference in average cumulative responses for corresponding cohort over different time periods after year 0.

	q1 (low)	q2	q3	q4 (high)
20 years				
ΔC	-0.36%	-0.58%	-0.88%	-3.40%
(eq. weighted %)	7.0%	11.1%	16.9%	65.0%
50 years				
ΔC	-0.68%	-0.90%	-1.27%	-4.83%
(eq. weighted %)	8.8%	11.7%	16.5%	62.9%

Table 8: Counterfactual cross-sectional impact for different age cohorts to baseline intervention scenario over different horizons. The table reports the difference in realizations across two alternative simulated paths: with and without government intervention at year 0 (intervention is defined in the text). Each entry is the difference in average cumulative responses for corresponding cohort over different time periods after year 0.

	Panel A			
	20-35	36-50	51-65	66-80
20 years				
ΔC	-0.38%	-0.82%	-1.68%	-2.92%
(eq. weighted %)	6.5%	14.2%	29.0%	50.3%
50 years				
ΔC	-0.70%	-1.08%	-2.02%	-4.10%
(eq. weighted %)	8.9%	13.6%	25.6%	51.9%
	Panel B			
	30	45	60	75
ΔC (15 years)	-0.25%	-1.03%	-1.76%	-2.49%
(eq. weighted %)	4.5%	18.5%	32.1%	44.9%

Table 9: Counterfactual responses to fiscal expansion over different horizons for longer intervention, without discounting. The table reports the difference in realizations across two alternative simulated paths: with and without government intervention at year 0 (intervention is defined in the text). Each column reports the differences in cumulative responses over different time periods after year 0.

Intervention	10 Years			Baseline (5 years)		
Time	10 years	20 years	50 years	10 years	20 years	50 years
dC	-0.52	-3.85	-6.26	-0.60	-1.91	-2.75
dY	1.31	-0.85	-2.19	0.45	-0.43	-0.88
dK	3.42	-2.61	-6.48	1.24	-1.30	-2.59
dCns	1.31	-0.84	-2.17	0.45	-0.43	-0.87
dCs	-1.93	-6.20	-9.45	-1.42	-3.06	-4.22

Table 10: Counterfactual responses to fiscal expansion over different horizons for lower foreign demand for government bonds, without discounting. The table reports the difference in realizations across two alternative simulated paths: with and without government intervention at year 0 (intervention is defined in the text). Each column reports the differences in cumulative responses over different time periods after year 0.

Foreign Demand	10%			Baseline (25%)		
Time	10 years	20 years	50 years	10 years	20 years	50 years
dC	-1.10	-2.31	-3.37	-0.60	-1.91	-2.75
dY	-0.39	-0.32	-0.87	0.45	-0.43	-0.88
dK	-1.08	-1.14	-2.72	1.24	-1.30	-2.59
dCns	-0.38	-0.31	-0.87	0.45	-0.43	-0.87
dCs	-1.67	-3.85	-5.32	-1.42	-3.06	-4.22

Table 11: Counterfactual responses to fiscal expansion over different horizons for larger increase in government debt, without discounting. The table reports the difference in realizations across two alternative simulated paths: with and without government intervention at year 0 (intervention is defined in the text). Each column reports the differences in cumulative responses over different time periods after year 0.

Gov. Debt Increase	35%			Baseline (25%)		
Time	10 years	20 years	50 years	10 years	20 years	50 years
dC	-0.57	-2.31	-3.37	-0.60	-1.91	-2.75
dY	0.84	-0.32	-0.87	0.45	-0.43	-0.88
dK	2.11	-1.14	-2.72	1.24	-1.30	-2.59
dCns	0.87	-0.31	-0.87	0.45	-0.43	-0.87
dCs	-1.69	-3.85	-5.32	-1.42	-3.06	-4.22

Table 12: Counterfactual responses to fiscal expansion with and without positive externality from intervention, without discounting. The table reports the difference in realizations across two alternative simulated paths: with and without government intervention at year 0 (intervention is defined in the text). Each column reports the differences in cumulative responses over different time periods after year 0.

	Positive Externality			Baseline		
Time	10 years	20 years	50 years	10 years	20 years	50 years
dC	-0.49	-1.83	-2.73	-0.60	-1.91	-2.75
dY	0.49	-0.32	-0.66	0.45	-0.43	-0.88
dK	1.39	-0.92	-1.91	1.24	-1.30	-2.59
dCns	0.49	-0.30	-0.64	0.45	-0.43	-0.87
dCs	-1.20	-2.86	-4.08	-1.42	-3.06	-4.22

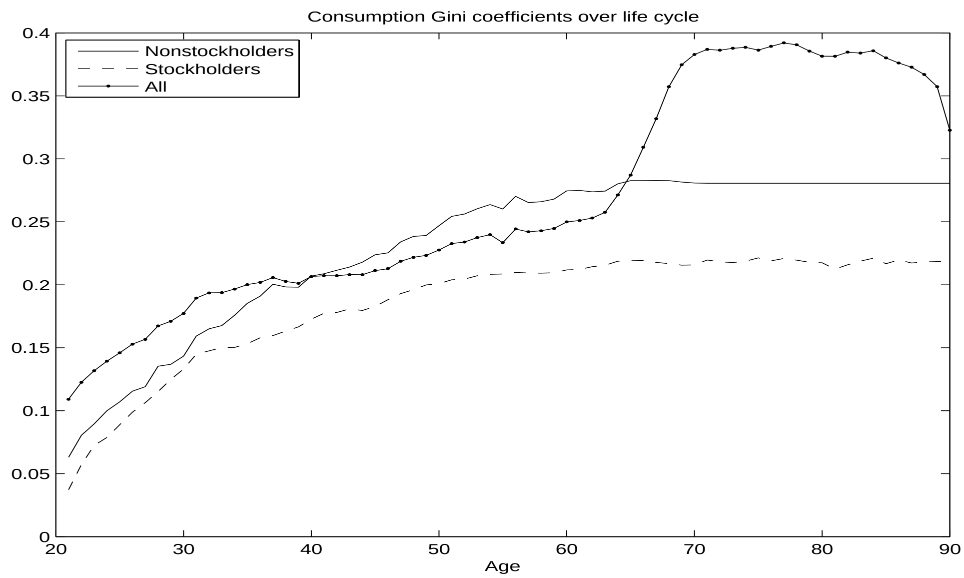

Figure 1: Consumption inequality over the life-cycle. The figure shows the cross-sectional gini coefficients for each age group.

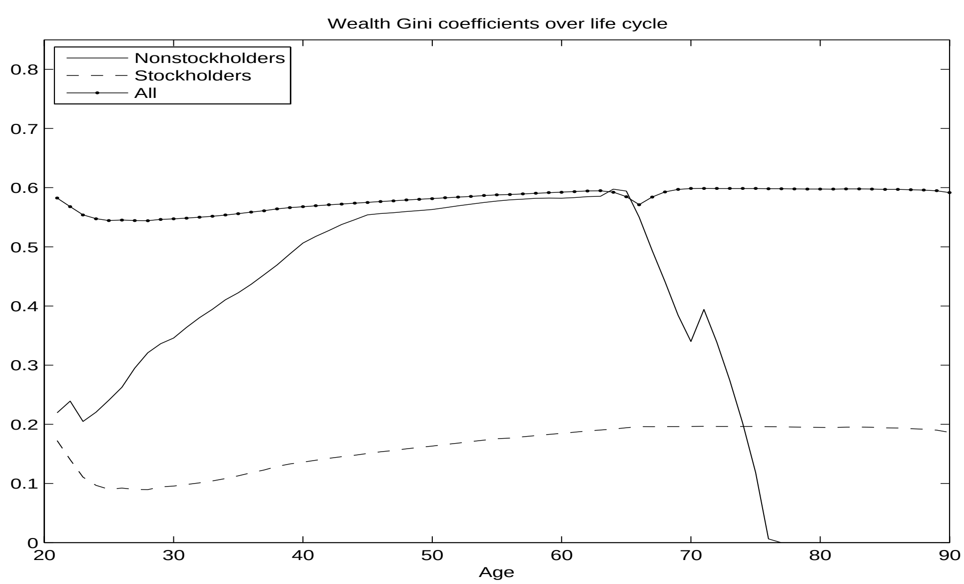

Figure 2: Wealth inequality over the life-cycle. The figure shows the cross-sectional gini coefficients for each age group.

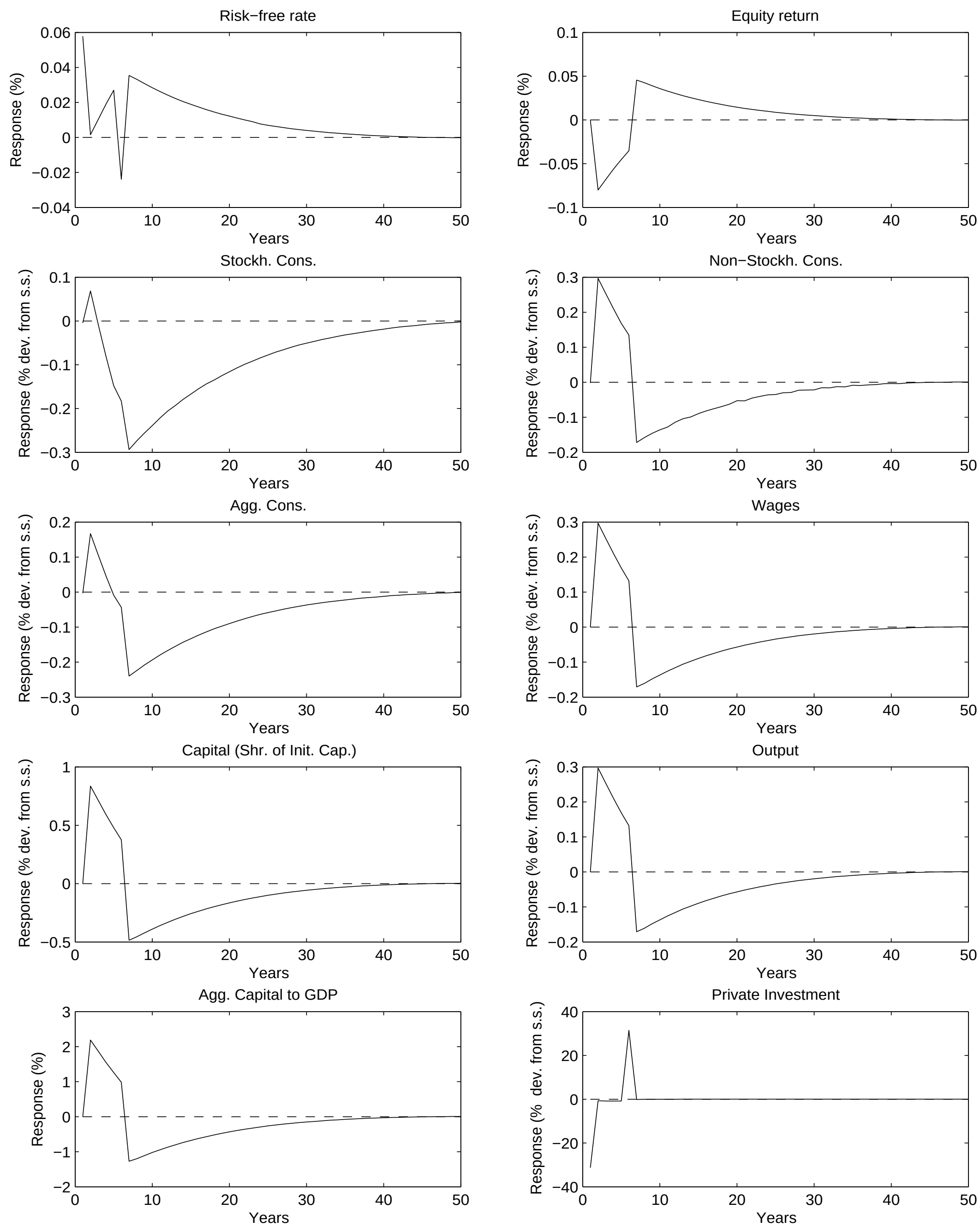

Figure 3: Differential responses to fiscal intervention across counterfactuals. Baseline scenario. The figure shows the differences in responses in each time period: with and without government intervention at year 0 (intervention is defined in the text).

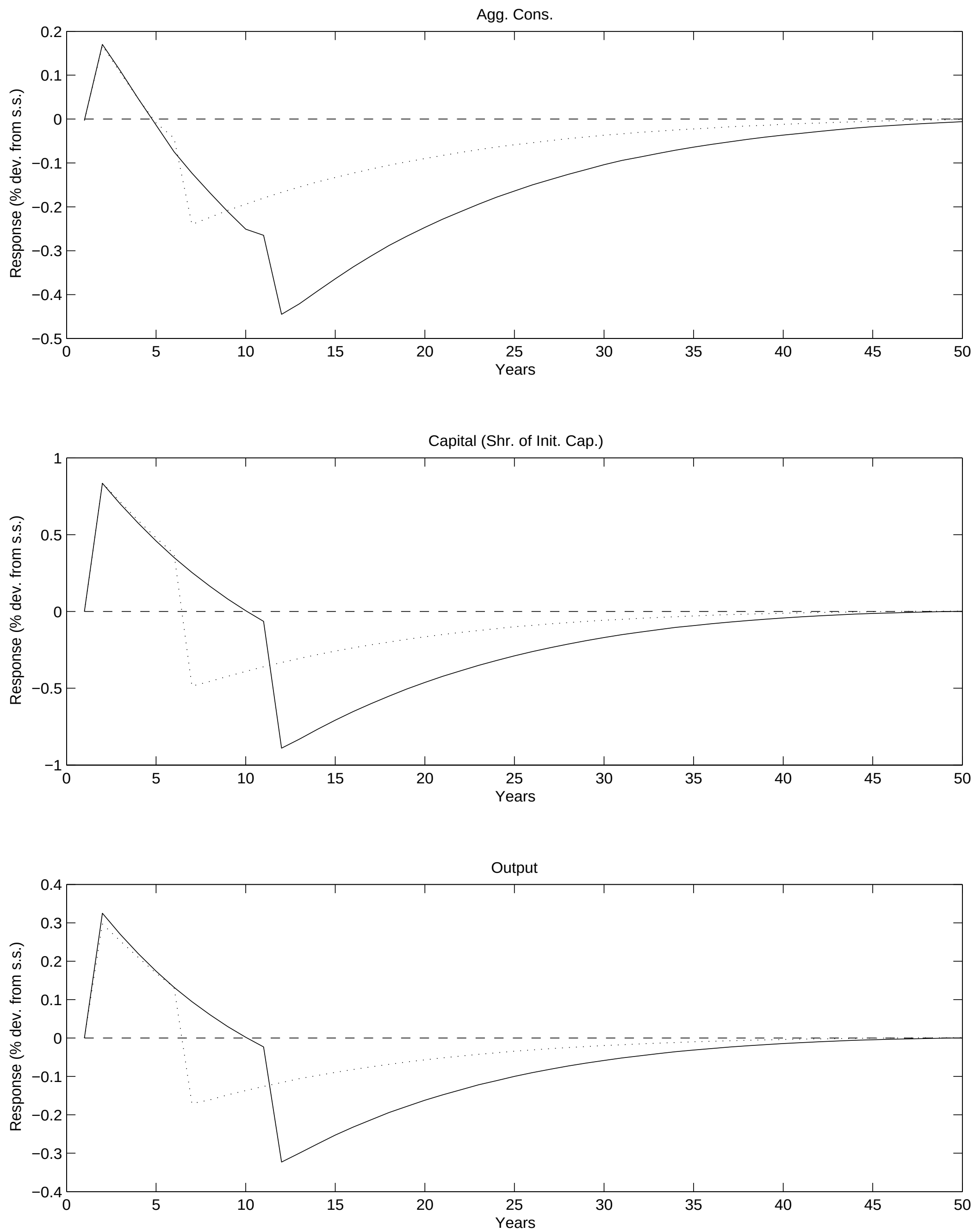

Figure 4: Differential responses to fiscal intervention across counterfactuals. Solid line: longer intervention, dotted line: shorter intervention. The figure shows the differences in responses in each time period: with and without government intervention at year 0 (intervention is defined in the text).